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# **Agricultural sciences**

## **TERRITORIAL INNOVATION IN ALBANIAN AGRI-TOURISM: UTILIZATION OF THE POTENTIAL FOR DEVELOPMENT AND GROWTH**

**Aldona Minga**

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### **Abstract**

At the very least, agri-tourism is evolving in an unprecedented way in the context of territorial innovation. It offers a wide range of activities and experiences that transcend the boundaries of time, including exploring nature, staying in log cabins on the mountain, and participating in culinary rituals that delight the senses, such as using fresh produce and local wines. Different. Agri-tourism is broadly defined as an agro-cultural activity that attracts visitors and encourages them to visit farms and rural areas away from urban centers, thereby promoting territorial innovation. However, agri-tourism is not only an opportunity to try delicious food; it also provides an avenue for farmers to increase income and improve their infrastructure. Fortunately, agri-tourism is not yet widespread in Albania, although there is an increased demand from foreign and local tourists. With increasing awareness of healthy food and environmental issues, research and involvement in this way of eating and living are becoming an important part of territorial innovation in Albania.

**Keywords:** Agro-tourism, Territorial innovation, Tourist experiences, Farms and rural areas, Healthy food, Economic development, Environmental awareness, Tourism potential

### **Introduction**

In the last ten years, Albania's rural economy has changed a lot because tourism has grown quickly and agriculture has remained a key part of the economy. Agri-tourism has grown at the crossroads of these two areas. It serves as a way for small farms to diversify their income and as a way to innovate in the area. Territorial innovation, defined as the ability of local systems to leverage endogenous resources and create enduring competitive advantages (Camagni, 2008), serves as a pertinent analytical framework for the examination of the Albanian case.

This study relies entirely on a systematic review of documentation as a research method. The documentary approach is considered appropriate in studies on territorial development and public policies because it allows for the analysis of institutional structures, strategic orientations, and normative frameworks that influence the development of specific sectors, such as agritourism. According to Bowen (2009), document analysis constitutes a valuable research method in qualitative studies, as it offers opportunities for in-depth interpretation of policies, strategies, and official documents, identifying patterns, discourses, and development priorities.

In this context, agritourism and territorial innovation in Albania have been addressed through the analysis of strategic and legal documents, to highlight the coherence between national policies and European frameworks of rural development and innovation. The method does not aim for empirical measurements through surveys or interviews, but focuses on interpreting the content of documents, considering them as a reflection of the institutional orientations and development vision of the territory. Therefore, territorial innovation in Albanian agri-tourism requires strengthening value chain integration, enhancing institutional coordination, and embedding digital and green transitions into rural strategies. Innovation is the central initiator of economic growth, development, and the creation of better jobs. It is the key that enables companies to compete in the global or local market successfully and the process that searches for solutions for social and economic challenges, from climate change to the battle against deadly diseases (Minga, A et al, 2023). The development of a territory and the role of business in innovation are closely intertwined. A thriving business sector can help drive economic growth and development in a region, while a supportive environment can foster innovation and entrepreneurship. (Jana, K et al, 2023).

Albania presents a unique structural configuration where agriculture retains high socio-economic importance, and tourism demonstrates rapid expansion. This combination creates favorable conditions for agri-tourism as a strategic instrument of territorial innovation. The challenge is not resource scarcity but the effective mobilization of territorial capital, institutional support, and coordinated governance mechanisms capable of transforming rural potential into sustainable development and growth.

The review includes national strategic documents, European Union documents and relevant academic literature. At the national level, rural and agricultural development strategies, documents on tourism development, policies for supporting agritourism, as well as documents addressing innovation and entrepreneurship in rural areas, were analyzed. These documents have been reviewed to understand how the role of agritourism is conceived in rural economic diversification, in increasing the value of local products, and in building territorial identity.

At the European level, Common Agricultural Policy (CAP) documents, the "Farm to Fork" strategy, and territorial cohesion policies have been taken into consideration, which emphasize sustainability, innovation, and integration of the agri-food value chain. European strategies consider the territory as a functional space where economic, social, and institutional actors interact, promoting the development of models such as "smart villages" and community-based innovation (European Commission, 2020).

The reviewed academic literature has contributed to building a theoretical framework on agritourism as an instrument of rural diversification and as a mechanism of territorial activation. Studies on rural tourism emphasize that agritourism creates synergy between agriculture, cultural heritage, and the local economy, generating not only technological, but also social and organizational innovation (Lane & Kastenholz, 2015). Along the same lines, the concept of territorial capital considers development as the result of the interaction of natural, human, and institutional resources within a given territory (Camagni, 2008).

The analysis process was developed in a structured and systematic manner. Initially, relevant documents were identified based on their thematic relevance and relevance, focusing mainly on the period after 2015, when agritourism in Albania began to be treated more clearly as a priority sector. The documents were then analyzed through the content analysis method, which, according to Krippendorff (2018), allows the identification of conceptual categories and discursive structures within the texts.

The analysis is oriented towards identifying four main dimensions: the role of agritourism in rural development, financial and institutional support instruments, the integration of local agricultural products into the tourism offer, and the conceptualization of territorial innovation in strategic documents. A comparative analysis between national and European documents was carried out to identify the level of strategic harmonization and potential gaps.

The interpretation of documentary data is based on the theory of territorial innovation, which sees the territory as an integrated system where social capital, infrastructure, institutions and natural resources interact (Camagni, 2008). In this context, agritourism is not treated only as an economic activity, but as an element of a territorial ecosystem that generates cooperation networks, strengthens local identity and promotes sustainable development.

The analysis is also based on the integrated rural development approach, which emphasizes the need for economic diversification and the creation of cross-sectoral synergies in rural territories (OECD, 2019). This approach places agritourism in a position between agriculture, tourism and innovation, considering it as an instrument for increasing territorial competitiveness.

The choice to exclusively use the documentation review is related to the nature of the study, which aims to analyze the policies and strategic frameworks that shape the development of agritourism and territorial innovation in Albania. This method enables the identification of institutional visions, strategic priorities, and coherence between different levels of government. As Bowen (2009) points out, documentary analysis is particularly useful in studies that address public policies and institutional structures, as documents represent stable and verifiable sources of information. In this way, the methodology used provides a structured and theoretically supported analysis of agritourism and territorial innovation in Albania, placing the study within a broader European and conceptual context.

### **Agritourism Potentials in Albania**

Agrotourism in Albania represents one of the most promising opportunities for sustainable rural development, integrating traditional agriculture with authentic tourism, local gastronomy and cultural experiences. Albania, with its agro-ecological diversity, untouched landscapes, rich biodiversity and cultural heritage, has a high potential to develop agritourism as a key sector linking agriculture (which contributes around 22% to GDP and employs 36.4% of the workforce) with rapidly growing tourism (over 10 million foreign visitors in 2023) (Ministry of Agriculture and Rural Development [MARD], 2024; United Nations, 2024). The National Agrotourism Development Strategy aims to exploit these potentials by targeting 100 certified agrotourism units by 2027, with an economic impact estimated at 14.2 million euros (MARD, 2024). The natural and geographical potentials are among the strongest. Albania offers a variety of landscapes – from the mountains of the Albanian Alps and national parks (such as Korab-Koritnik, Vjosa), lakes, rivers and Adriatic-Ionian beaches – to mountainous and plain areas with a Mediterranean climate ideal for diverse agricultural produc-



tion (olives, vineyards, medicinal plants, honey, livestock products). These natural resources allow the development of various forms of agritourism, such as ecotourism, farm tourism, and “farm-to-table” experiences (Baroli et al., 2025; Creative Business Solutions, 2019). Regions such as Dibra, Lezha, Gjirokastra, Korça, Berat and Shkodra have high potential thanks to protected landscapes, biodiversity and indigenous products, enabling activities such as harvesting, hiking, visits to olive groves or vineyards (MARD, 2024). The economic potentials are considerable. Agritourism diversifies farmers' incomes, creates short supply chains, and extends the tourist season beyond the summer. According to data, an average agritourism generates around 142,000–145,000 euros in annual turnover and employs an average of 9 permanent employees (and 8 seasonal ones), mainly women and young people (MARD, 2024). With the growth of tourism (doubling of visitors from 2016 to 2023), agritourism can attract a segment of tourists seeking authentic experiences, contributing to the reduction of rural poverty and emigration (United Nations, 2024). Programs such as IPARD, ARDA grants and “100 Villages” provide financial support of up to 65% of investments, with the potential for 1,200 new units in 5–7 years (Creative Business Solutions, 2019; Barolli et al., 2025). Success stories such as “Mrizi i Zanave” in Lezha (over 70,000 visitors per year) show how agritourism can generate additional income through the sale of local products and culinary tourism (Baroli et al., 2025). The social and community empowerment potentials are equally important. Agritourism empowers women (61–65% of staff and owners), youth (average age of entrepreneurs 40 years) and rural communities, promoting gender equality, the transfer of traditional knowledge and social cohesion (MARD, 2024). It helps combat rural depopulation (rural population 33.9%) by creating quality jobs and revitalizing villages through the “100 Villages” program (Baroli et al., 2025). Furthermore, agritourism preserves cultural identity by promoting traditions, crafts, folklore and authentic gastronomy, making them part of the tourist experience (United Nations, 2024). Environmental and sustainability potentials are linked to environmentally friendly agricultural practices. Over 83% of agritourisms produce organically or use indigenous seeds, contributing to the preservation of biodiversity, waste reduction and landscape protection (MARD, 2024). It supports green tourism and helps mitigate climate change through renewable energy and sustainable practices (Creative Business Solutions, 2019; Barolli et al., 2025). According to Marku et al, 2024, Students expressed limitations in social opportunities, scarcity of recreational activities, inadequate infrastructure, and limited access to public services as important factors contributing to migration trends. The potential of agritourism in Albania is large and strategic, offering a development model that balances the economy, society and the environment. Despite the lack of technological infrastructure in some areas, the interest of young people in pursuing careers in the fields of multimedia and digitalization is high, signaling the need for modernization of curricula, expansion of practical opportunities, and the establishment of special laboratories in universities and schools in non-urban areas. (Minga, A. et al., 2025). With government support (new laws, certification, training, and digital marketing), this sector can become an engine of shared prosperity, reducing rural-urban disparities and preserving Albanian heritage (MARDZHR, 2024; United Nations, 2024). Challenges such as infrastructure, training and marketing require coordinated action, but opportunities outweigh barriers (Baroli et al., 2025).

#### **The Role of Policies and Institutional Support**

The economic diversification of rural areas is provided by the development of Agrotourism, which is a form of rural tourism, which combines activity in the field of agriculture with services in the field of tourism such as; accommodation, food, recreational and educational activities, providing the opportunity to create jobs and preserve the cultural and natural heritage of a given region. Its sustainable development depends largely on the political framework and institutional support, which create a favorable environment for investment, training and cooperation between public, private and community actors. At the global level, government policies and institutional support play a catalytic role in the promotion of agritourism. According to a review of global trends, the success of agritourism is driven by strong policy frameworks that provide financial incentives (subsidies, tax breaks), investments in infrastructure, and clear regulations that ensure benefits for local communities and the environment (Ling et al., 2024). For example, in India, national and state strategies are required for diversifying farm incomes, while in Italy the European Union's Common Agricultural Policy (Pillar II) has helped small farms in disadvantaged areas integrate tourism (Ling et al., 2024, citing Giaccio et al., 2018). In France, cooperation between networks and the integration of existing support systems with specialized tourism bodies are emphasized (Ling et al., 2024). A successful institutional example is the strategy of the state of Michigan in the USA, where the development of agritourism is the result of close cooperation between the state government (Michigan Department of Agriculture and Rural Development – MDARD), universities (such as Michigan State University) and professional associations (Michigan Agritourism Association). The government has established advisory committees, protective laws (such as the Right to Farm Act), and promotional programs, while universities provide research, training, and extension services, leading to



increased income from agritourism (Jin et al., 2021). This suggests that institutional support—training, marketing, networking, and public-private partnerships—helps build the capacity of rural communities and align policies with local needs (Ling et al., 2024; Jin et al., 2021). In the Albanian context, policies and institutions have gradually evolved, but still present challenges. The basic legal framework includes Law No. 93/2015 “On Tourism”, which defines agrotourism as a farm activity that contributes to sustainable rural development, and the Decision of the Council of Ministers No. 22 dated 12.1.2018, which regulates the certification of agrotourism entities by an inter-ministerial commission (Ministry of Tourism and Environment and Ministry of Agriculture and Rural Development). Fiscal incentives such as 6% VAT and 5% profit tax have been offered to certified entities, as well as financial support through national schemes and the IPARD program (Domi et al., 2023). However, the lack of a dedicated law on agrotourism, strict certification conditions (such as the obligation of accommodation) and the distribution of competencies between ministries create obstacles. The National Strategy for the Development of Agrotourism in Albania (2024), drafted by the Ministry of Agriculture and Rural Development in collaboration with GIZ, aims to fill these gaps by proposing a dedicated department for agrotourism, mandatory training (90 hours), integration into the “100 Villages” Program, the creation of a “Certified Albanian Agrotourism” brand, and harmonization with the EU Common Agricultural Policies (Ministry of Agriculture and Rural Development [MARD], 2024). Institutions such as the Ministry of Rural Development, the Ministry of Tourism, the National Agency for Territorial Planning and donors (FAO, USAID, GIZ) play a key role in funding, training and networking, but cooperation remains largely informal (Domi et al., 2023). Policies and institutional support are crucial elements for the sustainable development of agritourism, providing economic incentives, clear regulations, and human capacity. International examples (USA, Italy, France) and efforts in Albania show that success depends on inter-institutional coordination, public-private partnerships, and the adaptation of policies to local realities. Key recommendations include drafting a dedicated law, strengthening institutional structures, and investing in infrastructure and training to maximize the contribution of agritourism to sustainable rural development.

### **Conclusion**

The meaning is immense – it can prompt the earth change in a way that will lead to considerable gains to the rural areas and general financial increase and socioeconomic progress. The most important thing is agritourism here, as it is through it that the union of the country's cultivation and natural power can bring the best. The setting for the investigation is agritourism as a change specialist in rural areas in Albania. Execution of this kind of travel through experience guest demands straightforwardly connected to the custom of cultivation and the climate assists the expansion of the local economy, and sociocultural significance around the Albanian farmer gathering as progress moves on. It is through the very much considered development of agritourism practices that the country's earth change will bring the upheaval of the reasoning of the country's individuals' sustainability levels. It will result in the earth changing to give a progressive state in supporting financial and social increment, ecological safeguard, and enduring qualities.

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**INVESTIGATIONS ON THE ASSESSMENT OF NET GREENHOUSE GAS EMISSIONS FIXED BY PHOTOSYNTHESIS AT THE FORAGE SYSTEM LEVEL IN A MIXED FARM-CASE STUDY**

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***Assessment of the soil organic carbon content at harvest***

Organic carbon content represents the soil organic matter (SOM) resulting from the decomposition of plant residues. Soil organic matter contains approximately 58% carbon, which comes from the atmosphere through plant photosynthesis. Soil organic carbon plays a very important role in its physical, chemical and biological properties, with a significant impact on fertility. Soil organic carbon determinations were carried out on the 0-30 cm depth horizon, every 10 cm, a depth that encompasses over 70% of the plant rhizosphere. The organic carbon content is 3.64% at a depth of 0-10 cm, 3.71% at a horizon of 10-20 cm and 2.91% at a horizon of 20-30 cm. In terms of hectare, the amount of carbon varies at different depths, as follows: 24t/ha at a depth of 0-10 cm, 49t/ha at a depth of 10-20 cm and 58t/ha at a depth of 20-30 cm.

In the wheat crop, cultivated on the largest area (335 ha) within the fodder system, the amount of organic carbon related to the three depth horizons increases proportionally from 21.3 t/ha (100%) at the depth of 0-10 cm to 42.2 t/ha (198%) for the depth of 10-20 cm and 62 t/ha (291%) for the depth horizon of 20-30 cm. The amount of organic carbon in barley is lower compared to wheat because barley has a much less developed root system.

It is found that on the three soil depths the amount of organic carbon registered a quantitative upward trend, characterized by the following values: 17 t/ha on the depth of 0-10 cm (100%), 32 t/ha (188%) on the interval of 10-20 cm respectively 47 t/ha representing a share of 276% on the terminal horizon of 20-30 cm. The analysis of the results associated with alfalfa highlights a progressive increase in the amount of organic carbon, from 14 t/ha (100%) at a depth of 0-10 cm to 34 t/ha (243%) at a second horizon of 10-20 cm and to 49 t/ha (350%) at a terminal depth of 20-30 cm, therefore 3.5 times more than the first depth horizon (compared to any other crop) and 1.4 times more than the 10-20 cm horizon. Sudan grass is a species of grass with a fasciculated, strongly branched and deep root system, reaching, like alfalfa, depths of over 2 m, which explains the 2-3 times increase in the amount of organic carbon at a depth of 20-30 cm compared to the 0-10 cm horizon. Analyses carried out on this crop show a quantity of 9 t/ha (100%) organic carbon at a depth of 0-10 cm, a quantity that increases progressively on the other 2 depth horizons, 18 t/ha for the 10-20 cm horizon (200%) and 27 t/ha (300%) for the 20-30 cm depth horizon. In the case of the mixed crop consisting of perennial grasses (100%), the amount of organic carbon in the soil records the following values: 15 t/ha (100%) for the depth of 0-10 cm, 33 t/ha (220%) for the horizon of 10-20 cm respectively 48 t/ha (320%) at the depth of 30 cm. In this case the increase in the amount of organic carbon in the soil was 120% at the depth of 20 cm respectively 220% for the depth of 30 cm compared to the first horizon between 0-10 cm. These increases are largely due to the fasciated root system, strongly developed to depths of 50-70 cm. The mixed crop consisting of alfalfa (40%) and perennial grasses (60%), through their highly developed root system, recorded a significant increase in the amount of organic carbon at soil depths within the 20-30 cm horizon. Thus, at a depth of 0-10 cm the amount of organic carbon was 16 t/ha (100%), increasing to 35 t/ha (219%) for the depth between 10-20 cm and 47 t/ha (294%) for the 20-30 cm depth horizon. The autumn crop, with a participation of autumn vetch of 75%, has a significant contribution to the increase in the amount of organic carbon due to the pivoting, deep and strongly developed root system in the superficial layers of the soil. In the case of this crop, the amount of organic carbon in the soil accumulated on the 0-30 cm depth horizon (15+33 t/ha) is symmetrical with that accumulated on the 20-30 cm depth (48 t/ha). The proportional increase in the amount of organic carbon at the three soil depths is determined by the 15 t/ha (100%) associated with the 0-10 cm horizon, 33 t/ha (220%) for the 10-20 cm depth and 48 t/ha (320%) for the 20-30 cm horizon. The cumulative analysis of the organic carbon content in the soil highlights the following results: - the average amount of organic carbon in the soil differs in relation to the soil depth horizon, as follows: 17.5 t/ha at a depth of 0-10 cm, 36.1 t/ha at a depth of

10-20 cm and 49.3 t/ha at a depth of 20-30 cm, - the total amount of organic carbon in the soil, at the level of the total surface of 1019 ha, has the following differentiation by studied depths: 17.5 thousand tons (11% of the total) at a depth of 0-10 cm, 36.8 thousand tons (23% of the total) at a depth of 10-20 cm and 103.7 thousand tons (66% of the total) at a depth of 20-30 cm, - the total amount of organic carbon in the soil at farm level, on the total surface studied is 158.000 tons.

***Carbon footprint associated to the agro technical works on the studied crops***

The increase in GHG emissions in agriculture is determined by the management applied in order to increase agricultural production. A classic plant cultivation system is applied in the experimental site, the specific diesel consumption being 115.5 l/ha. In terms of carbon emissions, agrophytotechnical works emit a quantity of carbon of 83 kg/ha, respectively 424 kg/ha CO<sub>2</sub> eq. The general inputs used (fertilizers, herbicides, pesticides) emit a quantity of carbon 5 times higher than the volume of technological works, respectively 419 kg/ha (1537 kg/ha CO<sub>2</sub> eq). Of these, the applied nitrogen fertilizers represent 85% of the total amount of carbon emitted, respectively 355 kg/ha or 1302 kg/ha CO<sub>2</sub> eq. At the level of the total area of 1019 ha, the agrophytotechnical works and the applied inputs consume a quantity of diesel of 118 t with total emissions of 511 t carbon respectively 1998 t CO<sub>2</sub> eq.

***The amount of "raw" C (CO<sub>2</sub> eq) captured through photosynthesis and fixed in the biomass of crops in the feed system***

From the data obtained, it is found that, in the case of wheat crop, the amount of carbon fixed by photosynthesis varies depending on the production structure. Thus, the highest content of fixed carbon is found in grain production, recording a quantity of 1890 kg/ha) or a total of 633 t, on a cultivated area of 335 ha. Compared to the total amount of fixed carbon of 1504 t, grain production fixes carbon in a share of 42%. Root production fixes a quantity of 1617 kg C/ha, or 36% of the total amount of fixed carbon. Plant residues (straw, stubble) fix smaller quantities of carbon, respectively 794 kg/ha (18% of the total) in the case of straw production and 188 kg/ha (4% of the total) for stubble production. The cumulative amount of fixed carbon in the case of wheat crop is 4489 kg/ha (16429 kg/ha CO<sub>2</sub> eq) and a total amount, related to the cultivated area, of 1504 t fixed carbon (5506 t CO<sub>2</sub> eq). The intensity of the decomposition rate of secondary production (straw, stubble) and of roots, which are part of the soil organic matter, is low (with C/N ratio values between 54.5-72.4). The corn grain crop captures through photosynthesis and fixes in the total biomass a quantity of carbon of 4438 kg/ha, respectively 16242 kg/ha CO<sub>2</sub> eq., of which: in the grain production a quantity of 1927 kg/ha (43%) is fixed, respectively 7053 kg/ha CO<sub>2</sub> eq; in the production of stems + leaves 2212 kg/ha is fixed, respectively 8095 CO<sub>2</sub> eq; in the production of roots 299 kg/ha carbon is fixed, respectively 1094 CO<sub>2</sub> eq. At the level of the total area cultivated with corn for grain (150 ha) the total amount of carbon captured and fixed is 667 t, respectively 2438 t CO<sub>2</sub> eq. The average C/N ratio is 31.2, which indicates an average intensity of the organic matter decomposition rate for all components of corn for grain production. Barley as a fodder importance, occupies an important place in animal feed and as a result is cultivated on a large area within the vegetable farm. The total amount of fixed carbon is 5807 kg/ha (21254 kg/ha CO<sub>2</sub> eq), structured as follows: grain production with a quantity of 2455 kg/ha (8985 kg/ha CO<sub>2</sub> eq, 42%), root production with 2319 kg/ha (40%) fixed carbon respectively 8488 kg/ha CO<sub>2</sub> eq, straw production with 903 kg/ha fixed carbon (16%) respectively 3305 kg/ha CO<sub>2</sub> eq, stubble production with 130 kg/ha (2%) with 476 kg/ha CO<sub>2</sub> eq. The total amount of fixed carbon at the level of the total barley area (100 ha) is 580 t, respectively in equivalence 2123 t CO<sub>2</sub> eq. The calculated average C/N ratio is 44.3, with a low intensity decomposition rate. In the case of the root system, a ratio of 30.6 was calculated and implicitly a medium intensity decomposition rate. In the case of the alfalfa crop, the biomass has only 2 components, namely the green mass or hay expressed in dry matter and the root production (SU). The largest amount of carbon is fixed in the root system, namely 10241 kg/ha (76% of the total amount of fixed carbon), representing, in equivalence, 37482 kg/ha CO<sub>2</sub> eq. In the aboveground production of dry matter, an amount of 3244 kg/ha (24% of the total fixed carbon) is fixed, the equivalence of 11873 kg/ha CO<sub>2</sub> eq. At the level of the 79 ha area cultivated with alfalfa, within the fodder system included in this project, a total amount of 1065 t C was fixed, equivalent to 3898 t CO<sub>2</sub> eq. The highly developed root system and the high production of aboveground phytomass directly influence the capacity to fix carbon, in the case of grass crops. The following conclusions result from the data presented above: the largest amount of fixed carbon is achieved within the production of roots (in proportion to 90% of the total), respectively 9029 kg/ha, equivalent to 33046 kg/ha CO<sub>2</sub> eq; the production of aboveground SU fixes an amount of 998 kg/ha fixed carbon (3653 kg/ha CO<sub>2</sub> eq); at the level of the cultivated area (58ha) a total amount of fixed carbon of 582 t was achieved, equivalent to 2130 t CO<sub>2</sub> eq. The analysis of the C/N ratio for root production highlights the threshold of 38.8, which characterizes an average intensity of the organic matter decomposition process. In the case of Sudan Grass culture, the root system fixes most of the carbon (65% of the total amount), respectively 4560 kg/ha, equivalent to 16690 kg/ha CO<sub>2</sub> eq. In the production of aboveground phytomass, the amount



of fixed carbon determined was 2445 kg/ha (35% of the total amount of fixed carbon), equivalent to 8949 kg/ha CO<sub>2</sub> eq. The total amount of carbon fixed on the cultivated area (22 ha) was 155 t, equivalent to 564 t CO<sub>2</sub> eq. The C/N ratio was 21.2, which indicates a medium-intensity decomposition rate of soil organic matter. The sown meadow formed by the mixture of alfalfa (40%) and perennial grasses (60%), is considered the most intensive crop. The root system, by transferring carbon to the underground biomass level, fixes a larger amount of carbon (68% of the total amount), respectively 5801 kg/ha in the equivalence of 21232 kg/ha CO<sub>2</sub> eq. The production of aboveground phytomass fixes an amount of 2687 kg/ha carbon in the equivalence of 9834 kg/ha CO<sub>2</sub> eq. At the level of the cultivated area (4 ha) the total amount of fixed carbon was 34 t, respectively 124 t CO<sub>2</sub> eq. The C/N ratio, on average 17.5, indicates an intense rate of decomposition of organic matter. The autumn grass produces a quantity of 7.27 t/ha SU and a double quantity of roots (14.8 t/ha SU). These proportions are also directly correlated with the fixation of specific quantities of carbon. Thus, the analyses carried out showed that the root system fixes a quantity of carbon of 4470 kg/ha (64% of the total amount of fixed carbon) in equivalence of 16360 kg/ha CO<sub>2</sub> eq. The production of aboveground phytomass fixes a quantity of 2581 kg/ha carbon, only 36% of the total, in equivalence of 9446 kg/ha CO<sub>2</sub> eq. The total amount of carbon fixed in relation to the total cultivated area (15 ha) was 105 t, equivalent to 384 t CO<sub>2</sub> eq. The C/N ratio, on average 16.2, indicates an intense rate of decomposition of organic matter in the soil. The production of aboveground dry matter associated with the corn grain crop fixes a quantity of carbon of 1683 kg/ha (56% of the total), equivalent to 6160 kg/ha CO<sub>2</sub> eq. The production of roots fixes a quantity of carbon of 1351 kg/ha (44% of the total fixed carbon), equivalent to 4945 kg/ha CO<sub>2</sub> eq. At the level of the area cultivated with corn for silage, a total amount of 777 t carbon is fixed, through photosynthesis, in the equivalence of 2843 t CO<sub>2</sub> eq. The C/N ratio is, on average, 29.1, which indicates a medium intensity decomposition of organic matter.

***The amount of "net" fixed carbon and the general distribution of carbon fixed through photosynthesis, at the level of the forage system***

Photosynthesis is the most efficient way to take up carbon C-CO<sub>2</sub> eq from the atmosphere, being characteristic of all plant species on Earth. As part of the research carried out in this project, a study was also carried out on the quantitative assessment of the "gross" carbon returned to the atmosphere through respiration and the determination of the amount of "net" carbon fixed in the plant. Following the studies carried out, the losses of gross carbon captured and fixed through photosynthesis due to plant respiration represent 15% of the aboveground biomass, respectively 30% due to the respiration of the root system, microorganisms and the processes of decomposition and mineralization of organic matter in the soil. The study investigates the total amounts of carbon associated with the 3 categories studied, namely "gross" C, C returned through respiration and "net" C. The analysis of these data highlights the following: - the total amount of carbon captured and fixed at farm level is 7173 t, of which 2639 t (37%) is found in aboveground biomass, respectively 4534 t (63%) at the level of belowground biomass. The average for each cultivated ha is 7040 kg C/ha, of which 2590 kg/ha found within aboveground biomass and 4450 kg/ha at the level of belowground biomass. The total value, expressed in CO<sub>2</sub> eq, is 26255 t CO<sub>2</sub> eq, with an average per ha of 9659 kg CO<sub>2</sub> eq at aboveground level and 16596 kg/ha CO<sub>2</sub> eq at underground level, - following the respiration processes in plants and soil, the total amount of carbon returned to the atmosphere is 1755 t, of which 1360 t comes from underground biomass (77%) and 395 t (23%) from aboveground biomass. The calculation per hectare highlights a total carbon loss, through respiration, of 1723 kg/ha, of which 1335 kg/ha from underground biomass and 388 kg/ha from aboveground biomass, - after calculating the difference between the total amount of raw carbon and the total amount of carbon returned through respiration, the total amount of carbon fixed through photosynthesis was obtained. In this regard, the data obtained highlights that at the farm level, on the total area of the forage system (1019 ha), the total amount of net carbon is 5417 t (19829 t CO<sub>2</sub> eq), of which, in the underground biomass we find the average amount of 3174 t (11617 t CO<sub>2</sub> eq, 59%) and in the aboveground biomass we find the amount of 2243 t (8212 t CO<sub>2</sub> eq, 41%). The average amount of net carbon fixed per hectare is 5317 kg (19460 kg/ha CO<sub>2</sub> eq) of which 3115 kg/ha (11401 kg/ha CO<sub>2</sub> eq) in underground biomass and 2202 kg/ha (8059 kg/ha CO<sub>2</sub> eq) in aboveground biomass, - carbon fixed and immobilized in the long or short term at the level of the main production (grains, phytomass, silage) and secondary production: 2.2 t/ha C (8.05 t/ha CO<sub>2</sub> eq) respectively a total amount of 2243 t (8209 t CO<sub>2</sub> eq) in proportion to 31.3%; - carbon fixed and immobilized in the long or short term at the level of roots, stubble, plant residues and soil: 3.12 t/ha C (11.42 t/ha CO<sub>2</sub> eq) respectively a total amount of 3174 t C (11617 t CO<sub>2</sub> eq) in proportion of 44.2%; - carbon fixed and returned to the atmosphere through plant-soil respiration: 1.72 t/ha C (6.3 t/ha CO<sub>2</sub> eq), respectively a total quantity of 1755 t C (6423 t CO<sub>2</sub> eq), in proportion of 24.5%.

***Determining the average degree of humification of organic matter in the soil***

Humus is a mixture of amorphous organic substances, found in the soil, usually to a depth of 20-30 cm. It represents 80-90% of the soil organic matter, being an important criterion for evaluating soil fertility. In the

case of variant V1, which includes only stubble and plant roots, the average amount of humus was 1309 kg/ha, with limits ranging between 88 kg/ha (corn crop) and 3011 kg/ha (alfalfa crop). Other crops with a higher humus content were the mixture of perennial grasses, with a quantity of 2655 kg/ha, the mixed crop of alfalfa and perennial grasses, with a content of 1706 kg/ha. At farm level, in this variant a total amount of humus of 819 t was estimated, with an average per hectare of 1309 kg. In the case of variant V2, where more organic field products were included (straw, stems, stubble, roots), the amounts of humus have higher values. Thus, depending on the amount of net carbon sequestered in the soil, the limits of variation of the amount of humus are between 397-3011 kg/ha, with an average of 1666 kg/ha (27% more than variant V1). Among the species studied, it is worth noting, again, as in the case of variant V1, perennial alfalfa crops and sown meadows (made up of perennial grass species or a mixture thereof with alfalfa). These have amounts of humus with values ranging between 1314-3011 kg/ha. At the farm level, the determined amount of humus amounted to 1114 t, respectively 36% higher compared to variant V1.

***The amount of “net” fixed carbon and the general distribution of carbon fixed by photosynthesis, at the level of the manure-fertilized forage system***

In this regard, the total amounts of carbon (per ha and per entire cultivated area) associated with the 3 studied categories were presented, namely “gross” C, C returned through respiration and “net” C associated with the manure fertilization variant. The analysis of these data highlights the following: - the total amount of carbon captured and fixed at the level of the 3 representative crops included in the study is 134 t, of which 57 t (43%) is found in the aboveground biomass, respectively 77 t (57%) at the level of the underground biomass. The average for each cultivated ha is 6352 kg C/ha, of which 2366 kg/ha found within the aboveground biomass and 3986 kg/ha at the level of the underground biomass. The total value, expressed in CO<sub>2</sub> eq, is 23185 t CO<sub>2</sub> eq, with an average per ha of 2878 kg CO<sub>2</sub> eq at aboveground level and 4850 kg/ha CO<sub>2</sub> eq at belowground level, - following the respiration processes in plants and soil, the total amount of carbon returned to the atmosphere is 21 t, of which 12 t comes from belowground biomass (57%) and 9 t (43%) from aboveground biomass. The calculation per hectare highlights a total loss of carbon, through respiration, of 952 kg/ha, of which 598 kg/ha from belowground biomass and 355 kg/ha from aboveground biomass, - following the calculation of the difference between the total amount of raw carbon and the total amount of carbon returned through respiration, the total amount of carbon fixed through photosynthesis was obtained. In this sense, the data obtained highlight a total net carbon quantity of 114 t (417 t CO<sub>2</sub> eq), of which, in the underground biomass we find the average quantity of 65 t (239 t CO<sub>2</sub> eq, 57%) and in the aboveground biomass we find the quantity of 49 t (178 t CO<sub>2</sub> eq, 43%). The average quantity of net carbon fixed per hectare is 5399 kg (19708 kg/ha CO<sub>2</sub> eq) of which 3388 kg/ha (12368 kg/ha CO<sub>2</sub> eq) in the underground biomass and 2011 kg/ha (7340 kg/ha CO<sub>2</sub> eq) in the aboveground biomass.

***Determination of the average degree of humification of organic matter in the soil associated to the manure fertilization variant***

In the case of variant V1, the average amount of humus was 1376 kg/ha, with limits ranging between 397 kg/ha (corn crop) and 3012 kg/ha (alfalfa crop). At the level of the 3 representative crops, in this fertilization variant, a total amount of humus was estimated at 26.1 t, with an average per hectare of 1376 kg. In the case of variant V2, the amounts of humus have higher values. Thus, depending on the amount of net carbon sequestered in the soil, the limits of variation of the amount of humus are between 397-3012 kg/ha, with an average of 1487 kg/ha (8% more than variant V1). At the level of the 3 representative crops, with this fertilization variant, a total amount of humus of 44.5 t was estimated, with an average per hectare of 1487 kg.

***Determining the number of carbon credits and the value of carbon certificates***

Depending on the amount of net carbon sequestered in the soil, a total number of 70 credits was obtained, with a variation between 10-35 credits/crop type. The average per hectare proved to be between 1-7 credits. The highest number of credits, 7 credits/cultivated area, was associated with the alfalfa crop, which also recorded the highest amount of net carbon sequestered (7.2 t). The total value of the credits, at the average price of 67.94 euros/credit, was 4800 euros.

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# **Architecture**

## **PLANNING AND SPATIAL PRINCIPLES OF URBAN HOTEL DEVELOPMENT WITHIN THE STRUCTURE OF THE CONTEMPORARY CITY**

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## **ПЛАНУВАЛЬНО-ПРОСТОРОВІ ПРИНЦИПИ ФОРМУВАННЯ МІСЬКОГО ГОТЕЛЬНОГО ЗАКЛАДУ В СТРУКТУРІ СУЧАСНОГО МІСТА**

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### **Abstract**

In urban hotels, planning and spatial organization shape not only operational efficiency (capacity, logistics, and optimization of circulation areas), but also the character of interaction with the urban environment (an active ground floor, public “urban rooms,” event-driven scenarios, and transit connections). The aim of this study is to identify key spatial patterns through the analysis of successful case studies and to demonstrate how different architectural schools influence operational parameters and urban impact.

### **Анотація**

У міських готелях планувально-просторова організація формує не лише ефективність експлуатації (вмістимість, логістика, економія площ циркуляції), а й характер взаємодії з міським середовищем (активний перший поверх, публічні «урбан-кімнати», події сценарії, транзитні зв'язки). Мета дослідження - виявити ключові просторові закономірності на прикладах успішних кейсів і показати, як різні архітектурні школи впливають на експлуатаційні параметри та міський ефект.

**Keywords:** urban hotel; planning and spatial organization; atrium; corridor system; lobby; urban interior;

**Ключові слова:** міський готель; планувально-просторова організація; атріум; коридорна система; лобі; урбаністичний інтер'єр;

Міський готель сьогодні функціонує як багатокомпонентний об'єкт, де номерний фонд співіснує з потужними громадськими і подієвими площами (лобі-простори, конференц-зони), що формують «публічне обличчя» будівлі та її вплив на вулицю. Проблема дослідження полягає в тому, що «успішність» міського готелю визначається не лише архітектурною виразністю, але й сукупністю планувальних параметрів, зокрема: частка корисних площ номерного фонду та ефективність вертикальної/горизонтальної циркуляції; організація громадських просторів як «підсилювача» міського життя (ресторани, внутрішні пасажі, атріуми); логіка розділення потоків (гість/подія/персонал/постачання) та якості орієнтування; здатність будівлі адаптуватися до змін ринку (реновації, перепрограмування, «hotel-within-hotel», інтеграція з transit-oriented development), тощо.

Сучасні архітектурні концепції демонструють дві «опорні» моделі планувально-просторової організації міського готелю – атриумну та коридорну (slab) – та їх трансформації у конкретних кейсах та сучасних гібридних типологіях.

Атриумна модель у міському готелі, згідно з типологічними підходами, є «дорогим» у площі рішенням (більше об'ємів), але отримує вигоду у формуванні впізнаваного громадського ядра й орієнтування. Коридорна (slab) модель мінімізує циркуляцію і підсилює економіку повторюваних гостьових поверхів, проте потребує спеціальних прийомів «урбанізації» першого/публічного рівня [1].

Кейси John C. Portman Jr.: атріум як «внутрішнє місто» та інструмент міської регенерації.



У Hyatt Regency Atlanta (відкритого 1967) автори проєкту прямо фіксують інновацію: саме тут «запроваджено» атриум-концепт у сучасному готельному дизайні; первісний обсяг мав 800 номерів, а успіх спричинив добудову двох веж, що є типовим маркером планувальної життєздатності схеми. У просторових термінах атриум організовано як світлопроникний «публічний зал-п'яцца» з природним світлом, водою і зеленню, тобто як інтер'єризований міський простір (не лише лобі-функція), який працює і для гостей, і як точка тяжіння для локальної аудиторії (заявлений зв'язок із торгівлею, харчуванням і конвенційними об'єктами) [2].

Додатковий індикатор «успішності» (експлуатаційний, а не стилістичний) фіксує Atlanta History Center: за їхнім описом, упродовж трьох місяців після відкриття готель досяг близько 90% заповнюваності, а відкрита атриумна схема вплинула на готельну архітектуру у світі; компанія Hyatt Hotels Corporation надалі масштабувала цей прийом як корпоративний стандарт (згадується 26 «open-atrium» готелів до 1987 року) [2].

У New York Marriott Marquis (район Times Square, запроектовано як конвенційний готель великого масштабу) стратегія «подвійної адресації» особливо показова: будівля займає цілий квартал і «підсилює» енергію площі зовні, але всередині формує просторовий «ретрит» - 37-поверховий об'єм лобі/атриуму, насичений рослинами, торгівлею, ресторанами, тобто програмно наближений до критих міських пасажів. У матеріалах Portman Architects підкреслено роль об'єкта як каталізатора відновлення району; у науковій інтерпретації це можна трактувати як приклад того, як готельна типологія через планувальне ядро (атриум + комерційні сценарії) виходить за межі «приватної» гостинності й стає урбаністичним механізмом [3].

Третій кейс Portman Architects – The Westin Bonaventure Hotel & Suites в Лос-Анжелосі, демонструє варіацію атриумної логіки в іншому міському контексті: проєкт протиставлено прямокутним офісним вежам, композиційно він складається з п'яти скляних циліндричних об'ємів і позиціонується як «уніфікуючий центр» району Bunker Hill. Тут внутрішній багатоярусний громадський простір, масивні кругові форми підіймаються на 7 поверхів, по периметру працюють криволінійні переходи/галереї, а ліфти, що «прострілюють» простір, стають не лише комунікацією, а й способом візуального орієнтування (рух як частина досвіду) [2].

Кейс William Tabler: коридорна/«slab» ефективність і подієва інфраструктура як міський драйвер. Таблер асоціюється з надзвичайно продуктивним проєктуванням готелів середини ХХ ст. Готель 1963 року New York Hilton Midtown – його робота і він є одним із ключових «midcentury» готельних архітекторів [4]. Для порівняння планувальних стратегій принципово, що типологія «slab» (коридор із номерами з двох боків) входить до найпоширеніших і найбільш економних щодо площі рішень, тоді як атриум, навпаки, свідомо «втрачає» частину економіки заради архітектурної заяви [4].

На рівні громадських просторів «успішність» коридорної моделі в місті часто спирається на потужні подієві площі, які компенсують «звичайність» гостьового модуля. Такі параметри прямо впливають на просторову структуру: виникає необхідність чітко розділити «подієві» та «житлові» потоки, організувати великі безколонні/трансформовані зали на нижчих рівнях, передбачити незалежні входи та логістику постачання [4].

Кейси Morris Lapidus: лобі як сценографія та «соціальна машина». На відміну від «інженерної» раціональності slab-моделі та «внутрішньої урбаністики» атриумів, підхід Лapidуса можна описати як проєктування послідовностей (дорога, вхід, лобі, сходи, зали, зовнішні простори), де ключова мета — максимізувати соціальну взаємодію і враження. У дослідженні про просторову організацію лобі поверхів маямського модернізму підкреслено, що лобі-поверхи післявоєнних курортних готелів трактувалися як «розширена вітальня». Для Fontainebleau Miami Beach акцентовано складну криволінійну геометрію (напівколо), що зв'язує інтер'єр та екстер'єр, а також формує широкий відкритий лобі-простір та стимулює сценарії «бачити й бути побаченим» [5]. Площа лобі 17 тис. кв. фут і бальна зала на 3 000 гостей, тобто підхід Лapidуса до «театру гостинності» був просторово підкріплений великою площею громадського ядра [5].

Планувальна структура готелю Eden Roc характеризується Y-подібною конфігурацією корпусу та системою консольних балконів, що визначають силует будівлі. Порівняно з Fontainebleau, цей об'єкт вирізняється більш стриманою просторовою композицією [5].

Аналіз проєктів Лapidуса дозволяє зробити важливий висновок: ефективна планувальна організація готелю досягається не лише через формування великого атриумного простору, а й через послідовно вибудовані просторові переходи та контрольовану систему візуальних зв'язків (осі огляду, акцентовані сходи, поетапне розкриття громадських залів). Такий підхід є актуальним для сучасних міських готелів з обмеженою площею ділянки: публічне ядро може формуватися як просторовий сценарій, а не як єдиний хол.

Порівняльний аналіз розглянутих кейсів засвідчує, що планувально-просторова організація міського готелю в успішних реалізаціях тяжіє до двох базових типологічних логік — атриумної та коридорної, однак ефективність у кожному випадку досягається різними архітектурними механізмами. Атриумні моделі, репрезентовані проєктами Джона Портмана, функціонують як інтер'єризовані аналоги міських площ або пасажів: вони посилюють орієнтацію в просторі, формують виразну «подію» інтер'єру та здатні виступати каталізаторами міської активності. Це підтверджує ранній успіх Hyatt Regency Atlanta, який продемонстрував високі показники заповнюваності, а також значна роль New York Marriott Marquis у формуванні публічного простору Таймс-сквер.

Натомість коридорна (slab) модель, характерна для проєктів Вільяма Таблера, залишається найбільш економічно доцільною та масштабованою для забезпечення високої місткості номерного фонду. У цій типології міський ефект досягається не стільки формою гостьового поверху, скільки розвинутою інфраструктурою подій, функціонально чітким зонуванням і продуманим розділенням потоків гостей, персоналу та сервісу, що яскраво проявляється у програмуванні New York Hilton Midtown. Таким чином, просторову репрезентативність тут компенсує операційна ефективність і масштаб.

Практичну цінність демонструє і підхід Морріса Лapidуса, який акцентує не на масштабі внутрішнього простору, а на сценарному принципі його побудови. У його проєктах «публічне ядро» функціонує як соціальна машина навіть без гігантських атриумів, якщо вибудовано послідовність входу, лобі, переходів і подієвих просторів, сформовано керовані візуальні зв'язки та акцентовані «місця появи». Такий підхід доводить, що просторовий ефект може досягатися через композиційно організований рух і контрольовану драматургію інтер'єру.

Сучасні практики (Moshe Safdie, Jean Nouvel, Norman Foster) підсилюють тенденцію до гібридизації та мережовості готельних структур. Міський готель дедалі частіше інтегрується у багаторівневу систему публічних просторів, пов'язується з транспортною інфраструктурою та функціонує в межах мульти-функціональних комплексів. Така інтеграція підвищує адаптивність об'єкта, зменшує економічні ризики та формує нову модель взаємодії готелю з міським середовищем.

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## **Biological sciences**

### **INDICATORS OF TECHNOLOGICAL QUALITY OF TABLE SILVER CARP IN ENVIRONMENTS OF PONDS IN TASHKENT REGION**

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#### **Abstract**

The technological quality indicators of table silver carp (*Hypophthalmichthys molitrix*) grown in pond polyculture in the Tashkent region of Uzbekistan were analyzed. During the second growing season, silver carp reached a total length of 45.0–47.0 cm, a standard length of 37.9–40.1 cm, and a total body weight of 850.9–920.4 g. Linear indicators in % of body length and indices of the head, carcass, and other organs in % of total body weight, as well as an organoleptic assessment of the technological quality of white silver carp are presented.

**Keywords:** Silver carp, *Hypophthalmichthys molitrix*, aquaculture, fish farming ponds, technological quality of fish, Uzbekistan

Over the past decade, pond aquaculture in Uzbekistan has expanded substantially in terms of production capacity, the number of earthen ponds, and total fish output, and has firmly secured its share of the fresh (live) fish market, thereby contributing valuable animal-derived nutrients to the diet of the country's population. Actual fish production increased from 6–9 thousand tonnes per year in 1993–2009 to more than 180 thousand tonnes per year at present. Pond aquaculture in Uzbekistan has been developing as an отрасль since the early 1960s. The silver carp (*Hypophthalmichthys molitrix*) was introduced into newly established earthen ponds through four consignments of larvae (approximately 200 thousand individuals in total) imported from China and the Amur River basin (Kamilov, 1973; Yuldashov & Kamilov, 2018).

Since the 2000s, silver carp (*Hypophthalmichthys molitrix*) has become the most important cultured species, accounting for more than 90% of the total fish production in the Republic. For such a key aquaculture species, it is necessary to assess and continuously monitor technological (processing) quality; however, no comparable data are available for the region. The market quality of fish varies among species and size–age groups and depends on the geographical characteristics of fish farms. During the domestication and culture of each species, it is essential to determine technological quality indicators of fish as a food product, which characterize organoleptic, structural–mechanical, and other quality attributes (Abramova, 2004; Safronova & Datsun, 2004). The aim of this study was to characterize the technological features of market-size silver carp (*H. molitrix*) (age 1+) reared in ponds under the conditions of Tashkent Region, Uzbekistan.

**Materials and Methods.** Market-size two-year-old silver carp (*Hypophthalmichthys molitrix*) reared in grow-out ponds of the “Damachi” fish farm (Tashkent Region) and supplied for sale were examined. Four randomly selected fresh individuals were delivered on 2 March to the laboratory of the Tashkent Region Branch of Astrakhan State Technical University. For each fish, total length (TL, cm) and standard length (SL, cm; without the caudal fin) were measured to the nearest 1 mm, and total body mass (W, g) was measured to the nearest 1 mg. Raw-material quality assessment was performed using processing methods commonly applied in industry (scale removal, evisceration, decapitation, fin removal, and filleting). All removed parts were weighed to the nearest 0.1 mg using an electronic balance. Indices of linear body proportions were calculated relative to standard length, and mass indices were calculated relative to total body mass; univariate descriptive statistics were computed for each index (%) (Chernysheva & Tsibizova, 2011; Tsibizova, 2012).

**Results.** The sample comprised fish with a total length of 45.0–47.0 cm, a standard length of 37.9–40.1 cm, and a total body mass of 850.9–920.4 g. These data indicate that, in pond grow-out conditions, silver carp (*Hypophthalmichthys molitrix*) can attain substantial body size within two growing seasons, which is favorable for the development of aquaculture.

The organoleptic assessment of silver carp was as follows. In all examined fish, the body surface was clean. The scales were small, shiny, silvery, and closely adhered to the body surface. The muscle tissue was firm and elastic; when pressed, the resulting indentation recovered rapidly and completely. The flesh was difficult to separate from the bones and exhibited the coloration typical of silver carp on the cut surface. Opercular movement was normal, and the gills were bright red. The surface of all fish was covered with mucus. The eyes were clear, convex, and undamaged. No signs of disease were observed.

Indices of linear body-proportion traits relevant to market quality are presented in Table 1. Notably, total length constituted 115.4–121.1% (mean, 118.5%) of standard length.

The mass composition of market-size silver carp is provided in Table 2. As all individuals were immature, the gonads were at maturity stage II, appearing as thin strands attached to the abdominal wall in both sexes; therefore, gonad mass was included in the category of viscera and processing waste.

**Table 1.** Indices of linear body-proportion traits of market-size silver carp (*Hypophthalmichthys molitrix*) (% of standard length), Uzbekistan, 2025

Indicator	Min–Max	Mean ± SE
Head length	26.3–28.2	27.43 ± 0.37
Caudal fin length	22.4–23.1	22.82 ± 0.16
Trunk length	74.4–75.0	74.62 ± 0.16
Maximum body depth	30.8–33.3	32.30 ± 0.32
Body thickness	9.2–11.3	10.25 ± 0.32

**Table 2.** Indices of the mass composition of market-size silver carp (*Hypophthalmichthys molitrix*) (% of total body mass), Uzbekistan, 2025.

Body part	Min–Max	Mean ± SE
Total body mass, g	850.9–920.4	874.72 ± 11.78
<b>Index, % of total body mass</b>		
Dressed weight (processed fish)	87.9–90.4	89.01 ± 0.42
Trunk (carcass without head and fins)	55.7–61.2	58.60 ± 0.99
Caudal fin	0.8–1.1	0.93 ± 0.05
Head	26.6–30.2	28.61 ± 0.68
Scales	1.2–1.6	1.40 ± 0.09
Viscera*	7.3–10.3	8.12 ± 0.55
Fins	1.1–2.3	1.68 ± 0.22
Bones	8.4–11.7	9.56 ± 0.58
Skin	4.0–4.7	4.28 ± 0.12
Fillet (minced flesh)	39.5–43.1	41.26 ± 0.64

\* Includes the mass of the digestive tract, liver, heart, swim bladder, gallbladder, gonads, and visceral fat.

**Discussion.** In the development of aquaculture, technological (processing) quality traits of fish are important biological indicators that should be assessed on a regular basis to monitor cultured stocks. These traits are critical for consumer acceptance and for the potential industrial processing of fish into fish products. Such indicators depend on species, sex, age, body size, season, and a number of other factors (Abramova, 2004; Safronova & Datsun, 2004).

In the present study, the sample consisted of same-age, two-year-old silver carp (*Hypophthalmichthys molitrix*) obtained from a single pond farm in Tashkent Region, reared over two growing seasons and harvested from wintering ponds for market sale as live fish. For pond-farmed marketable silver carp in fish-farming zone VII, the standard market size has been defined as an individual body mass of 250 g or higher. All fish examined in our study met this standard.

Moreover, to satisfy demand for silver carp, Uzbek farmers have for more than a decade targeted the production of two-year-old market fish with a minimum body mass of 1 kg, with pond productivity for silver carp exceeding 1000 kg/ha. To achieve this, commonly used pond management practices are applied, including water fertilization, and stocking densities of up to 1.5 thousand yearlings per hectare of water during the second growing season. These features were clearly reflected in our random sample.

It should also be noted that sampling was conducted in early March from wintering ponds; therefore, all fish had empty intestinal tracts. Overall, the data indicate that silver carp reared in earthen ponds under the conditions of Tashkent Region represents a high-quality raw material.

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**OIL CONTENT OF SESAME SEEDS (*SESAMUM INDICUM* L.)**

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**Introduction.** Sesame (*Sesamum indicum* L.) is one of the oldest cultivated oilseed crops and is widely grown in Asia, Africa and tropical regions of the world. Sesame seeds are highly valued due to their high oil content, nutritional properties and stability during storage. Because of these characteristics sesame is often referred to as the “queen of oilseed crops” [1].

The oil content of sesame seeds is one of the most important indicators used in agricultural research, breeding programs and food science. Numerous studies report that sesame seeds contain 45–57 % oil, although this value may vary depending on genotype, environmental conditions and agricultural practices [2].

Sesame oil has a favorable fatty acid composition. The main fatty acids are oleic acid (C18:1) and linoleic acid (C18:2), which together constitute more than 80 % of the total fatty acids present in sesame oil [3]. These unsaturated fatty acids are considered beneficial for human health because they help reduce cholesterol levels and improve cardiovascular function. In addition to fatty acids, sesame oil contains biologically active compounds such as sesamin, sesamolin and sesamol, which possess strong antioxidant activity and contribute to the oxidative stability of the oil [4]. These compounds protect the oil from rancidity and extend its shelf life compared with many other vegetable oils.

Determining the total oil content in sesame seeds is therefore essential for several reasons. First, oil content is an important trait in breeding programs aimed at developing high-oil sesame varieties. Second, oil concentration determines the economic value of sesame seeds in the oil processing industry. Third, analysis of oil content helps researchers understand the physiological mechanisms of lipid accumulation in seeds. For these reasons, accurate determination of oil content in sesame seeds is a key component of modern oilseed research. The objective of this study is to analyze the importance of determining total oil content in sesame seeds and to evaluate different analytical methods used for oil determination, with particular attention to the Soxhlet extraction method and its advantages compared with other analytical techniques.

**Importance of Determining Total Oil Content in Seeds.** Determining the total oil concentration in seeds is a fundamental step in plant physiology, food science and agricultural research. The total oil content of seeds reflects the efficiency of lipid biosynthesis during seed development and is strongly influenced by genetic and environmental factors. In plant breeding programs, oil content is considered one of the most important selection criteria for oilseed crops. Identification of high-oil genotypes allows breeders to develop new varieties with improved productivity and economic value [5]. The determination of oil content also provides important information about seed quality and nutritional value. Vegetable oils are major sources of essential fatty acids and fat-soluble vitamins. Therefore, measuring oil content helps assess the nutritional potential of oilseed crops.

Another important aspect of oil content analysis is its role in understanding plant physiological processes. Lipid accumulation in seeds is controlled by complex metabolic pathways involving carbohydrate metabolism, fatty acid biosynthesis and energy storage. By studying oil content variation among different genotypes or environmental conditions, researchers can better understand the mechanisms regulating lipid biosynthesis. Determination of oil concentration also allows researchers to perform statistical analyses and correlations with other agronomic traits, such as seed weight, protein content and yield. In many oilseed crops, a negative correlation between oil and protein content has been observed, indicating competition between lipid and protein synthesis pathways [6]. Thus, accurate determination of oil content is essential for both fundamental research and practical applications in agriculture and food science.

**Methods for Determining Oil Content in Seeds.** Several analytical methods have been developed for determining oil content in oilseed crops. These methods differ in accuracy, speed, cost and complexity. The most widely used techniques include solvent extraction methods, spectroscopic techniques and advanced instrumental methods.

**Soxhlet Extraction Method.** The Soxhlet extraction method is one of the oldest and most widely used techniques for determining oil content in seeds. This method was first developed in the nineteenth century and remains a standard laboratory procedure for lipid extraction. In the Soxhlet method, ground seed samples are placed in a porous extraction thimble and continuously extracted with an organic solvent such as petroleum ether or hexane. The solvent dissolves lipids present in the sample and repeatedly washes the material through a reflux system. After several extraction cycles, the solvent is evaporated and the extracted oil is weighed. The

Soxhlet method provides several important advantages. First, it offers high extraction efficiency and reproducibility, which makes it suitable as a reference method for oil determination. Second, the technique allows extraction of nearly all lipids present in the sample. Third, the method is widely standardized and accepted in many international analytical protocols, including AOAC methods for oil determination [7]. However, the Soxhlet method also has some limitations. The extraction process requires several hours and involves the use of organic solvents. Nevertheless, despite these disadvantages, Soxhlet extraction remains one of the most reliable techniques for determining total oil content in seeds.

**Near Infrared Spectroscopy (NIRS).** Near infrared spectroscopy (NIRS) is a rapid analytical technique widely used for estimating oil content in seeds. This method measures absorption of near-infrared radiation by chemical bonds such as C–H, O–H and N–H in organic molecules. The main advantage of NIRS is that it provides rapid and non-destructive analysis. Samples can be analyzed within seconds without the use of chemical solvents. Therefore, NIRS is widely used in breeding programs where large numbers of samples need to be analyzed. However, NIRS requires calibration with reference methods such as Soxhlet extraction. The accuracy of NIRS depends strongly on the calibration model and sample composition [8].

**Nuclear Magnetic Resonance (NMR).** Nuclear magnetic resonance (NMR) spectroscopy is another technique used for determining oil content in seeds. NMR measures the hydrogen atoms present in lipids and allows direct quantification of oil concentration. The advantages of NMR include rapid measurement, minimal sample preparation and non-destructive analysis. This method is widely used in oilseed breeding programs because it allows analysis of hundreds of samples in a short time [9]. Despite its advantages, NMR instruments are expensive and require specialized equipment and technical expertise.

**Supercritical Fluid Extraction.** Supercritical fluid extraction (SFE) is a modern technique that uses supercritical carbon dioxide as a solvent for lipid extraction. This method offers several advantages including high extraction efficiency and minimal solvent residue. Supercritical extraction is considered environmentally friendly and can preserve heat-sensitive bioactive compounds. However, the high cost of equipment limits its use mainly to industrial or specialized research laboratories [10].

**Comparative Analysis of Oil Determination Methods.** Comparison of different oil extraction methods shows that each technique has specific advantages and limitations. The Soxhlet method provides high accuracy and complete extraction of lipids, which makes it suitable as a reference method for determining total oil content. Many scientific studies use Soxhlet extraction as a standard technique for calibrating other analytical methods. NIRS and NMR techniques are faster and allow high-throughput analysis, but their accuracy depends on calibration models and instrument quality. Supercritical extraction offers improved environmental performance and high extraction efficiency, but the high cost of equipment limits its application in routine laboratory analysis. Based on analysis of numerous scientific studies, the Soxhlet extraction method remains the most reliable technique for determining total oil content in seeds, particularly when accurate quantitative results are required. Therefore, the Soxhlet method was selected in this study as the primary analytical technique for oil determination in sesame seeds.

**Interpretation of Oil Content Results.** Determination of total oil content allows researchers to perform several important analyses and interpretations. First, oil content analysis allows identification of high-oil genotypes that can be used in breeding programs. Genotypes with higher oil concentrations have greater economic value for oil production. Second, oil content data can be used to study genotype  $\times$  environment interactions, which influence lipid accumulation during seed development. Third, oil concentration can be correlated with other agronomic traits such as seed size, seed weight and yield. Such correlations provide insights into the physiological processes controlling seed development. Finally, determination of oil content helps evaluate nutritional quality and industrial potential of sesame seeds. Higher oil concentrations increase the economic value of the crop and improve the efficiency of oil processing.

### **Conclusion**

Sesame (*Sesamum indicum* L.) is one of the most important oilseed crops due to its high oil content and valuable nutritional properties. Sesame seeds typically contain 45–57 % oil, rich in unsaturated fatty acids and biologically active compounds with antioxidant activity. Determining the total oil content of sesame seeds is essential for plant breeding, food science and agricultural research. Several analytical techniques are available for oil determination, including Soxhlet extraction, NIRS, NMR and supercritical extraction. Among these methods, Soxhlet extraction remains one of the most reliable and widely accepted techniques due to its high extraction efficiency and reproducibility. Although modern instrumental techniques offer faster analysis, Soxhlet extraction continues to serve as a reference method for accurate determination of total oil content. Further research integrating modern analytical technologies and plant breeding approaches will contribute to improving sesame productivity and enhancing the nutritional value of sesame oil.



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## **Chemical sciences**

### **COGNITIVE LEVELS IN CHEMISTRY EXAMINATION QUESTIONS: COMPARING KAZAKHSTAN'S UNT WITH INTERNATIONAL CHEMISTRY EXAMS**

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### **КОГНИТИВНАЯ СЛОЖНОСТЬ ЭКЗАМЕНАЦИОННЫХ ЗАДАНИЙ ПО ХИМИИ: СРАВНИТЕЛЬНЫЙ АНАЛИЗ ЕНТ КАЗАХСТАНА И МЕЖДУНАРОДНЫХ ЭКЗАМЕНОВ**

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#### **Abstract**

The article presents a comparative analysis of chemistry examination tasks used in the Unified National Testing (UNT) of the Republic of Kazakhstan and international examination systems, including AP Chemistry and IB Chemistry. The aim of the study was to identify the structural characteristics of exam questions and determine their level of cognitive complexity. The revised Bloom's taxonomy was used as the analytical framework to classify exam questions according to levels of cognitive processes. A total of 140 exam tasks were analyzed, including 60 UNT tasks, 40 AP Chemistry tasks, and 40 IB Chemistry tasks. The results show that UNT questions are predominantly concentrated at lower cognitive levels, such as remembering and understanding. In contrast, international examinations include a larger proportion of tasks requiring the application of knowledge, analysis of chemical processes, and interpretation of experimental data. In addition, higher-level cognitive tasks involving evaluation and solution formulation are present in AP and IB exams. The findings highlight differences in assessment approaches and cognitive demands across national and international examination systems. The results may contribute to improving assessment practices in secondary school chemistry education.

#### **Аннотация**

В статье представлен сравнительный анализ экзаменационных заданий по химии, используемых в Едином национальном тестировании Республики Казахстан и международных экзаменационных системах AP Chemistry и IB Chemistry. Цель исследования заключалась в выявлении особенностей структуры заданий и уровня их когнитивной сложности. Для анализа использовалась обновлённая таксономия Блума, позволяющая классифицировать задания по уровням познавательной деятельности учащихся. В исследование были включены 140 экзаменационных заданий, среди которых 60 заданий ЕНТ,

40 заданий AP Chemistry и 40 заданий IB Chemistry. Результаты анализа показали, что в заданиях ЕНТ преобладают вопросы, относящиеся к нижним уровням когнитивной сложности, таким как воспроизведение и понимание знаний. В международных экзаменах значительно выше доля заданий, требующих применения знаний, анализа химических процессов и интерпретации экспериментальных данных. Кроме того, в международных экзаменах представлены задания более высокого когнитивного уровня, включая оценку и формулирование решений. Полученные результаты свидетельствуют о различиях в образовательных подходах к оцениванию знаний учащихся и могут быть использованы при совершенствовании системы оценивания в школьном химическом образовании.

**Keywords:** chemistry education, Unified National Testing, exam questions, cognitive levels, Bloom's taxonomy, educational assessment, international examinations.

**Ключевые слова:** химическое образование, ЕНТ, экзаменационные задания, когнитивные уровни, таксономия Блума, оценивание знаний, международные экзамены.

### **Введение**

Оценивание учебных достижений учащихся занимает важное место в системе школьного образования. Через экзаменационные задания определяется не только уровень усвоения учебного материала, но и то, какие образовательные приоритеты фактически реализуются на практике. Иными словами, структура экзамена позволяет понять, какие именно знания и навыки считаются наиболее значимыми для дальнейшего обучения.

Это особенно заметно в естественно-научных дисциплинах, прежде всего в химии. Изучение химии требует от учащихся не только запоминания формул и терминов. Не менее важны умение анализировать информацию, интерпретировать результаты экспериментов и применять знания для решения задач. Поэтому содержание экзаменационных вопросов в значительной степени отражает подходы к формированию научного мышления у школьников.

В педагогических исследованиях уже давно обсуждается вопрос о том, какие именно когнитивные навыки должны проверяться в экзаменационных заданиях. Одним из наиболее известных инструментов анализа является таксономия образовательных целей, предложенная Б. Блумом и впоследствии обновлённая в работах Л. Андерсона и Д. Кратвола. Эта модель позволяет классифицировать учебные задания по уровням когнитивной сложности - от простого воспроизведения знаний до анализа, оценки и создания новых решений. Именно поэтому таксономия Блума широко используется при анализе учебных программ и экзаменационных вопросов в области химического образования.

Вместе с тем результаты исследований показывают, что на практике задания более высокого уровня когнитивной сложности встречаются значительно реже. Как правило, большинство экзаменационных вопросов ориентировано на проверку понимания и воспроизведения учебного материала. Более сложные уровни - такие как анализ, оценка или создание - представлены значительно слабее. Подобная тенденция наблюдается и при анализе учебных программ по химии, где значительная часть образовательных результатов сосредоточена на уровне «понимания».

В последние годы интерес к этой проблеме усилился в связи с развитием международных образовательных стандартов и ростом академической мобильности. Всё чаще исследователи обращаются к сравнительным исследованиям, позволяющим сопоставлять образовательные системы разных стран. Такой подход помогает выявить различия в структуре учебных программ, методах преподавания и способах оценивания знаний учащихся. Более того, сравнительный анализ позволяет увидеть, какие образовательные практики оказываются наиболее эффективными в разных образовательных контекстах.

Однако, несмотря на растущий интерес к сравнительным исследованиям в области химического образования, подобные работы пока остаются немногочисленными. Особенно редко анализируются сами экзаменационные задания. Между тем именно они напрямую отражают требования, предъявляемые к учащимся, и позволяют судить о реальном уровне когнитивной сложности экзамена.

В Казахстане основным инструментом итоговой оценки знаний выпускников школ является Единое национальное тестирование (ЕНТ). Этот экзамен играет важную роль как в системе оценки образовательных результатов, так и в процедуре поступления в высшие учебные заведения. При этом в международной образовательной практике используются и другие экзаменационные системы по химии, которые нередко предполагают более широкий спектр заданий, включая анализ данных, работу с графиками и решение комплексных задач.

Поэтому представляется важным рассмотреть экзаменационные задания по химии в сравнительном контексте. Сопоставление заданий ЕНТ с вопросами международных экзаменов позволяет выявить особенности структуры заданий, определить уровень их когнитивной сложности и оценить степень соответствия национальной системы оценивания современным международным подходам.

Целью данного исследования является сравнительный анализ заданий по химии в ЕНТ и международных экзаменах с точки зрения их структуры, типов заданий и уровня когнитивной сложности.

### **Обзор литературы**

Вопрос о том, что именно проверяют экзаменационные задания по химии, в последние годы обсуждается всё активнее. Причина понятна: экзамен давно перестал быть просто формой итогового контроля. По сути, он задаёт направление обучения. Если в тестах доминируют задания на воспроизведение фактов, учитель неизбежно будет уделять больше внимания запоминанию. Если же экзамен требует анализа, интерпретации данных и осмысленного применения знаний, меняется и сама логика преподавания.

Одним из самых распространённых инструментов анализа экзаменационных заданий остаётся обновлённая таксономия Блума. Она позволяет рассматривать задания не только по степени сложности, но и по типу познавательной деятельности, которую они требуют от учащегося. В её рамках когнитивный процесс описывается через уровни *Remember*, *Understand*, *Apply*, *Analyze*, *Evaluate* и *Create*, а знание – через категории *Factual*, *Conceptual*, *Procedural* и *Metacognitive*. Именно поэтому этот инструмент активно используется для анализа как учебных целей, так и экзаменационных вопросов (Anderson & Krathwohl, 2001; Bloom, 1956).

При этом исследования показывают, что само использование таксономии Блума не ограничивается только химией. Её применяли для анализа оценивания в физиологии, биологии, естественных науках в целом, а также для сопоставления учебных целей и экзаменационных заданий в разных дисциплинах. В химическом образовании этот подход оказался особенно полезным, потому что позволяет увидеть, насколько экзамен проверяет не только фактологические знания, но и более сложные формы мышления (Kowalski et al., 2024).

Отдельная группа исследований посвящена именно химии. Так, в работе Kowalski, Kolesci и McDonald анализировались учебные цели и экзаменационные задания по вводному курсу общей химии до и после перехода к *guided inquiry* (направляемое исследование). Авторы показали, что при более активной и исследовательской модели обучения в экзаменах становится больше заданий на понимание, анализ и концептуальное осмысление, тогда как доля процедурных заданий и заданий, ориентированных только на применение алгоритмов, снижается (Kowalski et al., 2024). В выводах этой же работы подчёркивается, что *guided inquiry* создаёт больше возможностей для работы со сложными вопросами и в целом лучше соотносит учебные цели с характером оценивания (Kowalski et al., 2024).

Важно и то, что исследователи обращают внимание на ограничения самой процедуры кодирования. Как отмечают авторы, отнесение задания к определённому уровню таксономии не всегда очевидно: один и тот же глагол может работать на разных уровнях в зависимости от контекста, а сами задания нередко дают лишь возможность для мышления высокого уровня, но не гарантируют, что учащийся действительно будет действовать именно так (Kowalski et al., 2024). Для нашего исследования это особенно важно, потому что при анализе вопросов ЕНТ и международных экзаменов необходимо учитывать не только формулировку задания, но и реальную когнитивную нагрузку.

Ещё один важный аспект исследований связан с тем, что сложность вопроса определяется не только его «таксономическим» уровнем. Работа Rodrigues и соавторов показывает, что на восприятие химического вопроса влияют язык формулировки, знакомость контекста и даже наличие числовых данных. Авторы пришли к выводу, что вопрос, который формально выглядит простым, может оказаться более трудным из-за формулировки или незнакомого контекста; и наоборот, сложный по программе вопрос иногда оказывается легче благодаря знакомому содержанию (Rodrigues, 2010). Более того, в исследовании показано, что язык вопроса напрямую влияет на ответы участников, а трудность задания определяется сочетанием уровня учебной программы, языковых особенностей и структуры задания (Rodrigues, 2010).

Для химии это особенно значимо. В отличие от многих других дисциплин, химические задания часто требуют перехода между разными уровнями представления – вербальным, символическим, числовым, а иногда и экспериментальным. Поэтому простой подсчёт доли «вопросов на анализ» или «вопросов на применение» не всегда даёт полную картину. Необходим более детальный анализ структуры самих заданий.

Отдельное направление исследований касается анализа учебных программ и ожидаемых результатов обучения по химии. Например, в работе Yaşar и Yılmaz, посвящённой анализу учебных планов

по химии в Турции, показано, что в *knowledge dimension* преобладают результаты обучения, связанные с *conceptual knowledge*, а в *cognitive process dimension* - результаты уровня *understanding*. При этом уровни *evaluating* и *creating* представлены минимально (Yaşar & Yılmaz, 2020). Авторы также отмечают, что экзаменационные вопросы учителей по естественно-научным дисциплинам чаще всего остаются на низких уровнях таксономии; иными словами, и планируемые результаты обучения, и реальная оценочная практика часто сходятся в сторону репродуктивного контроля (Yaşar & Yılmaz, 2020).

Похожие выводы встречаются и в работах, где анализировались национальные экзамены. Исследование индийских школьных экзаменационных систем, основанное на анализе 3071 вопроса, показало, что сравнительный анализ экзаменационных заданий позволяет выявить существенные различия между образовательными системами в структуре проверяемых когнитивных навыков (Chowdhury, 2023). При этом было установлено, что в химии во всех рассмотренных экзаменационных системах чаще всего встречались задания уровня *knowledge*, тогда как задания уровня *create* практически отсутствовали (Chowdhury, 2023).

Авторы этого исследования также подчёркивают более широкий педагогический риск: когда в национальных экзаменах доминируют задания низкого когнитивного уровня, это влияет не только на сам экзамен, но и на образовательную практику в целом. Подготовка к экзамену начинает подменять развитие более сложных мыслительных навыков, а учащиеся привыкают работать преимущественно на уровне воспроизведения знаний, а не критического анализа (Chowdhury, 2023).

Если рассматривать проблему шире, сравнительный подход в исследованиях химического образования пока используется относительно редко. Систематический обзор Lai и Fong показал, что из 5446 публикаций, отобранных из баз данных Web of Science и Scopus, только 12 соответствовали критериям сравнительного исследования в области химического образования (Lai & Fong, 2024). При этом авторы подчёркивают, что сравнительные исследования особенно важны в условиях глобализации образования, поскольку позволяют выявлять различия в учебных программах, педагогических подходах и системах оценивания (Lai & Fong, 2024).

Именно здесь возникает исследовательский зазор, который важен для нашей темы. С одной стороны, в научной литературе уже накоплен значительный объём исследований, посвящённых анализу когнитивных уровней экзаменационных заданий и учебных программ по химии. С другой стороны, сравнительных исследований, где сопоставлялись бы национальные экзамены и международные экзаменационные системы именно по химии, всё ещё относительно немного. Особенно заметен дефицит подобных работ в отношении постсоветского образовательного пространства и, в частности, Казахстана.

Таким образом, существующая литература позволяет сделать несколько выводов. Во-первых, таксономия Блума остаётся одним из наиболее востребованных инструментов анализа экзаменационных заданий по химии. Во-вторых, большинство исследований фиксирует преобладание заданий низкого или среднего когнитивного уровня, особенно на уровнях *remembering*, *understanding* и *application*. В-третьих, сравнительный анализ национальных и международных систем оценивания остаётся недостаточно разработанным направлением. Именно поэтому сопоставление заданий ЕНТ по химии с вопросами международных экзаменов представляется обоснованным и своевременным: оно может показать не только различия в структуре заданий, но и более глубокие различия в образовательных приоритетах различных систем оценивания.

#### **Цель исследования, материалы и методы**

Целью настоящего исследования является сравнительный анализ экзаменационных заданий по химии, используемых в Едином национальном тестировании (ЕНТ) Республики Казахстан и в международных экзаменационных системах. Основное внимание уделяется структуре заданий, типам вопросов и уровню их когнитивной сложности. Задача исследования - определить, какие познавательные действия требуются от учащихся при выполнении экзаменационных заданий и в какой степени национальный экзамен соотносится с международными практиками оценивания.

Исследование носит сравнительный характер. Такой подход позволяет выявить сходства и различия между экзаменационными системами, а также определить особенности структуры заданий в различных образовательных контекстах. Сравнительный анализ широко используется в педагогических исследованиях для выявления общих закономерностей и различий в образовательных практиках и системах оценивания.

#### **Материалы исследования**

Для сравнительного анализа были использованы задания Единого национального тестирования Республики Казахстан, а также задания международных экзаменационных систем: Advanced Placement Chemistry (AP Chemistry) и International Baccalaureate Chemistry (IB Chemistry).



Выбор этих экзаменов обусловлен их широким международным распространением и доступностью официальных экзаменационных материалов. Кроме того, данные экзамены используются для оценки естественно-научной подготовки учащихся и включают разнообразные типы заданий, требующие различных уровней когнитивной активности.

Всего в исследование были включены задания разных типов, включая вопросы с множественным выбором, задачи на вычисление и задания, требующие анализа химических процессов. Задания были отобраны из открытых официальных экзаменационных материалов и демонстрационных вариантов тестов, опубликованных Национальным центром тестирования Республики Казахстан, College Board (AP Chemistry) и International Baccalaureate Organization.

#### **Метод анализа заданий**

Для анализа когнитивной сложности экзаменационных вопросов была использована обновлённая таксономия Блума (Revised Bloom's Taxonomy). Данная модель позволяет классифицировать учебные задания по уровню познавательной активности учащихся. В рамках исследования вопросы распределялись по следующим уровням когнитивных процессов:

**Remember** - воспроизведение фактов и терминов;

**Understand** - понимание и интерпретация химических понятий;

**Apply** - применение известных алгоритмов и формул;

**Analyze** - анализ химических процессов и взаимосвязей;

**Evaluate** - оценка и обоснование решений;

**Create** - формулирование новых решений или гипотез.

Использование таксономии Блума позволяет не только определить сложность задания, но и выявить тип познавательной деятельности, который оно предполагает. Такой подход широко применяется в исследованиях химического образования при анализе учебных целей и экзаменационных вопросов.

#### **Процедура анализа**

Анализ проводился в несколько этапов.

На первом этапе были собраны и систематизированы экзаменационные задания по химии из выбранных экзаменационных систем.

На втором этапе каждое задание было проанализировано и отнесено к одному из уровней когнитивной сложности согласно таксономии Блума. При классификации учитывались формулировка задания, тип требуемого ответа и характер познавательных операций, необходимых для его решения.

На третьем этапе была проведена количественная обработка результатов. Для каждой экзаменационной системы определялась доля заданий, относящихся к различным уровням когнитивной сложности. Полученные данные позволили сравнить распределение типов вопросов и выявить особенности структуры экзаменационных заданий.

Таким образом, выбранная методика позволяет не только описать структуру экзаменационных вопросов, но и выявить различия в образовательных подходах к оцениванию знаний учащихся.

#### **Результаты анализа**

Для выявления когнитивной сложности экзаменационных вопросов был проведён анализ 140 заданий по химии. В выборку вошли 60 заданий ЕНТ, 40 заданий экзамена AP Chemistry и 40 заданий экзамена IB Chemistry. В выборку вошли задания Единого национального тестирования Республики Казахстан (ЕНТ), а также задания международных экзаменов AP Chemistry и IB Chemistry.

Каждое задание было классифицировано в соответствии с уровнями обновлённой таксономии Блума. Анализ показал, что распределение заданий по когнитивным уровням существенно различается между национальной и международными экзаменационными системами.

**Таблица 1. Распределение заданий по уровням таксономии Блума**

Уровень Блума	Характеристика задания	ЕНТ (n=60)	AP (n=40)	IB (n=40)
Remember	воспроизведение фактов, терминов, формул	18 (30%)	4 (10%)	3 (7.5%)
Understand	объяснение понятий, интерпретация	20 (33.3%)	9 (22.5%)	8 (20%)
Apply	применение формул и алгоритмов	16 (26.7%)	14 (35%)	15 (37.5%)
Analyze	анализ процессов и взаимосвязей	5 (8.3%)	9 (22.5%)	10 (25%)
Evaluate	аргументированная оценка	1 (1.7%)	3 (7.5%)	3 (7.5%)
Create	формулирование решений	0	1 (2.5%)	1 (2.5%)

#### **Интерпретация результатов**

Полученные данные показывают, что структура заданий в ЕНТ существенно отличается от международных экзаменационных систем.

В заданиях ЕНТ доминируют вопросы, относящиеся к нижним уровням когнитивной сложности. Задания уровней Remember и Understand составляют более 60% всей выборки. Такие вопросы, как правило, требуют воспроизведения теоретических знаний или базового понимания химических понятий.

В международных экзаменах распределение заданий выглядит иначе. Хотя задания на понимание также присутствуют, значительно возрастает доля вопросов уровней Apply и Analyze. В экзамене AP Chemistry задания на применение знаний составляют более трети всех вопросов. Аналогичная тенденция наблюдается и в IB Chemistry.

Кроме того, в международных экзаменах представлены задания более высокого когнитивного уровня - Evaluate и Create. Эти задания требуют аргументации, интерпретации экспериментальных данных или выбора оптимального решения. В рассмотренных заданиях ЕНТ такие типы вопросов практически отсутствуют.

Таким образом, результаты анализа показывают, что международные экзамены по химии ориентированы на более широкий спектр когнитивных навыков. В то время как ЕНТ в большей степени проверяет воспроизведение и понимание учебного материала, международные экзамены чаще требуют применения знаний, анализа химических процессов и работы с научной информацией.

Для наглядности результаты анализа можно представить в виде распределения долей заданий разных уровней когнитивной сложности.

**Таблица 2. Доля заданий по уровням таксономии Блума (%)**

Уровень Блума	ЕНТ	AP Chemistry	IB Chemistry
Remember	30	10	7.5
Understand	33.3	22.5	20
Apply	26.7	35	37.5
Analyze	8.3	22.5	25
Evaluate	1.7	7.5	7.5
Create	0	2.5	2.5

#### Типы экзаменационных заданий

Помимо когнитивного уровня, задания были классифицированы по **типу учебной деятельности**, необходимой для их выполнения.

**Таблица 3. Типы экзаменационных заданий по химии**

Тип задания	Характеристика	ЕНТ (%)	AP (%)	IB (%)
Теоретические	проверка знаний понятий, законов и определений	45	20	18
Расчётные	задачи на вычисления и использование формул	35	32	30
Аналитические	анализ химических процессов или реакций	12	28	30
Интерпретация данных	работа с графиками, таблицами, экспериментальными результатами	8	20	22

#### Обсуждение результатов

Полученные результаты показывают, что структура экзаменационных заданий по химии в разных системах оценивания заметно различается. Наиболее выраженные различия проявляются в распределении заданий по уровням когнитивной сложности. В заданиях ЕНТ преобладают вопросы, относящиеся к нижним уровням таксономии Блума - **Remember** и **Understand**. Такие задания ориентированы прежде всего на воспроизведение фактов, знание терминов и базовое понимание химических понятий.

Подобная структура экзамена не является уникальной. Ряд исследований показывает, что во многих национальных экзаменационных системах вопросы чаще всего сосредоточены на проверке репродуктивных знаний (Yaşar & Yılmaz, 2020; Chowdhury, 2023). Это связано с тем, что тестовые задания с выбором ответа проще стандартизировать и использовать при массовом оценивании. Кроме того, такие задания позволяют обеспечить высокую объективность проверки и единые критерии оценивания.

В то же время международные экзамены по химии демонстрируют более разнообразную структуру заданий. В экзаменах AP Chemistry и IB Chemistry значительно выше доля заданий, требующих применения знаний, анализа химических процессов и интерпретации данных. Это свидетельствует о том, что данные экзамены ориентированы не только на проверку усвоения учебного материала, но и на развитие более сложных когнитивных навыков.

Особенно заметна разница в доле заданий уровня **Analyze**. В международных экзаменах такие задания занимают значительную часть теста и часто связаны с анализом экспериментальных данных, графиков или описаний химических процессов. Для выполнения подобных заданий учащимся необходимо не просто знать теоретический материал, но и уметь устанавливать причинно-следственные связи между химическими явлениями.



Кроме того, в международных экзаменационных системах встречаются задания более высокого когнитивного уровня - **Evaluate** и **Create**. Такие вопросы требуют аргументированного выбора решения, оценки предложенных вариантов или формулирования объяснения химического процесса. Хотя их доля относительно невелика, наличие подобных заданий свидетельствует о стремлении включить в оценивание элементы критического мышления и научного рассуждения.

Ещё одно различие связано с типами заданий. Анализ показал, что в ЕНТ преобладают теоретические и расчётные задачи. В международных экзаменах, напротив, чаще встречаются задания на интерпретацию экспериментальных данных и анализ химических процессов. Это отражает различия в образовательных подходах. В международной практике большое внимание уделяется формированию научной грамотности, которая предполагает способность работать с научной информацией, анализировать данные и делать выводы на основе экспериментальных результатов.

При этом важно отметить, что различия между экзаменационными системами обусловлены не только образовательными приоритетами, но и организационными особенностями самих экзаменов. ЕНТ представляет собой массовый стандартизированный тест, предназначенный для оценки большого количества выпускников. В таких условиях использование заданий закрытого типа является наиболее удобным и технологичным. Международные экзамены, напротив, часто включают задания с развернутым ответом и задания на анализ данных, что позволяет более полно оценивать когнитивные навыки учащихся.

Таким образом, проведённый анализ позволяет сделать вывод о том, что экзаменационные системы по химии могут существенно различаться по характеру проверяемых когнитивных навыков. Если в ЕНТ основной акцент делается на проверке знаний и понимания учебного материала, то международные экзамены в большей степени ориентированы на применение знаний, анализ химических процессов и интерпретацию научной информации.

Эти различия важно учитывать при обсуждении направлений совершенствования системы оценивания в школьном химическом образовании. Расширение спектра типов заданий и увеличение доли вопросов, требующих аналитического мышления, может способствовать развитию у учащихся более глубокого понимания химических явлений и формированию навыков научного рассуждения.

### **Заключение**

Проведённый сравнительный анализ экзаменационных заданий по химии позволил выявить особенности структуры вопросов, используемых в национальной и международных системах оценивания. В ходе исследования были рассмотрены задания Единого национального тестирования Республики Казахстан, а также задания международных экзаменов AP Chemistry и IB Chemistry. Для оценки когнитивной сложности вопросов использовалась обновлённая таксономия Блума.

Результаты анализа показали, что распределение заданий по уровням когнитивной сложности в рассматриваемых экзаменационных системах существенно различается. В заданиях ЕНТ преобладают вопросы, направленные на воспроизведение и понимание химических знаний. Большинство заданий относится к уровням Remember и Understand, что указывает на ориентацию экзамена преимущественно на проверку усвоения теоретического материала.

В международных экзаменах структура заданий выглядит более разнообразной. Значительную долю составляют вопросы, требующие применения знаний и анализа химических процессов. Кроме того, в экзаменах AP Chemistry и IB Chemistry присутствуют задания более высокого когнитивного уровня, предполагающие аргументацию решений, интерпретацию экспериментальных данных и формулирование выводов.

Различия между экзаменационными системами проявляются также в типах заданий. Если в ЕНТ преобладают теоретические и расчётные вопросы, то в международных экзаменах заметно больше заданий, связанных с анализом химических процессов и интерпретацией экспериментальных результатов. Это свидетельствует о различиях в образовательных подходах к оцениванию знаний учащихся.

Полученные результаты позволяют сделать вывод о том, что международные экзаменационные системы в большей степени ориентированы на развитие аналитического мышления и научного рассуждения. В то же время задания ЕНТ в основном направлены на проверку усвоения учебного материала.

Проведённое исследование показывает, что использование сравнительного анализа экзаменационных заданий может быть полезным инструментом для совершенствования системы оценивания в школьном химическом образовании. Расширение спектра типов заданий и увеличение доли вопросов, требующих анализа и интерпретации данных, может способствовать развитию у учащихся более глубокого понимания химических явлений и формированию научной грамотности.

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## **Economic sciences**

### **THE USE OF FINANCIAL REPORTING IN THE IDENTIFICATION AND PROOF OF ACCOUNTING VIOLATIONS**

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### **ИСПОЛЬЗОВАНИЕ ФИНАНСОВОЙ ОТЧЕТНОСТИ ПРИ ВЫЯВЛЕНИИ И ДОКАЗЫВАНИИ ПРАВОНАРУШЕНИЙ В БУХГАЛТЕРСКОМ УЧЕТЕ**

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#### **Abstract**

In the context of economic development, the importance of financial reporting as a source of information about an organization's performance and financial position is increasing. At the same time, the risks associated with economic offenses are also growing. In this regard, particular importance is attached to studying the potential of financial reporting as a source of evidentiary information for identifying violations within the accounting system. The study examines the specific features of financial reporting formation under conditions of a growing number of business entities and an increasing volume of reporting data. Special attention is given to analytical methods that make it possible to identify signs of potential violations based on financial reporting data. It is demonstrated that the use of analytical procedures enables a more objective assessment of an organization's financial and economic activities and helps identify potential risks of data misstatement. At the same time, it is noted that each analytical method has certain limitations, which necessitates the integrated application of various analytical approaches in order to improve the reliability of conclusions. The study also emphasizes that the development of analytical tools and the improvement of methodological approaches to the analysis of financial reporting can contribute to more effective detection of economic offenses and enhance the transparency of financial information.

#### **Аннотация**

В условиях развития экономики возрастает значение финансовой отчетности как источника данных о результатах деятельности организации и их финансовом положении. Одновременно с этим усиливаются риски возникновения экономических правонарушений. В связи с чем особую значимость приобретает исследование возможностей исследования финансовой отчетности как источника доказательно информации при выявлении нарушений в системе бухгалтерского учета. В работе рассматриваются особенности формирования финансовой отчетности в условиях роста числа хозяйствующих субъектов увеличения объема отчетных данных. Особое внимание уделяется исследованию аналитических методов, позволяющих выявлять признаки возможных нарушений на основе данных финансовой отчетности. Показано, что использование аналитических процедур позволяет формировать более объективное представление о финансово-хозяйственной деятельности организации и выявлять потенциальные риски искажений. Вместе с тем отмечается, что каждый из методов обладает определенным количеством ограничений, в связи с чем существует необходимость комплексного использования различных методов анализа для повышения достоверности выводов. Отмечается, что развитие анали-

тических инструментов и совершенствование методологических подходов к исследованию финансовой отчетности могут способствовать повышению эффективности выявления экономических правонарушений и укреплению прозрачности финансовой информации.

**Keywords:** financial reporting, accounting, economic offenses, financial analysis, analytical procedures, forensic accounting.

**Ключевые слова:** финансовая отчетность, бухгалтерский учет, экономические правонарушения, финансовый анализ, аналитические процедуры, forensic accounting.

В условиях усложнения экономических процессов и цифровизации учета, роль финансовой отчетности как ключевого инструмента прозрачности и доверия сильно увеличивается. В мире наблюдается увеличение числа хозяйствующих субъектов, усложнение моделей ведения бизнеса, активное внедрение новых технологий и рост объемов финансовой информации.

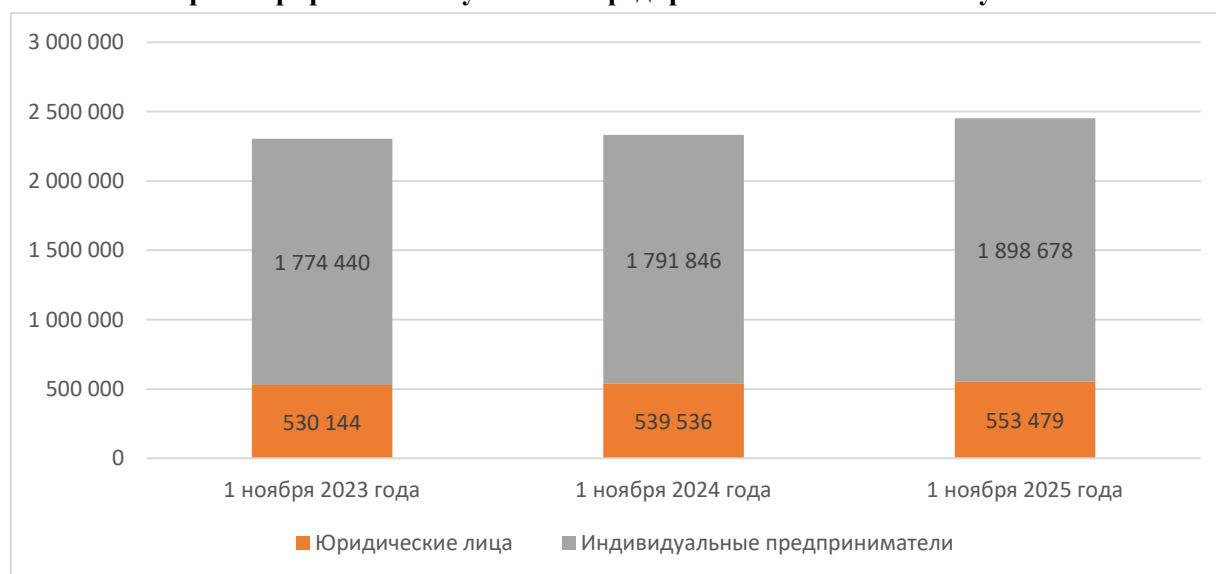
На фоне активного экономического роста и расширения предпринимательского сектора увеличивается не только объем финансовой отчетности, но и количество нарушений, совершаемых при ее составлении в бухгалтерском учете. Финансовая отчетность может содержать как, преднамеренные, так и случайные ошибки и искажения, которые могут использовать как инструмент мошенничества. В Казахстане практически отсутствует современные комплексные исследования доказательной функции финансовой отчетности, что говорит о важности данной темы. Научная новизна исследования определяется разработкой концептуальной основы для использования финансовой отчетности в доказательных целях, восполнением некоторых методологических элементов и предложением аналитического инструментария, адаптированного к правоприменительной практике Казахстана.

Все тенденции развития неизбежно приводят и к усложнению методов и способов совершения правонарушений. Современные возможности дают и толчок развитию более изощренным, скрытым и технологичным схемам, что требует соответствующего уровня контроля и анализа. Важно обеспечить достоверность отчетных данных, поскольку именно они становятся ключевым инструментом в борьбе с совершенными нарушениями.

В настоящее время наблюдается активный рост предпринимательской деятельности. Официальные данные Бюро национальной статистики Республики Казахстан демонстрирует постоянный рост субъектов предпринимательства. По данным статистики, по состоянию на 1 ноября 2023 года количество зарегистрированных юридических лиц по республике составило 530 144 единицы, а количество субъектов индивидуального предпринимательства – 1 774 440. По состоянию на 1 ноября 2025 года статистика показала значительно увеличение, по сравнению с 2023 годом, так общее количество зарегистрированных юридических лиц составило 553 479, еще большая тенденция наблюдается в индивидуальном предпринимательстве в количестве зарегистрированных – 1 898 678 единиц [1].

Диаграмма – 1

**Количество зарегистрированных субъектов предпринимательства в Республике Казахстан**



По данной диаграмме заметно, что статистические данные свидетельствуют о выраженной тенденции роста предпринимательской деятельности в Республике Казахстан. Общий прирост юридиче-

ских лиц с 1 ноября 2023 года по 1 ноября 2025 года составил +4,40%, у индивидуальных предпринимателей он составил +7,00%. Важно выделить и резкий скачок зарегистрированных субъектов предпринимательства в 2025 году в сравнении с предыдущим годом, куда и приходится основная часть прироста, что свидетельствует об активном развитии предпринимательского сектора.

В условиях роста числа хозяйствующих субъектов, особенно важно уделять внимание качеству бухгалтерского учета и финансовой отчетности, так как само увеличение количества юридических лиц, индивидуальных предпринимателей и других субъектов бизнеса влечет и увеличение объема отчетных данных.

Ведение бухгалтерского учета и финансовой отчетности организации осуществляется в соответствии с Законом Республики Казахстан «О бухгалтерском учете и финансовой отчетности» от 28 февраля 2007 года № 234. Так, в статье 2 Закона определяется круг субъектов, обязанных составлять финансовую отчетность. Такая обязанность распространяется на все юридические лица, включая филиалы, представительства и постоянные учреждения, зарегистрированные на территории Казахстана. Также такая обязанность предусмотрена и для всех индивидуальных предпринимателей, за исключением тех, кто одновременно принимает специальные налоговые режимы для субъектов малого бизнеса, не стоит на регистрационном учете по НДС, а также не относится к субъектам естественных монополий. Отсюда можно сделать вывод, что финансовую отчетность обязаны составлять все организации, не подходящие под описанные исключения [2].

По приведенной статистике заметно, что большее количество хозяйствующих субъектов, не подходящих под исключения, обязаны составлять финансовую отчетность в соответствии с законодательством Республики Казахстан, что говорит о достаточно большом объеме финансовых данных. При таком активном росте экономики и технологического прогресса, для достижения различных целей, субъекты могут искажать показатели финансовой отчетности, из-за чего уследить за ними становится сложнее. С каждым разом создаются все новые способы и схемы совершения таких преступлений, что создает сложность для их выявления. Соответственно, и с ростом экономики, растет количество экономических правонарушений.

Согласно Глобальному индексу организованной преступности (Global organized crime index), Казахстан занимает 107 место по рейтингу финансовых преступлений в мире из возможных 193. Под данным на 2025 год по оценке преступности Казахстан относится к странам со средним уровнем риска финансовых правонарушений. По последней оценке, общий индекс преступности составляет 6 баллов из 10, что указывает на существенную распространенность финансовых злоупотреблений и правонарушений. Однако с 2023 года по настоящее время наблюдалась тенденция роста совершения таких правонарушений по Казахстану, что подтверждает увеличение количества экономических преступлений [3].

Для того, чтобы определить финансовую отчетность как доказательный инструмент совершенных нарушений, стоит разобраться в определении видов нарушений, которые могут проявляться в отчетности. В зависимости от характера и тяжести совершенного деяния, правонарушение может быть отнесено как к уголовному, так и к административному законодательству, и влечь за собой разные меры наказания.

Кодекс об административных правонарушениях Республики Казахстан от 5 июля 2014 года № 235-V (КоАП РК) содержит в себе различные виды правонарушений, которые могут быть совершены с использованием финансовой отчетности. Так, в главе 15 – Административные правонарушения в области торговли и финансов существует ряд статей, которые имеют прямое отношение к бухгалтерскому учету и финансовой отчетности. Существуют и косвенные статьи КоАП РК, куда, например, можно отнести главу 16 – Административные правонарушения в области налогообложения, в которых не затрагивается прямое отношение отчетности, но требуется ее анализ при проверке [4].



**Правонарушения КоАП РК и их отражение в финансовой отчетности**

№	Статья	Связь с финансовой отчетностью
1	87 – Нарушение требований по оплате труда	Невыплата/задержка заработной платы отражается через заниженный фонд оплаты труда – необоснованно низкие социальные отчисления, несоответствия между начисленной и выплаченной зарплатой в отчете и т.д.
2	238 – Нарушение законодательства Республики Казахстан о бухгалтерском учете и финансовой отчетности физическими и должностными лицами	Ведет к искажению данных, неправильной классификации, несвоевременному отражению операций.
3	239 – Нарушение законодательства Республики Казахстан о бухгалтерском учете и финансовой отчетности	Ведет завышению/занижению активов и обязательств, искажению выручки и расходов, а также несоответствие между отчетными периодами.
4	245 – Сокрытие аудитором факта нарушения законодательства Республики Казахстан о бухгалтерском учете и финансовой отчетности	Ведет к пропуску существенных ошибок и формальных аудиторских заключений, что выражается в сохранении завышения/занижения статей и расхождении с требованиями МСФО.
5	278 – Занижение сумм налогов и других обязательных платежей в бюджет	Проявляется через фиктивные расходы, сокрытие выручки, несоблюдения налоговой базы.
6	280 – Выписка фиктивного счета-фактуры	Ведет к несоответствию видов отчетности между собой, что приводит к завышению/занижению расходов, созданию несуществующих запасов и отсутствию связи между поставками и производством.

В таблице приведены примеры прямых и косвенных правонарушений, которые отражаются на ведении бухгалтерского учета и составлении финансовой отчетности. Большое количество административных правонарушений, напрямую не относящиеся к сфере бухгалтерского учета, могут иметь документальные финансовые следы, что позволяет рассматривать отчетность как инструмент доказательственной базы при расследовании экономических правонарушений.

Анализ небольшого количества статей доказывает, что финансовая отчетность обладает комплексным криминалистическим значением. Так, статьи 238, 239 и 245 имеют прямо доказательственное значение, так как связаны с ведением учета и отчетности. Данные нарушения влияют напрямую на достоверность финансовой отчетности, что выражается в искажении в регистрах учета, корректности классификации активов и обязательств, а также в целом в полноте раскрытия информации. В примере со статьями 87, 278, 280 и 463 КоАП, несмотря на отсутствие прямого влияния, можно заметить наличие важного доказательственного потенциала, что может помочь при раскрытии и выявлении. Последствия нарушений могут быть зафиксированы в бухгалтерских записях и отчетности через несоответствие данных, аномальных изменений в статьях отчетности, расхождений между прибылью и денежными потоками, и в целом отсутствия реальной хозяйственной деятельности при формальной отчетности.

В случае с Уголовным кодексом Республики Казахстан от 3 июля 2014 года № 226-V (УК РК) прослеживается чуть иная система правонарушений. УК РК занимает ключевое место в правовом обеспечении экономической безопасности государства и противодействии правонарушениям, совершаемым в сфере бухгалтерского учета и финансовой отчетности. В законе предусматриваются более серьезные нарушения, соответственно более строгая ответственность за их совершение. Глава 8 УК РК содержит в себе уголовные правонарушения в сфере экономической деятельности, которые во многом используют финансовую отчетность как доказательную базу. Значительная часть из них связана с искажением хозяйственных операций, сокрытием финансовых потоков и нарушением норм бухгалтерского учета. Помимо прямых составов преступлений, связанных с искажением финансовой информации, УК РК содержит и ряд косвенных статей, которые не направлены на нарушения в финансовой отчетности, но их расследование невозможно без ее анализа [5].

**Правонарушения УК РК и их отражение в финансовой отчетности**

№	Статья	Связь с финансовой отчетностью
1	190 – Мошенничество	Проявляются через необоснованные списания, операции с ложными контрагентами, операции без первичных документов, что ведет к необоснованным расходам, фиктивным сделкам, расхождению между отчетностью и фактическими показателями.
2	216 – Совершение действий по выписке счета-фактуры без фактического выполнения работ, оказания услуг, отгрузки товаров	Проявляется как отражение несуществующих операций, фиктивные доходы/расходы, искусственное завышенное оборотов, что дает выявить отсутствие движения денежных средств по сделкам, расхождения между бухгалтерскими регистрами и первичными документами и т.д.
3	239 – Доведение до неплатежеспособности	Ведет к растущей кредиторской задолженности, занижению активов, нерыночных сделок, выводе денежных средств, что ведет к установлению причинно-следственной связи с наступлением неплатежеспособности.
4	245 – Уклонение от уплаты налога и (или) других обязательных платежей в бюджет с организаций	Проявляется как снижение прибыли, несоответствие между налоговым и бухгалтерским учетом, что ведет к расхождению в отчетности, необоснованности расходов, несоответствию финансовых потоков структуре доходов.
5	251 – Злоупотребление полномочиями аудитор и др.	Соккрытие аудитором фактов искажений, непредоставление корректного заключения, игнорирование ошибок, что влечет к недостоверности данных и отсутствия обязательных раскрытий.

Проведенный анализ норм УК РК показывает, что и здесь, финансовая отчетность играет существенную роль в выявлении и доказывании как прямых, так и косвенных правонарушений. Некоторые статьи непосредственно связаны с манипулированием финансовыми показателями, где как раз отчетность выступает основным объектом преступного посягательства и одновременном ключевым источником доказательной информации. Больше количество статей это те, которые не направлены непосредственно на финансовую отчетность, но неизбежно проявляются в ее структуре и динамике. Они могут проявляться в различных несоответствиях, ухудшениях финансовых коэффициентов и наличии несуществующих операций. Так, в случае доведения до неплатежеспособности отчетность позволяет проследить причинно-следственную связь между действиями лиц и финансовым положением организации.

Обобщая результаты анализа, финансовая отчетность в правовой сфере может выполнять двойственную функцию и выступать:

- объектом преступного посягательства, когда само нарушение направлено на искажение данных бухгалтерского учета и отчетности;
- инструментом доказательства, когда нарушение совершается посредством хозяйственных операций, оставляющих следы в отчетности, но не направлено на саму ее фальсификацию.

Стоит отметить, что грамотное использование аналитических процедур позволяют формировать объективную картину хозяйственных операций, что позволяет выявить признаки правонарушений еще на уровне внешнего или внутреннего анализа отчетности. Это подчеркивает необходимость совершенствования методик финансового анализа и усиления роли финансовой отчетности как инструмента доказывания нарушений. Финансовая отчетность, являясь отражением всех хозяйственных операций, выступает важнейшим источником доказательственной информации при расследовании экономических нарушений.

В рамках исследования особое значение имеет изучение методов анализа финансовой отчетности, так как именно такие аналитические процедуры позволяют выявлять различные признаки искажения данных и других манипуляций с отчетностью. Как структурно взаимосвязанная система, финансовая отчетность поддается различным видам анализа. На практике мы рассмотрим данные с использованием вертикального, горизонтального, коэффициентного и сравнительного методов, что позволит обнаружить несоответствия между формами отчетности, аномалии в динамике показателей и признаки возможных рассмотренных правонарушений в бухгалтерском учете.

Вертикальный анализ структуры отчетности способствует обнаружению несбалансированности финансовых показателей. Сюда можно отнести непропорциональный рост отдельных расходов, завышение себестоимости, аномально высокая доля запасов или дебиторской задолженности в активах. Такие отклонения обычно являются следствием фиктивных расходов, необоснованного списания активов, а также завышения стоимости приобретенных товаров и услуг. По ранее выделенным статьям УК РК и КоАП РК для примера данного метода анализа, стоит отметить нормы, которые связаны с выпиской фиктивного счета-фактуры. Вертикальный анализ позволяет выявить фиктивность за счет резкого увеличения себестоимости или расходов на приобретение товаров/услуг при неизменной или почти



неизменившейся выручке. В балансе проявляется рост доли запасов или кредиторской задолженности при отсутствии фактического движения товаров или движения денежных средств. Соответственно подобное отклонение в разрезе данной статьи закона может указывать на отсутствие экономического содержания операции, что служит признаком возможной фиктивности первичных документов.

При горизонтальном анализе можно выявить аномальные изменения статей отчетности, которые могут свидетельствовать о манипуляциях. Он подразумевает анализ динамики показателей, которые используются для выявления аномальных изменений за отчетные периоды. Данный метод эффективен при выявлении мошеннических действий, так как позволяет установить динамику изменения ключевых показателей отчетности за определенный период. Он позволяет выявить резкие скачки и провалы в доходах, расходах, запасах и прочих статьях отчетности. Если же такие изменения не характерны для хозяйственной деятельности организации, то это может служить важным индикатором возможных манипуляций и умышленного искажения данных. В контексте мошенничества результаты анализа приобретают важное доказательное значение, так как помогают установить причинно-следственную связь между отклонениями и действиями причастных лиц, что важно для подтверждения умысла и оценки размера причиненного ущерба.

В отличие от прошлого вида анализа, где сравниваются изменения внутри компании, сравнительный анализ также подразумевает сравнение, но показателей компании с другими организациями, или же со их средними нормативами. Так выявляются структурные отклонения от нормы, которые не видны при рассмотрении внутри самого предприятия. На примере правонарушения он может стать важным инструментом при выявлении признаков уклонения от оплаты налогов, так как позволяет сопоставить финансовые показатели организации с отраслевыми данными. Как правило, реализуется через искажение налоговой базы, что проявляется в сокрытии доходов, завышении расходов, использование фиктивных операций. Также такой анализ может позволить выявить расхождения между бухгалтерским и налоговым учетом в виде существенных различий финансовых результатов или налоговых обязательств. В аналогичных же отраслях и сферах деятельности сравнение заключается в отклонении в структуре затрат, рентабельности, что может указывать на манипулирование налоговой базой. Сравнение таких данных позволяет установить несоответствие между заявленной деятельностью и реальными масштабами бизнеса, что в последующем служит основанием для более глубокого анализа и формирования доказательственной базы.

В то же время коэффициентный анализ выявляет признаки ухудшения финансовой устойчивости, снижения ликвидности, падения рентабельности, а также роста долговой нагрузки. Несоответствие между коэффициентами и фактическими данными отчетности часть указывает на скрытые операции и искажения. Такой анализ может позволить выявить нарушение в виде доведения до неплатежеспособности, которое приводит к неспособности организации исполнить свои обязательства перед кредиторами. В показателях финансовой отчетности отражаются противоправные действия управленческих решений, которые заключаются в накоплении необоснованной задолженности, выводе активов, уменьшении ликвидных средств, и в целом резкое ухудшение финансовых коэффициентов, что влечет за собой падение ликвидности, ухудшение финансовой устойчивости, снижение рентабельности. Данный метод фиксирует критические значения, подтверждающие неплатежеспособность организации.

Каждый из приведенных методов в отдельности имеет большое значение в анализе финансовой отчетности, как доказательной базы для доказывания правонарушений. Каждый метод позволяет выделить определенные типы искажений от отклонений до несоответствия нормативам. Однако следует и учитывать ограниченность описанных методов, которые не всегда могут быть эффективны [6].

**Ограничения основных методов анализа финансовой отчетности и их проявления**

№	Метод	Ограничение	Как проявляется
1	Вертикальный	Не показывает динамику изменений Чувствителен к разовым операциям Требуем сопоставимости отчетности	При постепенном увеличении фиктивных расходов данный вид анализа может не выявить проблем При разовой крупной покупке анализ может показать аномалию при отсутствии нарушения
2	Горизонтальный	Зависимость от внешних факторов Возможность скрыть нарушение путем дробления операций Нестабильность в сезонных видах бизнеса	Может произойти рост цен на сырье, в связи с чем затраты вырастают, анализ может показать завышение себестоимости Резкие колебания могут указать на фиктивные операции при их фактическом отсутствии
3	Сравнительный	Необходимы определенные данные для сравнения Различия в учетной политике Большое количество отраслевых данных в Казахстане недоступны	При сравнении с неподходящей организацией выводы могут быть ошибочны При разных методах учета могут выявиться резкие расхождения
4	Коэффициентный	Важность корректности исходных данных Особенности отрасли	При искаженных данных коэффициенты будут ложными Коэффициенты могут варьироваться в зависимости от сектора экономики, что может повлечь ошибки

По таблице заметно, что каждый из методов анализа имеет объективные ограничения, связанные со структурой отчетности, корректностью данных, особенностями отрасли и внешними факторами. Такие ограничения могут приводить к ложным выводам, создавая видимость нарушения. Но стоит отметить, что вместе они формируют целостный комплексный инструмент финансово-правовой диагностики, который позволяет выявлять признаки и доказывать правонарушения в системе бухгалтерского учета.

В международной практике вопросы использования финансовой отчетности более подробно раскрыты, чем в отечественной, и активно развиваются в рамках Forensic accounting. Данное направление объединяет методы финансового анализа и криминалистики для выявления и доказывания экономических правонарушений на основе данных финансовой отчетности. Существуют и различные объединения, как Ассоциация сертифицированных специалистов по расследованию мошенничества (Association of Certificated Fraud Examiners) и Группа разработки финансовых мер борьбы с отмыванием денег (Financial Action Task Force), а также зарубежные методики, которые рассматривают подходы и дают рекомендации по использованию горизонтального, трендового и сравнительного анализа при расследовании экономических правонарушений [7, 8]. Для Казахстана адаптация таких подходов и методик может стать основой для формирования собственной методологии судебно-бухгалтерской экспертизы.

Таким образом, финансовая отчетность обладает большим доказательственным потенциалом при выявлении и расследовании правонарушений в системе бухгалтерского учета. Анализ административного и уголовного законодательства Республики Казахстан подтверждает, что многие экономические правонарушения либо непосредственно связаны с искажением данных финансовой отчетности, либо неизбежно оставляют документальные следы и ее структуры в динамике. Это позволяет рассматривать финансовую отчетность как возможный источник доказательственной информации.

В условиях увеличения объемов финансовой информации возрастает необходимости совершенствования методик анализа финансовой отчетности и развития судебно-бухгалтерских подходов к расследованию экономических правонарушений. В этом контексте адаптация международных практик и развитие национальной методологической базы могут способствовать повышению эффективности выявления финансовых нарушений и укреплению прозрачности экономической деятельности.

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**EVOLUTION AND CHARACTERISTICS OF E-COMMERCE PLATFORMS**

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**Introduction**

The development of information and communication technologies has had a significant impact on the mechanisms of commercial exchange, which has led to the emergence and development of e-commerce platforms as a key element of the digital economy.

Initially, e-commerce was based on electronic data interchange (EDI) systems, which were designed to increase the effectiveness of inter-organizational interactions. However, over time, it has evolved into complex platform ecosystems that include artificial intelligence, big data analysis, cloud computing, and mobile technologies.

E-commerce platforms not only simplify the transaction process, but also actively shape market structures, consumer behavior, and competitive dynamics, especially in cross-border contexts characterized by institutional, cultural, and regulatory heterogeneity.

The relevance of this study is due to several interrelated factors. Firstly, e-commerce platforms play a key role in global economic development by reducing barriers to market entry and enabling small and medium-sized enterprises to participate in international trade without a physical presence abroad.

Secondly, the process of platformization has led to the concentration of economic power in the hands of a limited number of global platforms that control access rules, pricing mechanisms, data flows, and algorithmic decision-making.

Thirdly, the growing use of artificial intelligence and data-driven personalization has fundamentally changed the logic of value creation and user engagement, making the long-term development of technology a critical strategic issue. Nowadays, cross-border e-commerce platforms increasingly perform quasi-institutional functions, filling institutional gaps and reducing transaction costs. This makes it relevant to study their evolution and characteristics for Data-driven business analytics.

The purpose of this study is to analyze the development and key characteristics of e-commerce platforms as multi-faceted digital ecosystems based on data. Special attention is paid to their technological architecture, management mechanisms, and role in ensuring the continuity of resource use and cross-border e-commerce.

To achieve this goal, the study solves two main tasks:

1. Systematization of the stages of development of e-commerce platforms and identification of the main technological, organizational and strategic changes that have occurred at each stage.
2. Study the defining characteristics of modern e-commerce platforms, such as network effects, platform architecture, modularity and scalability, algorithmic management and personalization based on artificial intelligence, and assess their impact on technology continuity and cross-border operations.

The scientific novelty of the research lies in an integrated approach to the analysis of e-commerce platforms as strategic and institutional actors, rather than just technological tools.

The study combines theoretical concepts from information systems, platform economics, and institutional theory to analyze the impact of data-driven management, artificial intelligence-based personalization, and trust mechanisms on long-term user engagement and the stability of cross-border e-commerce platforms.

Unlike previous studies that focused on the implementation and effectiveness of transactions, this study links user behavior at the individual level with architectural and management decisions at the platform level, which introduces a new analytical approach to research in the field of database administration.

The theoretical significance of the research lies in expanding existing theories of the continuity of technologies and platform-based markets into the context of intelligent, data-driven ecosystems operating beyond national borders.

By considering e-commerce platforms as multi-faceted markets embedded in an institutional environment and driven by algorithms, the study deepens the understanding of how network effects, legitimacy, and algorithmic decision-making are changing market coordination and the relationship between user and platform. This contributes to the development of more comprehensive theoretical models that can reflect the complexity of modern e-commerce.

The practical significance of the research lies in its relevance to platform owners, managers, and policy makers. The results of the study provide practical recommendations on the design of the platform architecture, personalization using artificial intelligence and trust-building mechanisms to increase user retention, scalability and sustainable competitive advantage, especially in cross-border markets.

For companies involved in e-commerce platforms, the study clarifies how the characteristics of the platform affect internationalization opportunities and long-term engagement.

For regulators and policy makers, the study's findings highlight the growing institutional role of e-commerce platforms and the importance of transparency, fairness, and effective data management in the digital economy.

### **Literature review**

Modern research in the field of e-commerce demonstrates a variety of approaches to understanding platforms and their role in the digital economy. Let's look at four main sources representing various aspects of this topic.

In an article published in an international scientific journal devoted to applied research and innovation, the authors, Mr. Anurag Maurya, Prashant Kumar, Aayush Kumar consider the prospects for the development of an e-commerce platform. They strive to create a platform that will be able to adapt to the different needs of users[1].

The authors focus on the impact of Web 2.0, mobile commerce, and analytics on the development of e-commerce platforms. These technologies ensure the security and functionality of the platforms, as well as expand their capabilities, allowing them to create a personalized user experience.

Studies such as those conducted by Geoffrey G. Parker and his colleagues lay the theoretical foundation for understanding the platform as a multilateral market[2]. They take into account that these indicators reflect the value of interaction between different groups of participants (for example, buyers and sellers), as well as how network effects contribute to the competitiveness and sustainability of the market. This theory is important for understanding the theory of the platform economy and structural transformations in the field of e-commerce.

Recent research published in MDPI examines how innovative platform management mechanisms affect the trust of sellers[3]. The authors note that in the context of cross-border e-commerce, political communities and legal systems play an important role in reducing economic risks and increasing the level of trust of participants, which contributes to the development of international trade operations.

In the work of Pekhterev D.O., the platform is analyzed with practical advice for sellers, especially for representatives of small and medium-sized businesses[4]. The author examines the prospects for market development, platform requirements for participants, and the growing interest of small companies in using e-commerce platforms as a driving force. This study covers both the economic and practical aspects of the application of these systems.

A review of the literature shows that research in the field of e-commerce platforms is developing in several key areas. Technological development of platforms, including the introduction of artificial intelligence, the use of big data and mobile solutions, increases their functionality and expands opportunities for users. Theoretical understanding of platforms as multilateral markets makes it possible to understand the mechanisms of value creation and network effects that affect competitive advantages. Governance and trust are becoming key elements of the platform ecosystem, especially in the context of cross-border operations, reducing risks and increasing the sustainability of international operations. Practical recommendations help businesses adapt to the requirements of the platforms and participate effectively in their ecosystems, which is especially important for small and medium-sized enterprises. Thus, an analysis of the scientific literature shows that research on e-commerce platforms includes the study of technological innovations, economic and institutional mechanisms, as well as practical strategies. This allows us to gain a comprehensive understanding of their development and justify the need for further research to analyze the strategic behavior of digital market participants.

### **Research methodology**

Within the framework of this study, a method was applied to analyze the evolution of e-commerce platforms, which includes a historical and technological approach to systematize the stages of development and content analysis of scientific publications and industry reports.



The research materials include information on the technological architecture of platforms, algorithmic management, personalization, institutional trust mechanisms and cross-border operations.

The use of these sources made it possible to compile a chronological map of the evolution of platforms, identify key factors affecting their functionality and sustainability, as well as identify mechanisms that facilitate the continued use of platforms by users and ensure their successful functioning in an international context.

### **Results and discussion**

The evolution of e-commerce platforms reflects a gradual but significant transformation of commercial transaction mechanisms, driven by advancements in information and communication technologies. The initial conceptual foundations of e-commerce can be attributed to electronic data interchange systems, which were introduced in the 1970s. These systems enabled standardized electronic communication between businesses, primarily aimed at enhancing supply chain efficiency rather than facilitating consumer-facing transactions [1].

In the 1990s, with the commercialization of the internet, electronic commerce (e-commerce) entered a new stage characterized by business-to-consumer (B2C) and business-to-business (B2B) transactions online. Early platforms acted as digital storefronts, mimicking traditional retail models in a digital environment. Their primary value proposition was increased market reach and decreased operational expenses. However, limitations in interactivity, consumer trust, and payment infrastructure development constrained adoption rates [2].

The early 2000s saw a shift towards platform-based models of e-commerce, with companies moving away from acting solely as sellers and instead positioning themselves as intermediaries facilitating transactions between various market participants. This transition occurred concurrently with the emergence of Web 2.0 technologies, which facilitated user-generated content, enabled social interaction, and provided real-time feedback mechanisms. As a result, e-commerce platforms have accumulated vast amounts of behavioural data, creating the basis for data-driven decisions and personalized experiences.

In the contemporary phase, e-commerce platforms have evolved into complex digital ecosystems integrating artificial intelligence, cloud computing, mobile technologies, and advanced analytics. These platforms no longer merely enable transactions but actively shape consumer behavior, market structures, and competitive dynamics. This evolution is particularly significant in cross-border contexts, where platforms operate across heterogeneous regulatory, cultural, and economic environments.

A key aspect of modern e-commerce is the phenomenon of platformization. In this process, digital infrastructures act as mediators for interactions between various user groups.

From a theoretical perspective, e-commerce platforms can be understood as multi-sided markets that create value by facilitating exchanges between different but interdependent groups of participants, such as buyers, sellers, advertisers, logistics providers, and payment processors [3], [4], [5].

Unlike traditional value chains, which have a linear structure, platform-based models depend on indirect network effects. The usefulness of the platform to one group of users increases as more participants from other groups join. This explains the tendency towards market concentration and the "winner-takes-all" outcomes seen in global e-commerce markets.

Platformization also involves a redistribution of economic power. Owners of platforms exercise control over access policies, pricing structures, data flow, and algorithmic transparency. As a result, e-commerce platforms act not only as marketplaces, but also as private regulatory bodies, shaping market behavior through governance mechanisms integrated into digital architectures.

The technological architecture of modern e-commerce platforms is defined by its modularity, scalability, and interoperability [6]. Key components of the platform typically include user interfaces, transaction processing engines, data management systems, and application programming interfaces, which enable third-party integrations [7].

The modular design of these platforms allows for the rapid introduction of new features, such as artificial intelligence (AI)-driven recommendation systems, dynamic pricing algorithms, and cross-border tax calculation tools. These capabilities are essential in today's highly competitive and rapidly evolving digital marketplace, where innovation and agility are critical to maintaining a competitive edge.

Cloud-based infrastructure solutions significantly enhance scalability, allowing platforms to handle peak demand, process vast amounts of real-time data, and expand geographically with relatively low additional costs [8]. Therefore, the technological architecture of a platform is not simply a technical aspect, but a crucial factor in determining its growth and long-term viability.

Data constitutes the central strategic resource of e-commerce platforms [9]. Through continuous monitoring of user interactions, platforms generate detailed digital traces that are analyzed using advanced analytics and machine learning techniques. These insights inform a wide range of strategic decisions, including product assortment optimization, inventory management, fraud detection, and personalized marketing.

Algorithmic governance emerges as a key characteristic of data-centric platforms. Algorithms determine search rankings, product recommendations, seller visibility, and even pricing dynamics. While these mechanisms enhance efficiency and personalization, they also raise concerns related to transparency, fairness, and power asymmetries between platforms and users [10].

From a theoretical perspective, algorithmic governance reshapes traditional notions of market coordination by embedding decision-making processes within automated systems. This shift has profound implications for user trust, perceived control, and technology continuance behavior.

Network effects are a fundamental economic principle that underlies the success of leading e-commerce platforms. As the number of users increases, these platforms benefit from a growing volume of data, improved algorithms, and higher service quality. This positive feedback loop enhances their competitive advantage and creates significant barriers to entry for new competitors.

Platforms employ lock-in strategies that make it difficult for users to switch to other platforms. These strategies include personalized recommendations, loyalty programs, integrated payment systems, and services that are part of an ecosystem. While these measures can help to retain users and ensure the continued use of a platform, they may also limit consumer choice and reduce market competition.

Trust is a fundamental prerequisite for the sustainable operation of e-commerce platforms. In particular, it is essential in environments characterized by uncertainty, information asymmetry, and geographical distance. Trust serves as a substitute for traditional face-to-face interactions and legal enforcement mechanisms in digital commerce. It plays a critical role in influencing user adoption and continued usage of e-commerce services.

Institutionally, e-commerce platforms act as private governance systems with formal and informal regulations governing market participation. Seller verification procedures, reputation systems, buyer protection measures, escrow payment mechanisms, and dispute resolution protocols are all integral components of these regulations. These mechanisms collectively reduce transaction risk and increase the legitimacy of e-commerce platforms in users' eyes.

Platform legitimacy extends beyond technical reliability and includes normative and cognitive aspects. Normative legitimacy relates to the alignment of a platform's practices with societal expectations for fairness, transparency, and accountability. Cognitive legitimacy, on the other hand, reflects users' perception of platforms as integral and necessary parts of the commercial environment.

For Data-Driven Business Analytics research, legitimacy is crucial because it affects long-term sustainability and strategic position of a platform, rather than short-term transactional success.

In the context of cross-border electronic commerce, institutional trust assumes even greater significance. Differences in legal frameworks, consumer protection regulations, and enforcement measures increase perceived risk, rendering platform-based trust mechanisms essential. Platforms that effectively internalize institutional functions such as compliance support, tax administration, and customs clearance are better positioned to promote the continued use of technology among international customers [11].

Cross-border e-commerce platforms have distinct characteristics compared to domestic platforms, in terms of their complexity, operational scale, and strategic considerations. While domestic platforms function within relatively uniform regulatory and cultural frameworks, cross-border platforms need to address heterogeneity across various dimensions, including language, currency, taxation, logistics infrastructure, and consumer preferences simultaneously.

The theoretical approaches to cross-border e-commerce focus on transaction cost economics and institutional theories. From a transaction cost perspective, these platforms aim to minimize the search, negotiation, and enforcement expenses associated with international transactions by providing standardized interfaces and automated procedures. From an institutional viewpoint, they act as intermediaries bridging institutional gaps, particularly in developing markets where formal market support institutions may be insufficient [12].

For businesses, participating in cross-border electronic commerce platforms reduces barriers to international expansion, allowing small and medium-sized enterprises (SMEs) to access global markets without the need for a physical presence abroad. For customers, these platforms increase product variety and transparency, while reducing risks through trust mechanisms facilitated by the platform [13].

Cross-border operations bring strategic challenges. Companies must strike a balance between global standardization and local adaptation, ensuring consistent core functionalities while meeting country-specific needs. This balance has implications for platform architecture, management, and personalization approaches.

Artificial intelligence has become a significant driver in the development of e-commerce platforms. It has fundamentally transformed the way value is created and delivered in these platforms. AI-powered personalization is the use of machine learning algorithms, predictive analytics, and real-time data processing to customize platform interactions for individual users.

This personalization takes place across various dimensions, such as product recommendations, search results, pricing strategies, promotional content, and customer communications. By aligning the platform's offerings with the user's preferences and contextual factors, AI systems enhance the perceived relevance and convenience of the user experience, which are crucial determinants of customer satisfaction.

From a theoretical perspective, AI-powered personalization enhances the relationship between perceived utility and continued engagement. Unlike static features, personalization dynamically adapts as algorithms learn from user interactions, creating a cycle of engagement and service improvement. This adaptability sets AI-driven systems apart from previous generations of e-commerce platforms.

In international contexts, personalization also plays a crucial role in addressing cultural and behavioral diversity. AI-powered systems can tailor content, recommendations, and interactions to match local preferences, reducing cultural barriers and enhancing the user experience.

However, the increasing use of AI also raises concerns about algorithmic bias, transparency, and privacy. These factors directly impact user trust and could mitigate the benefits of personalization for long-term technology adoption.

Continued use of technology refers to the intention of users to continue utilizing a digital system after its initial adoption. This is particularly significant in the context of e-commerce platforms due to the high costs associated with customer acquisition and intense competition in the market.

Previous models of continued use have emphasized factors such as perceived usefulness, satisfaction, and fulfillment of expectations. However, with the evolution of e-commerce, it is necessary to adopt a more comprehensive theoretical framework that takes into account specific characteristics of these platforms, including the quality of personalization, integration with other systems, and trust-building mechanisms.

E-commerce platforms are increasingly functioning as integrated digital environments rather than stand-alone systems. Users engage with these platforms through various touchpoints, such as mobile applications, social media, and third-party services. This integration increases switching costs and promotes continued use, but it also raises expectations for service consistency and reliability.

To systematize the evolution of e-commerce platforms and to highlight the key technological, organizational, and strategic shifts, it is necessary to present a structured overview of their developmental stages. The table 1 below summarizes the major phases in the evolution of e-commerce platforms, emphasizing changes in platform architecture, value creation logic, user interaction, and implications for technology continuance and cross-border commerce.

**Table 1 – Evolution of E-commerce Platforms**

Stage of evolution	Time period	Dominant technologies	Key platform characteristics	Value creation logic	Implications for technology continuance and cross-border e-commerce
Pre-platform electronic commerce (EDI-based)	1970s–early 1990s	Electronic Data Interchange (EDI), proprietary networks	Closed systems, limited interoperability, firm-to-firm transactions	Cost reduction and operational efficiency	Continuance driven by organizational necessity; cross-border use limited to large corporations
E-commerce 1.0: Transaction-oriented platforms	Mid-1990s–early 2000s	Static websites, basic databases, online payment systems	Online storefronts, one-way communication, limited trust mechanisms	Market reach expansion and transaction facilitation	Low user continuance due to trust and usability constraints; minimal cross-border adoption
E-commerce 2.0: Interactive platforms	Mid-2000s–early 2010s	Web 2.0, user-generated content, CRM systems	User reviews, ratings, social interaction, marketplace models	Network effects and user engagement	Improved continuance through interaction and trust signals; emergence of cross-border marketplaces
Platform-based e-commerce ecosystems	Mid-2010s–late 2010s	Cloud computing, APIs, mobile technologies	Multi-sided markets, ecosystem integration, modular architecture	Value co-creation among platform participants	High continuance supported by ecosystem lock-in; accelerated cross-border SME participation
AI-driven e-commerce platforms	2020s–present	Artificial intelligence, big data analytics, machine learning	Algorithmic governance, personalization, predictive analytics	Data-driven personalization and experience optimization	Strong continuance driven by personalization and trust; scalable and adaptive cross-border operations

Source – compiled by the author

The table 1 illustrates that the evolution of e-commerce platforms has been characterized by a gradual shift from transaction-focused systems to intelligent, data-driven ecosystems. Each stage of development has reflected not only technological advancements but also a shift in the logic of value creation and user-platform interactions.

From a database administrator's perspective, the most significant transformation occurs during the phase of platform-based ecosystems and AI-powered platforms, where user retention is no longer solely driven by perceived usefulness or ease of use. Rather, user retention becomes embedded in the broader dynamics of the platform, including network effects, personalized experiences, trust mechanisms, and integration with other ecosystem components.

The table demonstrates that the viability of cross-border e-commerce increases in parallel with the sophistication of the platform. As platforms develop, they increasingly take on institutional and coordinating functions, facilitating sustainable international transactions and long-term engagement with users. This developmental perspective provides a theoretical basis for analyzing cross-border e-commerce platforms as strategic and institutional players, rather than simply technological tools.

For database research, understanding continued use (continuance) behavior requires a strategic perspective that links individual perceptions with platform design and governance decisions. Artificial intelligence-driven personalization, cross-border service offerings, and institutional trust mechanisms all influence continuance outcomes. These factors highlight the need for integrated theoretical frameworks to understand continuance behavior [14].

The evolution of e-commerce platforms reflects a broader shift from transactional systems to intelligent, platform-based ecosystems that actively shape market dynamics and user behavior. Modern e-commerce platforms are characterized by modular architectures, data-centric logic, network effects, and algorithmic governance, all of which contribute to their scalability and competitive advantage.

In cross-border contexts, platforms assume institutional roles that extend beyond market facilitation, reducing transaction costs and mitigating institutional voids. AI-based personalization emerges as a critical evolutionary mechanism that enhances user experience, supports cultural adaptation, and strengthens technology continuance [15].

The development of e-commerce platforms demonstrates a consistent transition from simple systems for conducting transactions to complex, intelligently managed ecosystems. In such ecosystems, the key aspects are modular architecture, algorithmic management, personalization based on big data, and trust mechanisms based on institutions.

The discussion shows that e-commerce platforms are no longer just digital storefronts or intermediaries. They become strategic and institutional market participants capable of shaping user behavior, reducing cross-border barriers, and ensuring long-term customer engagement.

The information highlights the importance of network effects, lock-in strategies, and integration with other services to retain users. The role of artificial intelligence in adapting platforms to cultural and behavioral differences in international markets is also highlighted.

### **Conclusion**

The analysis allows us to conclude that modern e-commerce platforms are complex digital ecosystems in which technological, organizational and institutional aspects are closely interconnected.

To explore this topic, it is important to understand that the study of platforms should not be limited to the analysis of technical tools. It is also necessary to consider the strategic, economic and institutional mechanisms that determine the competitive advantages and sustainability of platforms in the international market.

The article the systematization of the stages of platform development provide a theoretical and practical basis for understanding how platforms create value, increase user trust, and ensure the long-term use of technology. This is a key provision for further research and development of recommendations for business and regulatory authorities.

The study demonstrates that for platforms to function successfully, it is necessary to integrate algorithmic solutions and use AI personalization. This allows you to adapt the user experience to the individual needs and cultural characteristics of different markets.

This approach confirms the importance of taking into account not only the technological component, but also socio-economic and institutional aspects. These include trust, reputation, and rules of engagement for participants.

This integrated approach allows platforms to reduce transaction costs, accelerate international expansion, and strengthen long-term user loyalty. This makes platforms strategic tools for the development of the digital economy and the object of further scientific research.



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**ECONOMIC FACTORS OF FLUCTUATIONS IN THE GLOBAL ECONOMY**

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**Abstract**

In recent decades, global turbulence has intensified worldwide, manifesting itself in increased uncertainty, nonlinear economic processes, and an increasing number of economic and geopolitical conflicts. The authors of the study identify a long-standing contradiction between the potential for growth in global production, the need for this growth to stimulate positive dynamics in the global economy, and the limited availability of global markets as one of the main factors driving these growing global fluctuations. This study analyzes a wide range of phenomena, problems, and contradictions associated with the limited availability of global markets, which are factors in global turbulence. By examining the problem of limited availability of markets and the contradictions generated by this problem, such as the confrontation between national and supranational development institutions, the conflict between national interests and the interests of transnational corporations, and others, the article analyzes possible scenarios for changes in the world order and the global economy.

**Keywords:** economic contradictions, geoeconomics, macroeconomic instability, capital consolidation, global turbulence, global economy, geopolitics, post-industrial development, sales markets.

**Introduction**

Economic instability across the globe, the increasing frequency of crises in the global economy, the intensifying competition for markets, and the challenges of finding new ways to improve the profitability of global business—all of this, in our view, is a sign of large-scale changes in the global economy.

Growing turbulence, defined by a wide range of researchers, is characterized by the fact that familiar fluctuations in the system are replaced by anomalies: established structures are shaken, new processes are unfolding, results become short-lived, and the system enters a period of prolonged disequilibrium. Regularities disappear [1], nonlinear processes predominate, events become chaotic and unpredictable, abrupt trend changes occur, and conflict increases [2]. The fluctuations that have arisen in the modern global system, with its permanent or periodically recurring instability, ambivalence, and uncertainty of processes, are partially controlled by the actions of individual actors in global politics [3].

The current global turbulence is caused by a number of factors, both political and economic. In this study, we intend to focus on the economic aspect of the problem and identify the factors that have led to the current global turbulence. We note from the outset that some of these factors are quite closely interconnected, but in our view, they are independent factors, each with its own actors pursuing their own interests.

**Discussion**

**Limited sales markets as a factor in global fluctuations**

One of the main factors of turbulence in the global economy, in our opinion, is the existing contradiction between potential production capacity and limited markets. Economic development in its current form, the capitalist model, requires unrelenting growth in sales, production, and consumption, while markets are limited by the size of our planet, the number of consumers, their income, and the structure of income distribution among different population groups. On the other hand, it is precisely the desire to resolve this contradiction that drives global economic development. Moreover, limited markets fit within the "full world" concept developed by Herman Daly and actively used in the Club of Rome's landmark report "Forward! Capitalism, Myopia, Population, and Planetary Destruction" [4].

It should be noted that the contradiction between increased production and limited markets has existed for as long as capitalism itself. However, its resolution is only possible through a transformation of the global economy and a change in its basic development model. Despite this, the capitalist model of economic organization has existed for centuries. The reason for this longevity is a series of large-scale events that effectively, albeit temporarily, resolved the problem of limited markets. One such event was the Great Geographical Discoveries, which provided Europe with a large-scale colonial source of cheap resources and a market that Eu-

European companies had long exploited under monopolistic conditions. The economic impetus of the Great Geographical Discoveries lasted for quite a long time – over 300 years. Its echoes are still evident today. Furthermore, the First Industrial Revolution contributed to the growth of the global market.

However, over time, the influence of these impulses faded, resulting in recurring economic crises every 7-10 years (1847, 1857, 1866, 1873, 1882, 1890, 1900, 1907, 1920, 1929) [5]. These crises occurred despite rising labor productivity and, correspondingly, a certain increase in global market capacity under the influence of the Second Industrial Revolution.

The accumulation of negative energy from these crises, resulting in a whole host of economic, political, and social problems, led to wars, the collapse of empires, the emergence of new states, and new markets. World wars also became a powerful economic impetus for global economic development. They required significant production of military equipment and supplies, destroyed significant resources, and necessitated the reconstruction of vast territories whose economies and infrastructure had been devastated by military action. All of this, taken together, significantly stimulated demand, production, employment, income growth, and consumption.

The post-war recovery of the global economy was compounded by the need to resolve the Condorcet-Arrow paradox—the difficulty, and often the impossibility, of making a choice through free voting. In the global economy, such voting refers to free trade, while the paradox refers to the question of which goods corporations should produce in a highly polarized society: for the poor or for the rich? The solution to this paradox was the formation of a sufficiently large middle class, demanding a specific range of goods. Moreover, the need to form a middle class forced major capital owners to share their incomes with their employees to a greater extent, which also became a reserve for increasing the efficiency of the global economy. The increase in the number of middle class members made it possible to homogenize demand and, consequently, standardize most of the economic sectors serving the needs of the middle class. This, in turn, facilitated the implementation of national economic strategy through state regulation.

However, like any other impetus, the economic boost provided to the global economy by two wars and the Third Industrial Revolution, better known as the Scientific and Technical Revolution, began to wane, and quite quickly. The first crisis, which engulfed several countries, including the United States, Canada, Great Britain, and Belgium, occurred as early as 1957–1958. Eleven years later, the next economic crisis (1969–1970) erupted. It was followed by the overproduction crisis of 1973. Seven years later, the global economic crisis of 1980–1982. Eight years later, the crisis of 1990–1992. Regular crises once again became a hallmark of capitalist economies.

But then an event occurred that allowed the solution to some of the problems associated with market limitations to be postponed: the collapse of the USSR. The knowledge, resources, and technologies accumulated in the USSR were absorbed into the global economy at virtually no cost. And the former Soviet bloc became a massive market for Western products. The world ceased to be bipolar. The center of civilization has become a conglomerate of developed countries, conventionally designated as the "West," although this group includes countries such as Australia, Japan, and Taiwan. Some researchers even thought that the times of confrontation and contradiction had come to an end. For example, F. Fukuyama expressed similar aspirations in his bestseller, *The End of History* [6].

However, further developments demonstrated that the problems of the era of global confrontation have been replaced by new ones, and their nature is such that they persist for years without a clear solution. The world has entered a period of global uncertainty, or global turbulence—a state in which it is extremely difficult for political actors to make a clear decision, and for economic actors to build a long-term development strategy.

It should be noted that the contradiction between unlimited production growth and limited sales markets can be resolved from both ends: on the one hand, by expanding sales markets, including geographically, and on the other, from the production side, by combating competing producers, including by securing access to new, cheap sources of resources—materials, minerals, and skilled and affordable labor. This is precisely what we are currently witnessing in the fierce struggle for control of Ukraine's resources and, if the outcome is favorable for the developed countries, for Russia's resources. At the same time, the US and UK are quite successfully pursuing the goal of economically weakening continental Europe by depriving it of cheap energy.

#### **Consolidation of international capital**

Another highly significant economic factor in global turbulence, much less visible to the general public, is the large-scale consolidation of global capital. This manifests itself, in particular, through the shareholder control of the world's largest corporations by a small group of transnational financial holdings (see Table 1).

**Table 1.** Share of financial holdings in the share capital of the largest TNCs as of 2024

Company	Shareholder, %			
	Black Rock	Vanguard	State Street	Bcero
Bank of America	6,87	8,65	3,88	19,4
Apple	7,48	9,29	3,96	20,73
Amazon.com	6,5	7,77	3,44	17,71
Microsoft	7,75	9,2	3,97	20,92
Meta	7,52	8,73	3,93	20,18
Alphabet	6,51	7,31	3,41	17,23
JPMorganChase	7,39	9,74	4,55	21,68
WellsFargo	7,82	9,18	4,32	21,32
Citigroup	8,69	8,83	4,43	21,95
MorganStanley	5,9	6,83	6,9	19,63
Chevron	6,91	8,92	8,5	24,33
ConocoPhillips	8,1	9,57	5,79	23,46
Tesla	6,29	7,56	3,49	17,34
Raytheon	7,42	8,89	8,48	24,79
NorthropGrumman	7,43	8,76	9,46	25,65
Mcdonald's	7,33	9,82	4,97	22,12
BerkshireHathaway	8,25	11,06	5,36	24,67
Johnson&Johnson	8,36	9,67	5,58	23,61
Walmart	4,19	5,26	2,29	11,74

Compiled from: Yahoo finance. World Indices // Yahoo finance. <http://finance.yahoo.com/> (accessed: 23.08.2025).

At the same time, the global transnational financial holdings themselves are quite closely intertwined (see Table 2).

**Table 2.** Share of the analyzed financial holdings in each other's share capital as of 2024.

Company	Shareholder, %		
	Black Rock	Vanguard	State Street
BlackRock	6,47	8,62	4,06
Vanguard	7,64	5,61	1,15
StateStreet	8,74	12,88	4,89

Source: Yahoo Finance. <https://finance.yahoo.com>

This intertwining of equity investments allows each financial multinational to send its representatives to the boards of directors of other financial multinationals. This "cross-pollination" allows the multinationals to avoid competition, acting as a united front and creating a situation closer to a monopoly than an oligopoly in the global market for large investments. This consolidation alleviates the problem of limited markets for a small group of beneficiaries, transferring control over the most profitable areas of the global economy to them.

More detailed studies of the connections of a wide range of global companies through their equity capital, confirming this conclusion, were conducted by the Swiss mathematician James Glattfelder, who used methods of network analysis and complex systems theory. His work showed that control over significant parts of the global economy is concentrated in the hands of a small group of legal entities and individuals forming a dense network of relationships: 737 shareholders control 80% of the value of all global TNCs, while 150 shareholders control 40% of the property of global TNCs [7]. These facts indicate a large-scale and increasing corporate concentration of the global economy.

#### **The conflict between international corporate and national interests**

By geographically expanding their sales markets, TNCs entering a given country initially strengthen their economic influence there. They then seek to convert this economic influence into political influence, shifting the country's political system from protecting national interests to serving the interests of TNCs [8]. Let us quote S.R. Ibrahimov on the influence of TNCs on national economies: "Through foreign direct investment, TNCs introduce new technologies and increase labor productivity. However, the population is unable to benefit from these results, since these companies permanently displace local producers, becoming monopolies. By shifting the bulk of their profits abroad, they deprive countries of the opportunity to increase their national well-being" [8]. Thus, by establishing monopoly power, TNCs subordinate an additional sales market to their influence, ignoring the national interests of that market.

It should be noted that the activities of TNCs in the modern economy do not exclusively generate negative impulses that contribute to the growth of global turbulence. Thus, Alfred Chandler highlights the economies of scale among the advantages of TNC development, according to which the growth of production volumes to a certain level leads to the distribution of relatively fixed costs over an increasing number of units of output. As a result, the cost of production per unit of output decreases. Chandler also points out that by expanding the geographic scope of their activities, TNCs distribute risks across different markets and countries,

reducing their dependence on a single territory or economic sector. Companies gain access to the latest scientific developments and best practices by opening branches and divisions in countries with developed scientific and technological potential. The activities of TNCs, based on the growth of business scale, require the development of effective management structures and tools for planning, analysis, and control that extend throughout the economy. Transnational corporations create recognizable brands that attract consumers in different regions of the world, ensuring stable demand and customer loyalty. International activity allows TNCs to respond more quickly to market changes and develop new sales markets. The development of an international network of branches and divisions helps mitigate the effects of economic crises, political instability, and changes in the legislation of individual countries [9]. Thus, the activities of transnational corporations, aimed at increasing their influence and, accordingly, their income where possible, ignore national interests and act as a factor in global turbulence.

#### **The contradiction between national and supranational institutions**

Another economic factor driving global turbulence is the tension between national and supranational institutions. Market limitations create this tension, as in a struggling economy, resources to support a high standard of living for both national and supranational elites are becoming insufficient. Conditions for a struggle for resources are emerging, with national and supranational interests colliding.

Hungary, after arguing with the European Union over the rule of law, lost over €1 billion in EU aid. Using the levers of financial aid, the EU is attempting to influence Georgia's domestic politics. Lithuania, under pressure from the EU and initially experiencing energy shortages, agreed to close and dismantle the Ignalina Nuclear Power Plant, despite the fact that this decision led to an increase in electricity prices in Lithuania and was detrimental to the country's economic development [10]. It is also worth noting that, regardless of economic needs and rationale, EU bureaucrats are consolidating European countries under sanctions pressure on Russia. Supranational institutions are seeking to control the global economy by establishing their own, binding rules. These include, for example, the pandemic agreement and the European system of a single legal entity identifier (LEI), which allows for the identification of participants in financial transactions, and similar tools. This system was initially created to address straightforward objectives—combating money laundering and combating corruption.

#### **Confrontation between traditionalists and postmodernists in the field of Economic policy**

Another factor driving global fluctuations is the confrontation between traditionalists and postmodernists in economic policy. A striking example of this confrontation in modern times is the actions of Donald Trump, a traditionalist, and George Biden, a postmodernist. However, one of the first stages of this struggle between traditionalists and postmodernists was the Islamic Revolution in Iran in 1979. Traditionalism and postmodernism define two different approaches to economics, including two different approaches to resolving the contradiction associated with limited markets.

Traditionalists largely oppose excessive globalization and the integration of world markets. They support protectionist policies, restrictions on foreign investment, and support for domestic producers. The goal of this "neo-mercantilism" is to limit "leakages" from national economic growth associated with cross-border economic flows. Traditionalists do not always consider stimulating economic growth through transnational ties (see the losses suffered by American companies as a result of Donald Trump's tariff policy). The emphasis is on expanding markets by stimulating domestic consumption of national products and increasing export volumes. This effectively amounts to an economic redistribution of markets.

The BRICS countries, which actively support traditional values, on the one hand advocate for market integration, but on the other, have long been implementing strategies such as import substitution and a sovereign economy. It is worth noting that reliance on the country's domestic potential, strengthening its financial sovereignty, tightening control over foreign investment in strategic economic sectors, and other similar objectives more characteristic of economic traditionalism are outlined in the National Security Strategies of many BRICS countries.

According to the traditionalist approach, the state should play an active role in regulating the economy, supporting strategically important industries, and providing social protection to the population. This is manifested in increased control over domestic financial markets, fiscal policy, and intervention in business processes. Among other things, such behavior by foreign actors could create additional barriers to exports and intensify competition in the country's domestic market through the expansion of imports. It should be noted that the sanctions pressure imposed by Biden, a clear globalist and postmodernist, on some countries was certainly not shaped by a traditionalist strategy. It was designed to inflict a strategic defeat on these countries, with the goal of returning them to the conglomerate of transnational economic ties as a source of raw materials and a market. Trump's policy is more pragmatic and is primarily concerned not so much with sanctions pressure on the BRICS countries as with addressing the challenges of relocating production to the United States and



reducing the American economy's dependence on imports—that is, maintaining traditionalist positions. This is primarily explained by the fact that Trump represents the interests of national (American) capital, which is his electoral base, while Biden is a protégé and spokesman for the interests of transnational corporations.

The postmodern economy is largely characterized by the following features:

1) the emancipation of the economy from the state through increasing control of transnational corporations (TNCs) over national economies and the formation of a global financial market. This emancipation of the economy is accompanied by globalization, which erases national characteristics [11]. Almost every major city in the world features similar restaurants, stores with identical clothing, the same music, films, and so on. This economy counteracts the limited availability of markets by reducing production costs through economies of scale, but it also tends toward dehumanizing standardization. The emancipation of the economy from the state, imposed by foreign actors, poses a threat to Russia, as foreign TNCs are focused on actively suppressing domestic competitors. Even before sanctions, they were not interested in developing modern production technologies in Russia, as the creation of an additional competitor in the form of Russia would exacerbate the problem of limited markets for such TNCs;

2) the artificial creation of differences. Depersonalizing standardization does not promote the growth of consumption necessary to expand markets. The current situation in the global economy was well characterized by M. Orucov: “The main challenge is the exhaustion of the modern type of economic management, capitalism, based primarily on profit, and for this purpose, the unbridled consumption of goods and services is encouraged in every possible way...” [12].

It is precisely for this purpose that the artificial creation of differences is stimulated – from the irrational invention of new human genders to the constant rapid and accelerated release of new collections of gadgets and clothing, making older collections unfashionable and requiring consumers to replace them with new ones. This approach largely leads to the intellectual foundation of the postmodern economy becoming less and less morally constrained. There is a “narrowing of the scope of one's own moral high ground” [13]. Largely fictitious differences in self-identification, differences in the ability to demonstrate one's status through conspicuous consumption, contribute to the atomization of society and the fact that the economy is no longer “a direct part of society, ensuring its vital functions; it... becomes an independent and self-sufficient system, with its own goals, dynamics, and results” [13].

By spreading the above, foreign actors are capable of exerting a negative impact on various spheres of the Russian economy – from demography to lending.

3) Simulation of post-industrial development. The emerging postmodern economy is largely based on 20th-century technologies. Internal combustion engines, microelectronics, and spacecraft are all being modernized, but large-scale technological breakthroughs similar to those of the early 20th century that dramatically stimulated global economic growth are absent. Peter Thiel, founder of Palantir Technologies, specifically addresses this in an interview, lamenting that the apogee of technological development was Concord and the Apollo missions. According to Thiel, in the current situation, humans as creators of new technologies must be replaced by artificial intelligence.<sup>6</sup> In turn, new technologies created by AI, like internal combustion engines and microelectronics, are expected to stimulate new waves of global demand, income growth, and higher profit margins, which could temporarily put the contradictions associated with limited sales markets into a dormant state.

But isn't the reliance on artificial intelligence (AI), with its learning recursion problem, overstated? Indeed, the increasing volume of information generated by AI leads to subsequent versions of AI being trained on data generated by previous versions, accumulating errors. For example, according to the Massachusetts Institute of Technology, business projects using artificial intelligence fail for 95% of private enterprises.<sup>7</sup> It's also worth noting that reliance on artificial intelligence can degrade the competencies of specialists. For example, a study conducted by the Lancet journal shows that doctors, after several months of using AI in their practice, lose their ability to independently diagnose cancer.<sup>8</sup> The deterioration of specialists' competencies as a long-term result of delegating some of their skills to artificial intelligence can reduce the efficiency of the economy. Furthermore, AI errors (as a “last resort”), including those related to the problem of learning recursion, can worsen this situation, which, to resolve these problems, will require additional, but for objective reasons impossible, expansion of sales markets. A similar effect is associated with the inefficient use of resources to implement AI in various companies.

The struggle between traditionalists and postmodernists is manifesting itself in a specific struggle between national elites (prominent representatives include Donald Trump) and transnational bureaucracies (prominent representatives include Klaus Schwab, the EU authorities, etc.). For the general public, this is clearly expressed in the persistent promotion of gender issues, mass migration, and the use of movements like BLM to achieve political goals [14]. This also includes the tariff war unleashed by Donald Trump, which seeks



to reshape the global economy in the interests of the United States, even at the cost of inflation and the severing of established economic ties. In such a situation, economics becomes a weapon.

The limited nature of global markets, coupled with the impossibility of their rapid expansion, highlights the redistribution of these markets by key actors operating within both traditionalist and postmodern frameworks. This exacerbates global conflicts, increasing turbulence in the global economy. A striking example of the above is the conflict in Ukraine, in which the collective West clearly supports one of the sides in the hope of expanding its economic advantages after the conflict ends.

#### **Restricting freedoms as a response to increasing turbulence**

It should be noted that we view restrictions on freedoms primarily as a response to increasing turbulence, intended to stabilize the situation by somewhat "freezing" social activity. However, in the near future, this response could transform into a factor in turbulence due to growing social discontent in developed countries.

One of the consequences and significant signs of growing contradictions and increasing global turbulence is the shrinking middle class. The problem of limited markets is driving a downward trend in the rate of profit in certain sectors of the economy, illustrated, in particular, by the dynamics of the price index for individual goods. As an example, consider the clothing price index in the US, which has remained unchanged for the past 30 years (see Figure 1).

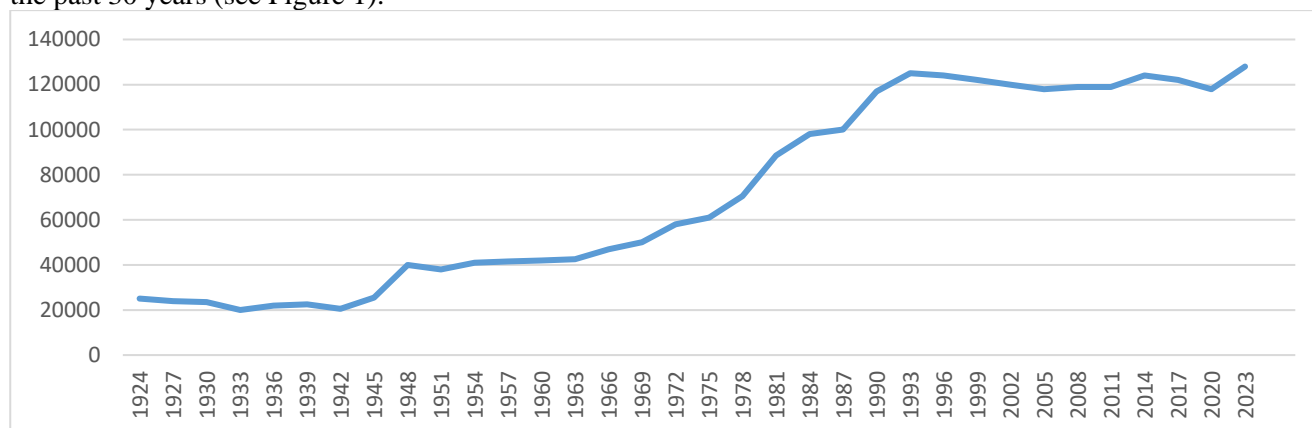


Fig. 1. US clothing price index, in nominal terms (1982–1984 = 100)

Source: Apparel priced at \$810 in 1924, \$3,888 in 2025 // In 2013 dollars. [https:// www.in2013dollars.com/Apparel/price-inflation/1924?amount=810](https://www.in2013dollars.com/Apparel/price-inflation/1924?amount=810) (accessed: 04.11.2025).

Global competition accelerates the decline in prices of goods and the subsequent decline in profit margins for their producers. However, the situation is somewhat different in the service sector, as services are provided locally and are less dependent on global competition. In the US economy analyzed, the cost of healthcare services increased by 256% between 2000 and 2024. College tuition increased by 188%. Childcare prices increased by 139%. Moreover, wages in the US have increased by 68% since 2000. The price of new cars increased by 24.3% during this period. The cost of cellular communications decreased by 41.6%. The cost of computer software decreased by 73.5%. The cost of toys decreased by 73.8%. The cost of televisions decreased by 97.9%.<sup>9</sup>

It is also worth noting the negative multiplier effect of declining profit margins in some sectors of the economy on revenue and, consequently, profit margins in other sectors. For example, declining profit margins at European automakers reduce their demand for steel, aluminum alloys, plastic, and glass. This, in turn, reduces sales volumes for European manufacturers of these auto components, which lowers their profit margins through both operating leverage and the discount mechanism designed to counteract the decline in sales. Also noteworthy is the decline in demand for labor at all these enterprises, resulting in lower labor incomes and demand for consumer goods, which, in turn, negatively impacts sales volumes and profit margins for a wide range of manufacturers of these goods.

Slower economic growth and declining profit margins (especially in real terms) all have a negative impact on the well-being of the population. New sources of profit, generating profit for a limited period of time, are typically monopolized by capital owners. The result is a shrinking middle class, which is both a consequence of the unresolved problem of limited markets and a characteristic of increasing global turbulence. For example, in the United States, the total wealth of the top 1% of citizens currently exceeds the total wealth of the entire middle class in the country (see Fig. 2).

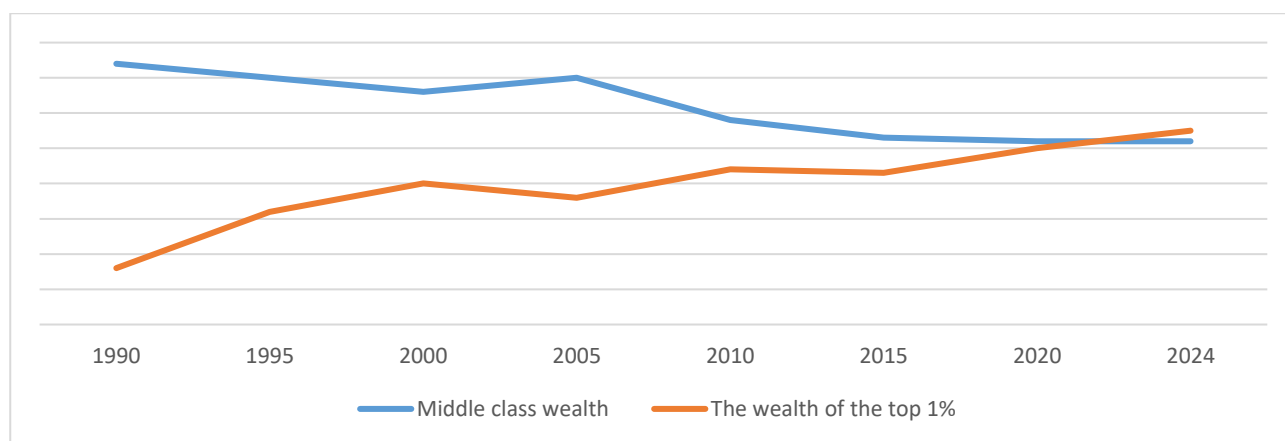


Fig. 2. Share of total household wealth in the US, % (Q2 of the current year compared to Q2 of the previous year)

Source: *Wealth by wealth percentile group* // Website of the Board of Governors of the US Federal Reserve System. <https://www.federalreserve.gov/releases/z1/dataviz/dfa/distributed/chart/> (accessed: August 23, 2025).

A decline in prosperity and a decline in living standards all contribute to public discontent, increasing the state's need to control society. One of the key events of this kind, which led to serious consequences, was September 11, 2001, when the response to the terrorist attacks was a significant restriction of American public freedoms (see, for example, the Patriot Act). Increased security requirements at all levels, additional checks, additional spending, as well as restrictions on freedoms—all of this, to a certain extent, became a brake on the American and global economy. The additional large-scale expenditures associated with these measures contributed to the formation of budget deficits in a number of countries and increased state participation in the economy.

This applies primarily to the United States, but many European countries have also followed a similar path, resulting in an additional slowdown in their economies, requiring additional budgetary stimulus, which provokes inflation [15]. A visible, but not fully understood by the general public, phenomenon of the present time is the active use of digital tools to strengthen control over the population as tools to counteract mass discontent with the deterioration of living standards – from “social rating” systems to the introduction of centralized digital currencies.

#### **The ambivalent position of the People's Republic of China**

Recently, the role of Asia-Pacific countries has been growing both economically and politically, exerting a positive influence on delaying the realization of contradictions related to limited markets. However, one of the driving forces of the global economy – China – is experiencing crisis phenomena related to demographic and environmental issues. Researchers are documenting a situation in which China has reached the peak of its power, and its further development is becoming problematic. This opinion is shared, for example, by Nobel laureate Peter Krugman, who expresses it in an article with the eloquent title “Stagnation with Chinese Characteristics” [16].

Limited technological transfer from the United States, coupled with the underdevelopment of its own fundamental science compared to the collective West, make China's prospects uncertain. Despite China's clear achievements in applied science and engineering, where it often surpasses even developed countries, its achievements in basic research are significantly inferior to its success in applied fields. This is well understood by the country's leadership—for this reason, back in 2023, Xi Jinping published an article entitled “Strengthening Basic Research to Achieve High-Level Scientific and Technological Self-Reliance and Self-Enhancement”<sup>12</sup>. This article addresses the need to develop its own sovereign fundamental, rather than applied, science, so that China can base its applied solutions on its own achievements, overcoming its dependence on the West.

It should be noted that, as recent history shows, this task cannot be accomplished within a short period of time. A similar challenge faced the leadership of Japan, which demonstrated remarkable success in applied science in the 1960s–1980s, building on the achievements of Western fundamental science. Attempts to build its own fundamental science have so far been unsuccessful. It took Europe centuries to achieve this, as cutting-edge science requires the creation of a special environment and the development of scientific schools. In any case, this is a very slow process.

It should be noted that within the global market, China is both a major supplier of goods to this market and a major consumer of resources, technology, and, more recently, finished goods. Consequently, not only a

major economic crisis but also a sustained slowdown in China's economic growth will negatively contribute to the exacerbation of global contradictions related to limited sales markets. Added to this is China's debt problem. According to IMF estimates, the credit-driven growth of the Chinese economy has led to the following results: Municipal debt related to infrastructure development accounts for 48% of GDP, or 60 trillion yuan. But this is only a portion of China's regional debt. Direct regional debt (40 trillion yuan) should be added to this. Local Chinese authorities are paying off and servicing these debts through new debt borrowings—bond issuances, the volume of which is increasing (see Figure 3).

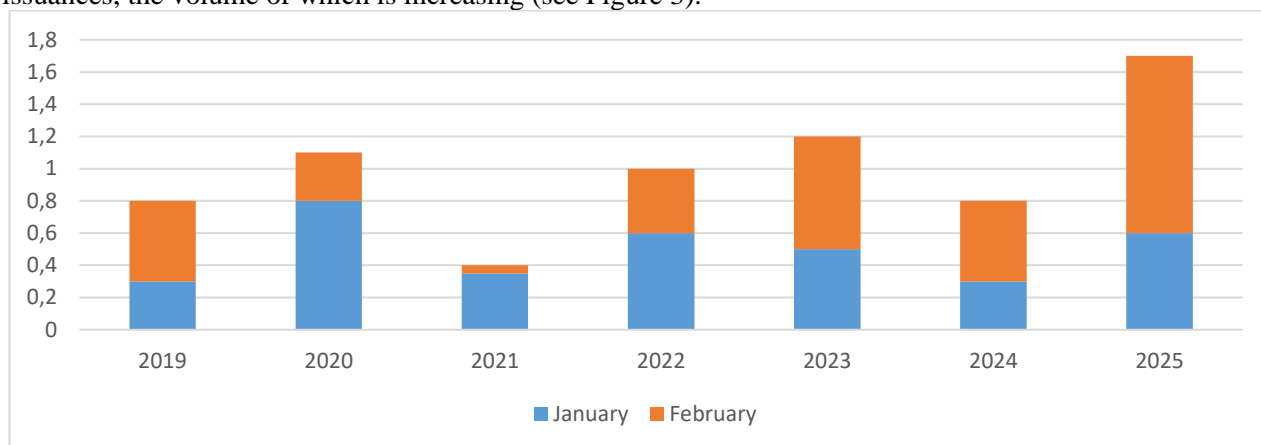


Fig. 3. Dynamics of bond issuance by local governments in China

*Note: Data as of February 21, 2026. Source: China's Local Government Bond Rush Worsens Liquidity Strain // Bloomberg. <https://www.bloomberg.com/news/articles/2026-02-23/china-s-local-government-bond-rush-worsens-liquidity-strain> (accessed August 23, 2026).*

At the same time, according to Fitch forecasts, China's public debt (the sum of local and central government debt) could rise to 68.3% of GDP in 2025, from 60.9% in 2024 and 37.9% in 2019.<sup>14</sup> The worsening debt burden of the Chinese economy could have a negative impact on both its production and consumption volumes, reducing the size of this sector of the global market, thereby exacerbating the overall problem of limited sales markets. It is worth noting that, unlike the US, the Chinese currency is not freely convertible, which prevents China from shifting its debt problems onto the rest of the world to the same extent as the US does by increasing its dollar-denominated external debt.

China is one of the main players in the global market and global economy. Despite China's obvious desire to become one of the world's poles, it still does not abandon cooperation with the West. Following tariff disagreements with the US, it has shown increased interest in the European Union. There is still no clear answer to the question of whether China will pursue a path of self-sustainability, focusing its foreign economic relations on the Asia-Pacific region, or whether it will focus on continued cooperation with the West, which once fueled China's transformation from a backward country into a modern China. There is also no clear answer to the question of China's future development or the degree of resilience of the Chinese economy. This uncertainty is one of the factors contributing to increasing global turbulence.

### Conclusion

Each of the above phenomena, factors, contradictions, and trends impacts the global economy, individually or in combination, creating a synergistic effect. The current global economic model is no longer sustainable. A new model is unknown, and the paths for transforming the current model into a new one are undefined, but such a transformation is long overdue.

Since the number of influencing factors is so large, and the number of their combinations is even greater, predicting the future trajectory of the global economic system is extremely difficult. Throughout history, the Gordian knot of insoluble contradictions was usually cut with the sword, i.e., the contradictions were resolved by war. But modern weapons are such that in the event of war, all problems would disappear—along with our civilization, and perhaps even the entire human species. Therefore, beyond this dire scenario, two possible scenarios for changes in the world order and the global economy are theoretically possible, which could temporarily reduce the severity of global turbulence.

The first scenario for changing the world order and global economy, in our view, is associated with a return to a bipolar model based on North–South in the broad sense and the United States–China in the narrow sense. These two major countries could become politically and economically "encapsulated," with a desire to interact only within their own bloc, restricting their controlled markets from foreign influence. Something similar occurred during the Cold War, but today, thanks to information technology, intra-bloc cooperation could be more effective than in the past. A new non-aligned movement will emerge, and blocs will struggle

for increased influence in the Third World (including a struggle for control over the markets of these countries). It cannot be ruled out that, as a result of this bloc confrontation, new centers of economic and political concentration will emerge, and the world will become multipolar, moving away from the bipolar model. A new globalization has emerged, but not from a position of superiority and dominance, but from a position of taking into account historical, political, ideological, religious, ethnic, and other particularities. Then, the global turbulence of today could enter a latent phase.

Since a multipolar world will have its own architecture, the emergence of new connections between the poles, and possibly accelerated development, will lead to increased production of goods and services, accompanied by a simultaneous rise in effective demand. This development, which reduces the severity of global fluctuations, could continue for quite some time – until a new tangle of contradictions emerges.

A second possible scenario for global economic change, counteracting turbulence, is linked to technological progress. Two future technologies exist, each capable of transforming the daily life and existence of every inhabitant of the Earth, permanently resolving the fundamental contradictions associated with limited markets. These technologies are controlled thermonuclear fusion and quantum computing. Experts are finding it difficult to estimate the timeframe separating us from the advent of a commercial thermonuclear facility, although a positive energy balance was recently achieved at an experimental thermonuclear facility in the United States. A quantum computer, according to conservative estimates, will appear in 30–40 years, although the first commercial applications of quantum computing are a matter of the next decade.<sup>15</sup> We are talking about the 1960s–1980s, when the Fourth Industrial Revolution will likely occur. After all, industrial revolutions occurred precisely in the 1960s–1980s of the last three centuries. However, we are not proponents of numerology.

While the vector of change with industrial thermonuclear fusion is fairly clear and has a clearly defined energy focus, the commercial applications of quantum computing have a multi-vector focus. Their applications in pharmaceuticals and the new materials industry are obvious.<sup>16</sup> Quantum computing will be used in modern digital technologies such as artificial intelligence, Big Data, the Internet of Things, neural networks, and neural interfaces. At the same time, the capabilities of existing technologies will increase exponentially and, most likely, will transition to a new quality. As with microelectronics, a vast array of new goods and services will emerge, their production volumes will increase, stimulating the incomes of workers and their effective demand. This will expand the overall capacity of markets and temporarily overcome their limitations, thereby counteracting the growing global turbulence.

As for Azerbaijan, in the current situation, its task is to reap the benefits of globalization, for example, by generating revenue from hydrocarbon exports, while shaping its economy based on traditionalist principles. Based on this, Azerbaijan needs to invest in the exploration of new hydrocarbon deposits with high recovery rates and develop the non-oil sector of the economy. Economics and seek ways to reduce the cost of hydrocarbon production. This will allow our country to secure the necessary funds for the development of new technologies capable of creating new global markets and, most importantly, to establish and expand production using these technologies globally, as national control over production standards means national control over the markets for products manufactured according to these standards, even if some of these products are produced outside the country. This approach is primarily aimed not at integrating Azerbaijan into competition in existing, limited markets with a large number of established, technologically advanced manufacturers, but at identifying new, promising markets emerging from new technologies and establishing a dominant position in these markets before competitors from other countries enter. Implementing this approach in practice is extremely complex, but it will allow Azerbaijan to significantly reduce its technological gap with Western countries and China.

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**PROSPECTS FOR THE APPLICATION OF BLOCKCHAIN TECHNOLOGY IN ACCOUNTING**

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**ПЕРСПЕКТИВЫ ПРИМЕНЕНИЯ ТЕХНОЛОГИИ БЛОКЧЕЙН В БУХГАЛТЕРСКОМ УЧЕТЕ**

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**Abstract**

In the context of the digital transformation of the economy, the introduction of modern information technologies into accounting systems is becoming increasingly important. One of the most promising technologies is blockchain, which represents a distributed data ledger that ensures a high level of transparency, reliability, and security of information. The article examines the main directions of blockchain technology application in accounting and analyzes its potential advantages for improving the efficiency of accounting processes. Particular attention is paid to the possibilities of automating accounting procedures, increasing the reliability of financial information, and reducing the risk of fraud. In addition, the existing limitations and challenges associated with the implementation of blockchain technologies in accounting practice are considered. The study concludes that blockchain has significant potential for the development of digital accounting infrastructure and the formation of a more transparent and reliable financial reporting system.

**Аннотация**

В условиях цифровой трансформации экономики особую актуальность приобретает внедрение современных информационных технологий в систему бухгалтерского учета. Одной из наиболее перспективных технологий является блокчейн, представляющий собой распределенный реестр данных, обеспечивающий высокий уровень прозрачности, надежности и защищенности информации. В статье рассматриваются основные направления применения технологии блокчейн в бухгалтерском учете, а также анализируются ее потенциальные преимущества для повышения эффективности учетных процессов. Особое внимание уделяется возможностям автоматизации учета, повышению достоверности финансовой информации и снижению риска мошенничества. Кроме того, рассматриваются существующие ограничения и проблемы внедрения блокчейн технологий в практику бухгалтерского учета. В результате исследования сделан вывод о значительном потенциале использования блокчейна в развитии цифровой инфраструктуры бухгалтерского учета и формировании более прозрачной и надежной системы финансовой отчетности.

**Keywords:** blockchain, accounting, accounting digitalization, financial reporting, smart contracts, information technologies, digital transformation.

**Ключевые слова:** блокчейн, бухгалтерский учет, цифровизация учета, финансовая отчетность, смарт-контракты, информационные технологии, цифровая трансформация.

Современный этап развития мировой экономики характеризуется активным внедрением цифровых технологий в различные сферы деятельности, включая систему бухгалтерского учета. Развитие информационных технологий, автоматизация бизнес-процессов и рост объемов обрабатываемых данных формируют новые требования к организации учета и подготовке финансовой отчетности. В условиях цифровой экономики традиционные методы ведения бухгалтерского учета постепенно трансформируются, уступая место цифровым платформам, облачным решениям и интеллектуальным информационным системам.

Цифровизация бухгалтерского учета предполагает использование современных информационных технологий для автоматизации учетных процессов, обработки финансовых данных и повышения

эффективности управления финансовой информацией. В последние годы особое внимание уделяется таким технологиям, как искусственный интеллект, роботизация бизнес-процессов (RPA), большие данные и блокчейн. Их внедрение позволяет существенно повысить скорость обработки информации, снизить вероятность ошибок и обеспечить более высокий уровень прозрачности финансовых операций [1].

Одной из наиболее перспективных технологий, оказывающих влияние на развитие бухгалтерского учета, является блокчейн. Данная технология представляет собой распределенный реестр данных, в котором информация о транзакциях хранится в виде последовательной цепочки блоков и защищена с использованием криптографических методов. Благодаря децентрализованному характеру хранения данных блокчейн обеспечивает высокий уровень надежности, прозрачности и неизменяемости учетной информации.

Современные исследования показывают, что применение блокчейн технологии способно существенно изменить традиционную модель ведения бухгалтерского учета. Использование распределенного реестра позволяет фиксировать финансовые операции в режиме реального времени и обеспечивает возможность одновременного доступа к информации для различных участников экономических отношений. Это способствует повышению доверия к финансовой отчетности и снижению рисков манипулирования учетными данными [2].

Кроме того, внедрение блокчейн технологии создает предпосылки для дальнейшего развития цифровой инфраструктуры бухгалтерского учета, включая автоматизацию учетных процедур с использованием смарт-контрактов и формирование новых подходов к организации финансовой отчетности. В связи с этим исследование возможностей применения блокчейна в бухгалтерском учете представляет значительный научный и практический интерес.

Технология блокчейн представляет собой распределенную базу данных, в которой информация о транзакциях хранится в виде последовательной цепочки блоков, связанных между собой с использованием криптографических методов. Каждый новый блок содержит сведения о проведенных операциях, а также криптографическую ссылку на предыдущий блок, что обеспечивает целостность и неизменяемость всей системы данных.

Основной особенностью блокчейна является использование распределенного реестра (Distributed Ledger Technology, DLT), при котором информация хранится одновременно на множестве узлов сети. В отличие от традиционных централизованных баз данных, управление системой осуществляется не одним центральным оператором, а всеми участниками сети, что повышает уровень надежности и прозрачности хранения информации [3].

Процесс функционирования блокчейн системы включает несколько последовательных этапов. Сначала формируется транзакция, содержащая информацию о совершаемой операции. Далее транзакция передается участникам сети для проверки и подтверждения. После подтверждения данные объединяются в блок, который добавляется к существующей цепочке блоков и становится частью распределенного реестра. Благодаря криптографической защите и механизму консенсуса изменение ранее записанных данных становится практически невозможным.

На рисунке 1 показан механизм работы блокчейн технологии.

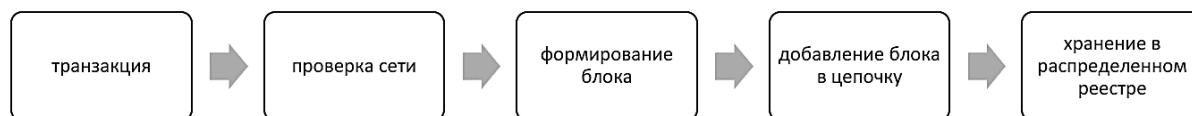


Рисунок 1 – Принцип функционирования блокчейн технологии

В современных научных исследованиях также отмечается, что применение блокчейн-технологии способствует повышению достоверности финансовых данных и снижению рисков несанкционированного изменения информации. Использование распределенных реестров позволяет повысить прозрачность финансовых операций и упростить процессы контроля и аудита, что способствует формированию более надежной системы финансовой отчетности [4].

Использование распределенного реестра позволяет фиксировать хозяйственные операции в единой цифровой системе, доступной для всех участников экономических отношений, что снижает вероятность искажения данных и повышает уровень доверия к финансовой отчетности.

Одним из перспективных направлений использования блокчейн технологии является концепция тройной бухгалтерской записи (triple-entry accounting). В отличие от традиционной системы двойной

записи, при использовании блокчейна каждая хозяйственная операция фиксируется не только в учетных регистрах сторон сделки, но и в распределенном реестре, что обеспечивает дополнительный уровень подтверждения и проверки данных.

Кроме того, важную роль в развитии цифрового бухгалтерского учета играют смарт-контракты. Смарт-контракт представляет собой программный алгоритм, автоматически исполняющий условия договора при наступлении определенных событий. Использование смарт-контрактов позволяет автоматизировать выполнение финансовых операций, снизить административные издержки и минимизировать влияние человеческого фактора на учетные процессы.

В таблице 1 сведены основные характеристики направлений применения технологии блокчейн в бухгалтерском учёте.

Таблица 1 – Основные направления применения блокчейн-технологии в бухгалтерском учете

№	Направление применения	Характеристика
1.	Фиксация финансовых операций	хранение информации о транзакциях в распределенном реестре
2.	Повышение прозрачности учета	доступ участников к единой базе данных
3.	Автоматизация операций	использование смарт-контрактов
4.	Повышение достоверности отчетности	невозможность изменения ранее записанных данных

Вместе с тем применение блокчейн технологии в бухгалтерском учете связано с рядом ограничений. К числу основных проблем относятся высокая стоимость внедрения, сложность интеграции блокчейн решений с существующими учетными системами, а также недостаточная разработанность нормативно-правового регулирования использования данной технологии в финансовой сфере [5].

Несмотря на существующие ограничения, многие исследователи отмечают значительный потенциал использования блокчейн технологии в системе бухгалтерского учета. Распределенные реестры позволяют обеспечить более высокий уровень прозрачности финансовых операций, повысить достоверность учетной информации и сократить вероятность ошибок при обработке финансовых данных. Кроме того, внедрение блокчейна способствует формированию единого информационного пространства, в котором данные о хозяйственных операциях могут быть доступны всем заинтересованным участникам.

Развитие цифровой экономики и распространение информационных технологий создают предпосылки для более широкого использования блокчейн технологии в учетной практике. В перспективе возможна интеграция блокчейна с другими цифровыми технологиями, такими как искусственный интеллект, большие данные и облачные платформы, что позволит значительно повысить эффективность обработки финансовой информации и автоматизировать значительную часть учетных процедур.

Таким образом, применение технологии блокчейн в бухгалтерском учете является одним из перспективных направлений цифровой трансформации учетных систем. Использование распределенных реестров и смарт-контрактов позволяет повысить прозрачность финансовых операций, обеспечить надежность хранения данных и сформировать более достоверную систему финансовой отчетности.

Дальнейшее распространение блокчейн технологии в бухгалтерском учете будет зависеть от развития нормативно-правовой базы, совершенствования цифровой инфраструктуры и подготовки специалистов в области современных информационных технологий. В этих условиях исследование возможностей применения блокчейна в учетной практике сохраняет высокую научную и практическую актуальность.

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**MARKETING AND SOCIAL MEDIA**

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**Relevance:** Considering that civilization is developing day by day in the modern world, development in the fields of business and marketing requires a new approach.

In today's world, the internet is not only a source of information, but also determines the criteria for development. [1, p. 55]. The paper considers the importance of social networks as a marketing tool. The key reasons for their use are identified, the main advertising formats and current approaches to social media promotion are described. An active and engaged audience makes social media particularly attractive for companies looking to connect with their customers and increase brand awareness. These platforms unite millions of users around the world and are becoming not only a means of communication, but also a powerful marketing tool [4]. Social media gives marketers the opportunity not only to disseminate product information but also to collect important data on consumer preferences [3, p. 201]. This allows companies to more accurately tailor their offerings to audience needs and enhance brand influence. The most common formats include banner ads, contextual ads, and native publications. Another direction is special projects – promotions, competitions, quizzes, which involve the audience and help reach new user segments [2, p. 155].

**Aim to study:** This method involves planning the work to be done to increase economic efficiency and the appoint main role of SMM in development marketing.

**Results:** Social media is now central to companies' marketing strategies. They allow not only to promote products but also to build trusting relationships with the audience. Success in this environment is achieved not through intrusive advertising, but through engaging content, interaction, and user engagement in brand communication [5].

**Keywords:** social networks, marketing, advertising, the Internet.

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# **Medical sciences**

## **THE ROLE OF ARTIFICIAL INTELLIGENCE IN MODERN MEDICINE**

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**Relevance.** The medical field is a field that is constantly evolving and improving with the integration of new technologies. The application of modern approaches to protect human health and achieve high efficiency in the treatment of diseases is one of the main goals of doctors and researchers. Modern algorithms, such as deep neural networks (DNNs) and convolutional neural networks (CNNs), significantly increase the accuracy and speed of disease diagnosis by analyzing medical images such as X-ray, MRI, CT, and electron microscopy (EM). This not only improves the quality of medical services, but also contributes to the development of new treatment and prevention methods. In medical diagnostics, AI helps detect diseases such as cancer at an early stage through mammography, CT and MRI analyses. Algorithms can detect small tumors and abnormalities that may be missed by humans. Electron microscopy provides detailed images of cell and tissue structures at high resolution in medical diagnostics. AI can be used to accurately identify viruses, bacteria and cellular abnormalities by analyzing electron microscopy images. This is especially important in the investigation and treatment of infectious diseases. So, first of all, let us emphasize that medical robots equipped with artificial intelligence increase the accuracy of surgical operations: During microinvasive operations, robots can move with high precision and intervene without damaging tissues. It becomes easier to manage surgical processes and optimize results. The application of artificial intelligence in medicine has led to significant changes in the field of healthcare in recent years. The application of artificial intelligence in medicine has led to significant changes in the field of healthcare in recent years.

**Aim to study.** The main goal was to investigate the advantages and disadvantages of applying artificial intelligence in medicine.

**Materials and methods.** A comprehensive literature search was conducted across 8 databases: OVID MEDLINE, OVID Embase, OVID PsycINFO, EBSCO CINAHL Plus with Full Text, ProQuest Sociological Abstracts, ProQuest Philosopher's Index, ProQuest Advanced Technologies & Aerospace, and Wiley Cochrane Library.

**Results.** However, persistent concerns remain, including biases ingrained in AI algorithms, a lack of transparency in decision-making, potential compromises of patient data privacy, and safety risks associated with AI implementation in clinical settings. So we can say Artificial Intelligence plays mainly key roles in medicine, which aimed at improving accuracy, efficiency and patients outcomes. Helping AI analyzes databases it helped to detect diseases earlier and accurately. Also we can see some benefits also. For example: reduces diagnostic errors and supports clinicians decisions, enhances evidence-based medicine, saves time and improves consistency during research process.

**Conclusion.** Based on all the information, we can say that although some shortcomings of the method can be identified, the application of artificial intelligence in modern medicine is of great importance for more accurate diagnosis.

**Keywords.** Artificial intelligence, modern medicine, advantages and disadvantages.

**CANCER THERAPY-RELATED CARDIOTOXICITY: CLINICAL IMPLICATIONS, DIAGNOSTIC APPROACHES AND PREVENTION**

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**Abstract**

Cardiotoxicity is one of the most significant limiting factors in modern anticancer therapy, significantly impacting its safety and long-term outcomes. The increasing use of anthracyclines, targeted agents, and immune-mediated therapies increases the risk of myocardial dysfunction, arrhythmias, myocarditis, and other cardiovascular complications. Of particular clinical significance is the fact that cardiotoxic effects can manifest both during treatment and years after its completion. Improved early diagnostic methods enable the detection of early signs of myocardial damage and prompt adjustment of treatment strategies. Assessing individual risk factors, such as age, comorbidities, and cumulative doses of cardiotoxic drugs, is crucial. Advances in cardio-oncology and a multidisciplinary approach ensure more effective prevention and treatment of cardiac complications. Therefore, the problem of cardiotoxicity requires further research and the integration of cardiological strategies into oncology practice.

**Keywords:** oncology, cardiology, cardio-oncology, cardiotoxicity, cardiac complications, cardiovascular complications, cardiovascular disease, anticancer therapy, chemotherapy, radiotherapy, biomarkers, Cardio-miRNAs, cardiac risk factors.

In recent decades, oncology has experienced rapid progress, driven by the introduction of new classes of anticancer drugs, refined surgical approaches, and the development of radiation therapy and personalized medicine. These advances have significantly increased the life expectancy of patients with various forms of malignancy, and for many patients, cancer has become a chronic, potentially manageable condition. However, alongside the increased effectiveness of anticancer therapy, the problem of its adverse effects is becoming increasingly pressing, with cardiotoxicity being the key and most clinically significant. Cardiovascular damage caused by chemotherapy, targeted agents, immune drugs, and radiation exposure is now considered one of the most serious limitations to treatment effectiveness and a cause of decreased quality of life for surviving patients.

The relevance of cardiotoxicity research is driven by several factors. First, the number of cancer patients is steadily increasing worldwide due to increasing life expectancy and improved diagnostic methods. Secondly, modern therapy is becoming increasingly intensive and multi-component, increasing the risk of cumulative toxic effects on the myocardium. Thirdly, improved survival creates a new set of clinical challenges related to the long-term consequences of treatment, which manifest themselves years after remission. Cardiac complications are becoming one of the leading causes of late morbidity and mortality among cancer patients, making the problem interdisciplinary and requiring the collaboration of oncologists, cardiologists, rehabilitation specialists, and primary care physicians.

In clinical practice, cardiotoxicity manifests itself in a wide range of conditions – from subclinical reduction in myocardial contractility to severe chronic heart failure, arrhythmias, ischemia, arterial hypertension, and thromboembolic complications. Various drugs can cause myocarditis, vasculitis, conduction disturbances, pericarditis, and resistant hypertension, which often progresses rapidly and requires urgent diagnosis and treatment.

A separate area of research is the study of radiation therapy cardiotoxicity. Despite improvements in irradiation technologies and reductions in doses to critical structures, radiation-induced cardiac damage remains a pressing problem for patients with lymphomas, breast cancer, and chest tumors. Radiation exposure can lead to late changes, such as valve fibrosis, coronary artery disease, restrictive cardiomyopathy, and conduction system abnormalities, which manifest decades after completion of treatment.

The growing interest in cardio-oncology reflects the understanding that successful cancer treatment is impossible without managing associated risks. Current research focuses on developing strategies for early identification of high-risk patients, optimizing cardiac monitoring methods, and implementing programs for the prevention and treatment of cardiac complications. However, despite the accumulated data, a unified strategy for monitoring and long-term risk management of cardiotoxicity is still being developed, underscoring the importance of further research.

Understanding the mechanisms of cardiotoxicity remains an important task. The molecular pathways of cardiac tissue damage caused by antitumor agents are extremely diverse and include oxidative stress, mitochondrial dysfunction, cardiomyocyte apoptosis, impaired angiogenesis, immune responses, and inflammation. Understanding these mechanisms opens the way to personalized approaches – the use of cardioprotectors, dosage optimization, selection of drugs with a lower risk profile, and individualized adjustment of concomitant therapy. A particularly promising area is the development of biomarkers of predisposition, allowing for the prediction of the development of cardiac complications before treatment and the adjustment of the therapeutic regimen in advance.

The problem of cardiotoxicity extends beyond purely medical considerations. It affects socioeconomic aspects, as complications associated with cardiac damage require expensive and lengthy treatment, increase the number of hospitalizations, and impact patient productivity. With the growing number of cancer survivors, the need for specialized cardio-oncology centers providing a multidisciplinary approach to patient care is growing. The development of such services facilitates the timely diagnosis of complications, improves prognosis and quality of life, and reduces the risk of interruption or modification of anticancer therapy for cardiac reasons.

An additional layer of complexity is created by the fact that many patients begin treatment with pre-existing cardiac risk factors, such as hypertension, dyslipidemia, obesity, diabetes, genetic predisposition, and others. These conditions increase the likelihood of developing cardiotoxicity and require comprehensive intervention. Thus, modern approaches to cancer treatment require not only the selection of optimal anticancer therapy but also active primary and secondary prevention of cardiovascular complications.

As noted by Belenkov Y.N. et al. [1], over the past few decades, due to the extensive implementation of cancer screening programs, up-to-date early diagnostic methods, and effective combinations of antitumor therapy, it has become possible to significantly improve survival of cancer patients. At the same time, despite the effective treatment of malignancies, most patients face adverse and often life-threatening effects of specific treatment on the heart and blood vessels. All this resulted in active development of a new field in cardiology, cardio-oncology.

In the work of Chan M.F. et al. the authors say that they conducted a comprehensive database search to review and consolidate data regarding chest radiotherapy and effects on the heart as well as techniques to minimize exposure to the heart. The research findings demonstrate associations between radiation exposure to cardiac substructures and subsequent cardiotoxicity. At the same time, advanced cardiac-sparing techniques, notably respiratory motion management, have emerged as pivotal strategies to minimize the likelihood of cardiac events. Radiation-induced heart disease is a known potential toxicity in patients undergoing chest radiotherapy and thus there is a need to understand the associated risks and find methods to minimize them. Our colleagues focus on the fact that proton therapy can spare the heart and other vital organs while still delivering high radiation doses to tumors, potentially making it a superior option for treating breast and lung malignancies. Ongoing studies with longer follow-ups are needed to further elucidate its cardiac sparing advantage. Additionally, we need to investigate the effects of concurrent radiotherapy and immunotherapy on the heart, as existing research indicates that immunotherapy can lead to cardiac issues such as myocarditis, arrhythmias, and heart failure. The combination of these therapies may exacerbate these negative effects, so they should be used cautiously. Lastly, we need to further study how patient specific factors, such as pre-existing coronary artery disease or reduced ejection fraction, can help tailor radiation therapy more effectively [2].

Advances in cancer treatment have improved in patient survival rate. On the other hand, management

of cardiovascular complications has been increasingly required in cancer patients. Thus, cardio-oncology has attracted the attention by both oncologists and cardiologists. Cardiovascular imaging has played a key role for non-invasive assessment of cardiovascular alterations complementary to biomarkers and clinical assessment. Suitable imaging selection and interpretation may allow early diagnosis of cardiovascular injury with potential implications for therapeutic management and improved outcomes after cancer therapy. Echocardiography has been commonly used to evaluate cardiac dysfunction in cardio-oncology area. Cardiac computed tomography is valuable for assessing structural abnormalities of the myocardium, coronary arteries, and aorta. Molecular imaging has an important role in the assessment of the pathophysiology and future treatment strategy of cardiovascular dysfunction. Cardiac magnetic resonance imaging (MRI) is valuable for characterization of myocardial tissue. Positron emission tomography (PET) and Single Photon Emission Computed Tomography molecular imaging has potential roles for quantitative assessment of cardiovascular disorders. Particularly, Fluorodeoxyglucose-PET is considered as an elegant approach for simultaneous assessment of tumor response to cancer therapy and early detection of possible cardiovascular involvement as well. Cardio-oncology represents an important new area that should be covered by multiple specialist teams, including medical and radiation oncologists, cardiologists, diagnostic radiologists, technologist, nurses, and pharmacists. Interdisciplinary cooperation among these specialists is mandatory for accurate and timely diagnosis and also suitable management for each cancer patient. Cardiologists should be knowledgeable about the strengths and limitations of various imaging modalities, including echocardiography, cardiac MRI, and nuclear imaging. They should select the appropriate modality based on the clinical scenario and the specific information needed. Many oncologists should understand various cardiotoxic effects after new cancer treatments. In addition, radiologists should play an important role for selecting suitable imaging modalities and interpreting not only the tumor itself but also the condition of the heart when viewing tumor images in order to provide important messages from these images for both cardiologists and oncologists. Radiologists should be aware of the critical role that imaging plays in the diagnosis, monitoring, and management of cardiotoxicity in cancer patients. Understanding the appropriate use of each imaging modality is essential for providing comprehensive care. Radiologists should stay informed about the latest advancements in imaging technologies and techniques, such as cardiac MRI and nuclear imaging, to ensure accurate assessment and timely detection of cardiotoxic effects. Cardiovascular imaging has evoked as a key role for this purpose, allowing non-invasive evaluation of cardiovascular alterations complementary to biomarkers and clinical assessment. Suitable imaging selection and interpretation may permit not only for early diagnosis of cardiovascular injury but also accurate assessment treatment effects. Thus, the imaging will provide impact on therapeutic management and improved outcome after cancer therapy [3].

A very indicative and interesting study in the clinical and prognostic aspect was conducted by Klotzka A. et al. [4]. The purpose of this study was to gather information on respondents' knowledge of their treatment, awareness of cardiovascular risks associated with cancer therapy, and the factors associated with these outcomes. The level of awareness was related to age, education, as well as health behaviors and communication with the physician. As the authors note cardio-oncology is a relatively young but rapidly developing branch of medicine. It combines cardiology and oncology. Both of these fields are associated with the largest number of morbidity cases in the world, and thus the largest number of deaths. Cardio-oncology addresses the cardiac complications of oncological treatment at every stage of cancer therapy. Cardiovascular complications have become increasingly common among cancer survivors, largely due to improved treatment outcomes and longer survival. As events like myocardial infarction and heart failure now significantly affect long-term health, assessing patients' awareness of these risks is essential. Cardio-oncologic complications extend beyond the duration of oncologic treatment. Chemotherapy, radiotherapy, or immunotherapy, which are widely used in oncology, can lead to adverse cardiovascular events both during and years after oncological treatment.

A cross-sectional study was conducted among 243 patients attending an outpatient cardio-oncology clinic in Poznan, Poland. Participants were informed about the aim of the study while in the clinic waiting room. Subsequently they completed an anonymous questionnaire voluntarily after the visit to the office. Completing the paper-and-pencil survey took an average of 10-15 min. If necessary, patients could count on professional assistance in completing the questionnaire. They could ask questions while completing the survey and withdraw from the study at any time. Eligibility criteria included being an adult and having a confirmed diagnosis of any type of cancer. Data collection was carried out between October 2023 and April 2024. According to the statement KB-919/22 issued by the Bioethics Committee of the Poznan University of Medical Sciences (Poznan, Poland) the study did not constitute a scientific experiment.

Based on a review of the literature and relevant recommendations, a structured questionnaire was developed, comprising three sections: (1) questions related to cardio-oncology, (2) questions related to health behaviors, and (3) sociodemographic items. 37 items were single-choice, and 3 were multiple-choice. The tool



was reviewed by four subject-matter experts in the fields of cardiology, public health, patient education, and healthcare.

The following questions examined patients' awareness of cardiac complications:

What is cardio-oncology?

In your opinion: Can chemotherapy "damage" the heart?

In your opinion: Should the heart be monitored during chemotherapy?

In your opinion: Should one go to a cardiologist for follow-up after cancer treatment?

In your opinion: Should the heart be monitored after radiation therapy to the chest?

In your opinion: Can radiation therapy to the chest "damage" the heart?

Other questions concerned examinations and providing information by the doctor:

Did your doctor inform you about possible cardiac complications caused by cancer drugs?

Did your doctor inform you about possible cardiac complications caused by radiation therapy to the chest?

Did a cardiologist examine you during cancer treatment?

Did you have an echocardiogram, known as a cardiac echo, during your cancer treatment?

The response options "no" and "I don't know" or "I don't remember" were combined during the statistical process because we wanted to obtain a clear classification of respondents in terms of their knowledge. Differentiating between a lack of knowledge and an uncertainty about one's knowledge did not result in a significant statistical difference [4].

The response rate was 80%. The majority of participants were women, comprising 75.7% of the total sample. The mean age of respondents was 51.2 years ( $SD = 9.8$ ), and the mean Body Mass Index (BMI), calculated based on self-reported weight and height, was 27.0 ( $SD = 18.7$ ). More than half of the participants (53.5%) were classified as having an elevated BMI. The largest educational subgroup included individuals with secondary education (38.7%). Additionally, over half of the sample resided in large urban areas (53.5%) and were actively employed (61.7%). Only a small proportion of respondents (9.1%) rated their financial situation as good or very good. Breast cancer was the most commonly reported cancer type, accounting for 55.6% of cases. In terms of treatment, approximately 32% of patients reported receiving both chemotherapy and radiotherapy, whereas nearly 27% were unaware of the specific oncological treatment they had undergone. Patients' awareness of cardiac complications associated with their cancer treatment and the relationship with various demographic variables were analyzed. In questions concerned patients' awareness, examinations and providing information by the doctor the response options "no" and "I don't know" or "I don't remember" were combined during statistical process. The researchers wanted to obtain a clear classification of respondents in terms of their knowledge. The respondents were divided into two groups - those having knowledge and the rest - in order to examine the differences between them. As a result, we observed a statistically significant difference between these groups. Patients were asked to select the correct definition of cardio-oncology. Only 23.5% of respondents knew what cardio-oncology is. Statistical significance was identified in age, education level, BMI and type of oncological therapy received by the patient. Among patients under 40 years old, awareness of cardiac complications was the highest. This awareness declined with increasing age and increased with the level of education. Additionally, most individuals with obesity and those unaware of the type of oncological therapy they were receiving also lacked knowledge of cardio-oncology. Statistical significance in relation to financial situation was identified only in questions concerning complications after chemotherapy. Patients who declared an average financial situation were least likely to say that the heart should be monitored. A significant correlation was also noted between patient awareness and physician actions. Only 24.3% of patients were informed by their oncologist (or remember being informed) about possible cardiac complications caused by cancer drugs. An even smaller proportion (12.4%) remembered that their doctor informed them about possible cardiac complications caused by chest radiotherapy. Nearly 32% of patients were not examined by a cardiologist during cancer treatment, and more than half (53.5%) underwent echocardiography during cancer treatment. However, 95.5% of patients believed that every patient undergoing cancer treatment should have a cardiology consultation. Patients who were informed about possible complications and underwent cardiological examinations had better knowledge about complications and the need to monitor their heart after cancer treatment. The results from Health Behavior Scale domains showed that out of a possible 45 points, respondents scored an average of 24.21 ( $SD = 8.18$ ) points. Preventive behaviors related to the healthcare system received the lowest score (1.33 out of 3 possible), which indicates that patients diagnosed with cancer relatively rarely underwent preventive prostate cancer screening or smear test. On the other hand, patients scored highest in the Unhealthy behaviors domain, which indicates that they rarely consume tobacco or alcohol products ( $2.05 \pm 0.46$ ). The Mann-Whitney U test indicated a statistically significant association between patients' health be-



haviors and cardio-oncology knowledge ( $p < 0.001$ ). Individuals who knew what cardio-oncology is and provided correct answer declared healthier behaviors ( $M = 27.9 \pm 6.0$ ) than those who did not have this knowledge ( $M = 23.1 \pm 8.5$ ). Patients who were aware that chemotherapy and radiotherapy could have negative cardiac consequences also exhibited better health behaviors related to diet, physical activity or healthcare system. Among those who completed our questionnaire, 54 participants (22.22%) reported receiving chemotherapy, while 79 (32.51%) received both chemotherapy and radiation therapy. Radiation therapy alone was used in 45 individuals (18.52%). Notably, 65 participants (26.75%) did not know what type of cancer treatment they had undergone. As the authors note it is concerning that such a large group of patients, despite having undergone potentially cardiotoxic therapy, were not aware of the need for regular follow-up. Nearly half of them had received chest radiotherapy, and it is well known that its complications increase over time - coronary artery disease or valvular dysfunction may appear even 20 years after treatment. In the absence of follow-up, patients often present to a cardiologist only at an advanced stage of disease. Even more striking are the data showing that more than 26% of patients in the cardio-oncology clinic did not know what type of oncologic therapy they had received. It is difficult to determine whether this results from denial of the cancer diagnosis, lack of interest in their health despite the disease, or concomitant depression [4].

Summarizing the conducted research, our colleagues state that cardio-oncology is becoming an indispensable component of comprehensive care for oncology patients. As cancer treatments continue to improve in effectiveness, they are increasingly associated with a risk of cardiovascular complications that can significantly impair patients' quality of life and affect overall prognosis. The early involvement of a cardiologist at the stage of planning oncological therapy allows for individualized risk assessment and timely implementation of preventive measures. Unfortunately, as demonstrated by study, the level of knowledge among oncology patients regarding potential complications of chemotherapy and radiotherapy remains insufficient. There is a clear need to implement effective educational programs aimed at increasing awareness of these risks and fostering stronger interdisciplinary collaboration between oncologists, cardiologists, and primary care physicians. Greater emphasis should be placed on prevention through the control of comorbidities that already increase baseline cardiovascular risk, such as hypertension, diabetes, and obesity, even before the initiation of cancer treatment. Regular cardiac monitoring during and after therapy should become the standard of care. Patients must also receive clear and comprehensible information about the potential adverse cardiovascular effects of oncological treatment. Improved patient education may enhance patient engagement in the treatment process and facilitate the early detection of cardiac complications. As shown in survey, patients who were informed by their physician about the potential cardiotoxicity of oncological therapies demonstrated more health-conscious behaviors. Early identification of cardiotoxicity enables timely intervention, reducing the likelihood of long-term complications. This proactive approach not only enhances treatment safety but also strengthens patients' trust in the healthcare system as a whole [4].

Yang M. et al. [5] in their work emphasize that with the increase of aging population and prevalence of obesity, the morbidity of cardiovascular disease (CVD) and cancer has also presented an increasing tendency. These two different diseases, which share some common risk factors. Relevant studies in the field of reversing cardio-oncology have shown that the phenotype of CVD has a significant adverse effect on tumor prognosis, which is mainly manifested by a positive correlation between CVD and malignant progression of concomitant tumors. This distal crosstalk and the link between different diseases makes us aware of the importance of diagnosis, prediction, management and personalized treatment of systemic diseases. The circulatory system bridges the interaction between CVD and cancer, which suggests that we need to fully consider the systemic and holistic characteristics of these two diseases in the process of clinical treatment. The circulating exosome-miRNAs has been intrinsically associated with CVD-related regulation, which has become one of the focuses on clinical and basic research (as biomarker). The changes in the expression profiles of cardiovascular disease-associated miRNAs (Cardio-miRNAs) may adversely affect concomitant tumors. In this article, we sorted and screened CVD and tumor-related miRNA data based on literature, then summarized their commonalities and characteristics (several important pathways), and further discussed the conclusions of cardio-oncology related experimental studies. The cellular regulatory processes and mechanisms between miRNAs and CVD have been well studied, but the role of miRNAs as a systemic influence in the synthesis of cross-talk between different diseases is still less. Especially, some typical biomarkers reflected by changes of expression profile for Cardio-miRNAs in circulation. The authors sorted out the relevant mechanism of Cardio/Onco-miRNAs involved in CVD phenotype on tumor regulation according to the objective background of reverse cardio-oncology. These mechanisms will be key to revealing the systemic or holistic effects of CVD on tumors, which is also an important value for the application of precision medicine in the diagnosis and treatment of systemic diseases. These mechanisms might serve as evidence to supplement the importance of predictable diagnosis and personalized treatment between CVD and tumors, and it also provides a reference for developing systemic

principles of improve individual outcomes. Based on the reported contribution of related miRNAs to the regulatory mechanism of malignancy process of tumor cells, combining with the fact that exosome-derived Cardio-miRNAs can regulate tumors via circulation, the researchers have deeply analyzed and summarized the different signaling pathways involved in Cardio-miRNAs. The aim is to predict and evaluate the impact on adaptive survival of tumor cells based on the regulatory mechanisms of different pathways and related Cardio-miRNAs as markers. Different expression levels of circulating Cardio-miRNAs predict the progression of concomitant tumors and can be used to develop personalized treatment options. Concludes that CVD and tumors can be linked through miRNAs, and these miRNAs may have a dual role (Cardio-/Onco-miRNAs). However, with aging, the dysfunctions of cardiovascular system may appear and changes of systematic phenotypes of circulating miRNAs showed the adverse effects of Cardio-miRNAs for middle-aged and elderly or obese tumor patients. Furthermore, the dual properties of Cardio-/Onco-miRNAs suggest that CVD is systemic and holistic problem or risk factor affect distant tumor cells via the circulation, which may be a potential target for treatment and intervention. Therefore, based on the perspective of CVD phenotyping in oncologic disorders, we need a systemic evaluation, prediction and diagnosis of the patients with concomitant tumors, which may provide a reference for avoiding poor prognosis.

Kojic A. et al. indicate that [6] heart disease and cancer share common risk factors, genetic predispositions, and metabolic and inflammatory components. Metabolic reprogramming can drive disease progression in both, with cardiometabolic syndrome - marked by obesity, insulin resistance, dyslipidemia, and hypertension - contributing to cancer development. Studies link around 20% of cancer cases to obesity, while elevated glucose and triglyceride levels increase the risk of liver, thyroid, and respiratory cancers. Beyond treatment-related cardiotoxicity, cancer patients often have pre-existing CVD at diagnosis, highlighting their bidirectional relationship. Patient-specific induced pluripotent stem cells (iPSCs) offer a powerful platform to study these links at a personalized level. iPSC models help explore shared molecular mechanisms, metabolic dysregulation, inflammation, and cardiotoxicity.

The authors state that as cancer therapies continue to extend survival, patients are increasingly facing long-term cardiovascular consequences – not only from the treatments themselves but also from cancer-related inflammation and metabolic disruption. This is especially true for individuals with underlying cardiometabolic disease, who may experience synergistic effects on cardiac function. In this context, cardio-oncology must evolve beyond reactive management toward a proactive, integrative approach. Preventative strategies targeting metabolic risk factors (e.g., statins, glycemic control, etc.) hold promise for improving both cancer and cardiovascular outcomes. These considerations set the stage for translational efforts, including dietary interventions and patient-specific iPSC-based strategies, to optimize therapy and minimize harm. Several lines of evidence support the central role of metabolism in the development of both CVD and cancer. Targeting specific metabolic signatures – whether through direct enzyme inhibition or dietary modulation – can influence tumor growth, improve therapy tolerance, and reduce cancer-associated cardiovascular risk. These efforts are exemplified by the clinical use of inhibitor of mutant isocitrate dehydrogenase 1 and 2 inhibitors. Additionally, preclinical studies have shown that intermittent fasting can delay tumorigenesis and reduce growth factor signaling, offering another potential avenue for systemic metabolic intervention. Furthermore, the investigation into how risk factors for both cancer and CVD such as obesity, diabetes, and dyslipidemia might provide new avenues for systemic solutions to both diseases through dietary interventions. Fasting has been shown to have positive effects on cancer prevention and treatment in mice. Just 1 day of fasting per week delays tumorigenesis in p53-deficient mice, with other effects including decreased plasma levels of glucose, insulin, and insulin-like growth factor 1. Periods of fasting are also followed by high cellular proliferation, characterized by cellular repair pathway activation and driven by the replenishment of growth factors during refeeding that can reverse atrophic cellular remodeling. iPSC technologies offer a versatile and powerful platform for accurately modeling CVDs, metabolic disorders, cancer, and their complex interactions. By providing an essentially unlimited supply of targeted cell types derived from either healthy controls or patients, these models enable the recapitulation of disease-specific phenotypes influenced by genetic and environmental factors. As an accessible, precise, and highly adaptable system, iPSCs can enable groundbreaking discoveries in disease mechanisms and toxicity progression while also facilitating the development of effective therapeutic strategies. iPSCs' ability to reflect the unique genetic background of the individual from which they are derived positions them as a cornerstone for advancing personalized precision medicine. In cardio-oncology, iPSCs provide a robust platform to assess individual responses to anticancer therapies, enabling the identification of treatment combinations that maximize tumor suppression while minimizing detrimental side effects. This approach holds immense promise for tailoring treatments to the unique needs of each patient with transformative implications for improving outcomes in cancer survivors, who face heightened risks of developing CVD. To fully realize

the potential of these technologies, cross-disciplinary research integrating cardio-oncology, oncology, and cardio-metabolism is essential. Such collaboration can bridge the critical gap between molecular studies and clinical applications, leveraging patient-derived samples for mechanistic insights and risk stratification, and promote the development of novel therapeutic strategies. Ultimately, this integrated approach promises the advent of a new paradigm to transform patient care, by effectively treating both cancer progression and its cardiovascular consequences [6].

A fundamental study concerning the assessment of global trends in publications and the identification of the most cited scientific articles on cardio-oncology was conducted by Suero-Abreu G.A. et al. [7]. They note that as novel cancer therapies continue to improve patient outcomes, there is an increased need for prevention and management of the cardiovascular side effects of these therapies. For this reason, the field of cardio-oncology has experienced significant scientific growth, particularly during the last decade. A bibliometric analysis of the literature in the field of cardio-oncology was performed using the multidisciplinary databases Scopus, Pubmed, and Web of Science Core Collection. The terms “cardio-oncology”, “onco-cardiology”, “cardio-onco-hematology” and “cardio-immuno-oncology” were searched (both hyphenated and non-hyphenated) for all languages for the years 1864 to 2020. The final search was conducted on March 31, 2021, and the terms were queried as “abstract title, abstract, and keywords” for Scopus and Pubmed, and as “topic” for Web of Science Core Collection. All articles from the search results were independently verified by two reviewers and were included in the analysis if they addressed cardio-oncology as a field of study in the keywords, title, or abstract. Articles that did not focus on cardio-oncology were excluded. Each article was reviewed for its number of citations, year of publication, and journal of publication. When duplicates were found, the entry with fewer citations was eliminated. For those articles that were co-published in two or more journals, the entry with the highest citations was kept and the citations from the other entries were added to this entry. Publication output for each year was analyzed and a list of the 50 most cited articles in the field was generated, as well as a list of journals publishing cardio-oncology articles. The top 50 most cited articles were reviewed for their citations, year of publication, type of article (i.e., original article, position paper/society guideline, review, systematic review, conference paper, letter to the editor, and case report), journal, and characteristics of the corresponding author (i.e., field of study and country of origin). Due to the public nature of the data used in the study, informed consent for this study was not obtained and it was exempt from Institutional Review Board approval. This study was conducted in compliance with all applicable institutional ethical standards for human study. As of March 31, 2021, a total of 1,294 publications related to cardio-oncology as a field with a total of 14,494 citations were found. There was a consistent increase in the number of articles referring to cardio-oncology and the number of citations over the past two decades. The articles per year were 1 in 1996, 1 in 2003, 2 in 2008, 7 in 2010, 14 in 2011, 12 in 2012, 28 in 2013, 47 in 2014, 75 in 2015, 115 in 2016, 176 in 2017, 184 in 2018, 261 in 2019, and 371 in 2020.

Cardio-oncology was the first term used to describe the field and has remained the most used in the literature compared to the other names associated with the field. In this regard, we identified additional terms referring to the field which arose later in the literature such as: onco-cardiology (in 2008), cardio-onco-hematology (in 2017), and cardio-immuno-oncology (in 2018). There was no further mention of the term “cardio-oncology” until 2003 (one article, one citation), and then later in 2008 (two articles, one and 25 citations). After 2010 and particularly between 2015 and 2020, there has been a significant growth in the number of publications referring to cardio-oncology as a field, likely triggered by the increased recognition of cardiac-related side effects of novel cancer treatments, such as targeted and immunomodulating therapies. The top 50 most cited articles in the field of cardio-oncology had a combined total of 7,192 citations as of March 2021. The number of citations per publication ranged from 49 to 986 (mean  $143 \pm 157$ ). The most cited articles to date were published between 2010 and 2020, with the majority between 2015 and 2020 ( $n = 31,62\%$ ). All articles were in English and most article types were reviews ( $n = 28,56\%$ , with 3,208 citations), followed by guidelines and position papers ( $n = 9,18\%$ , with 2,299 citations) and original articles ( $n = 9,18\%$ , with 1,451 citations). The rest of the articles were one letter to the editor, one systematic review, one case report, and one conference paper. The authors found that the three journals with the most articles on the 50 most cited list were Journal of the American College of Cardiology (eight publications with 1,347 citations), European Heart Journal (four publications with 1,372 citations), and Circulation (four publications with 241 citations). The researchers point out that cardio-oncology has blossomed as a field and its impact is expected to continue to expand. At the same time, despite the growth of the field, there is a need to expand our research efforts towards more original basic and translational research studies and to adopt standard terms for the indexing of research related to the field [7].

Ng C.T. et al. [8] note in their work that in recent years, there has been growing interest in the subspecialty of cardio-oncology worldwide. Cardio-oncology is an emerging multi-disciplinary field, which aims to

reduce morbidity and mortality of cancer patients by preventing and managing cancer treatment-related cardiovascular toxicities. With the growth in cardiovascular and cancer burden in Asia, there is a greater need for cardio-oncology awareness among physicians managing this unique group of patients and need to develop country-specific cardio-oncology initiatives. Our colleagues emphasize that in Asia, the top priority is to boost cardio-oncology services to cope with the upcoming cancer and CVD pandemic. The timely and appropriate intervention of cancer patients who experience CV toxicity can potentially help to reduce both CVD and cancer mortality. Concurrently, establishing a regional registry or joining an international registry such as Global Cardio Oncology Registry would facilitate the collection of country-specific data to better understand the disease prevalence and outcomes of cardioprotective strategies, and provide feedback for improving existing cardio-oncology programs. Based on the epidemiology of cancer therapy-related cardiovascular toxicity (CTR-CVT) in Asian patients, as well as ongoing research into the pharmacogenetics/pharmacokinetics of cancer and cardio-protective agents, customized guidelines for the Asian population can be developed. Given that there is significant healthcare and socio-economic disparity in Asia, countries with established cardio-oncology services should take the lead in mentoring upcoming centers by sharing their experiences and knowledge. The field of cardio-oncology is transforming the way cardiologists, oncologists, and hematologists screen for and manage CTR-CVT. While it is still in the developing phase, the various cardio-oncology communities in Asia and across the world are working closely together to advance the field by optimizing clinical care, education, and research, with a united mission of allowing cancer patients to complete their treatment and lead quality lives with minimal CVD burden thereafter.

I would also like to touch upon such an important aspect as the participation of mid-level medical personnel in cardio-oncological care.

Fadol A. et al. [9] say that with early detection and improvements in systemic and local therapies, millions of people are surviving cancer, but for some at a high cost. In some cancer types, cardiovascular disease now competes with recurrent cancer as the cause of death. Traditional care models, in which the cardiologist or oncologist assess patients individually, do not address complex cancer and cardiovascular needs. Nursing disciplines should be an integral part of holistic assessment in cardio-oncology care. To learn what educational needs nurses perceive important for provision of competent cardio-oncology nursing care, authors undertook an international survey, aiming to understand their learning needs and preferred learning modalities. As the researchers note cardio-oncology is a relatively new field of study and the nursing knowledge standard to provide holistic care has not been established. Moreover, nurses commonly have knowledge based in either cardiology or oncology but rarely both. For competent cardio-oncology nursing care to be fostered, accessible and acceptable educational opportunities must be readily available. Accordingly, they undertook an online survey to assess the learning needs of nurses in the competent care of cardiovascular issues in patients with cancer, aiming to understand their learning needs and preferred learning modalities.

A cross-sectional survey was developed by members of the International Cardio-Oncology Society (IC-OS) Nursing Research group, with invitations distributed through IC-OS as well as national and international nursing societies and associations. The survey was in English and consisted of 23 questions which include demographic information, clinical specialty (oncology, cardiology, or cardio-oncology), multiple-choice questions related to clinical topics that nurses might be interested in learning, and preferred methods of instruction. No identifying information was requested thus participants remained anonymous. The survey qualified for exempt status by institutional board review and completion was considered implied consent of participation. The survey was conducted online via the IC-OS website with submissions accepted between the dates of December 1, 2023, to February 29, 2024. The secure Research Electronic Data Capture program was utilized to administer the survey which took approximately five minutes to complete [10]. Survey questions were purposefully developed to describe potential cardio-oncology events across the treatment and survivorship continuum. Depending on the format of the question, respondents could choose as many areas of interest as desired. Aiming for the broadest perspectives and representation of different health care systems, participants were recruited by convenience sampling in multiple countries and were currently working in cardiology, oncology or cardio-oncology programs [9].

Three hundred and twenty-nine responses were received during the study time frame. The majority of respondents reported as residing in the United States (n = 206), Canada (n = 45), United Kingdom (n = 14) China (n = 12), Qatar (n = 5), Australia (n = 1), Ireland (n = 2), Poland (n = 2), Turkey (n = 1) and Italy (n = 1). The majority were female (n = 290, 93%) with 49% educated to Bachelor's level (n = 151, 49%) and working in oncology (n = 218, 70%) in direct patient care roles (n = 260, 85%). A total of 201 (65%) nurses stated they had cardio-oncology experience. In terms of previous education and training in cardio-oncology, the majority stated that they had no formal education (n = 268, 88%) and approximately one-third have formal cardio-on-



cology programs in their workplace (n = 110,36%). The majority of respondents expressed an interest in learning more about cardio-oncology related topics, primarily via pre-recorded webinars (n = 206,67%) and live virtual meetings (n = 192,63%). Formal programs leading to certification were highly endorsed (n = 247,80%). Respondents were asked about training topics categorised into cardio-oncology, oncology and cardiology. In relation to specific cardio-oncology topics, there was a strong interest in learning more about cardiovascular toxicities and their management (n = 205,66%) along with interest in cardio-oncology programs and cancer therapeutics. The survey authors conducted described the sample's characteristics, identified cardio-oncology learning needs and preferred methods of delivery. A cardio-oncology core curriculum based on the survey responses can offer convenient, accessible and learner-directed education for nurses worldwide. Ultimately, as our colleagues point out, development of cardio-oncology nursing expertise will benefit cancer patients and survivors worldwide [9].

Now, regarding the Cardio-Oncology Rehabilitation and Exercise (CORE) programmes. Adams S.C. et al. [11] focus on the fact that there is an urgent need to reinforce and extend the evidence informing the cardiovascular care of cancer survivors. CORE is an attractive model that is potentially scalable to improve the cardiovascular health of cancer survivors as it leverages many of the existing frameworks developed through decades of delivery of cardiac rehabilitation. However, there are several challenges within this burgeoning field, including limited evidence of the efficacy of this approach in patients with cancer. CORE incorporates a model like cardiac rehabilitation programmes, including medical evaluation, prescriptive exercise, cardiovascular risk factor modification, education, counselling, and nutritional support. This intervention potentially has diverse and complementary patient-, HCP-, and system-level benefits and may be a leading strategy to address the current care gaps and optimize long-term cardiovascular outcomes for oncological patients and survivors. Close collaboration of CORE stakeholders (e.g. oncologists, cardiologists, primary care physicians, nursing, exercise physiologists/therapists, nutritionists, etc.) is required to accelerate discovery, improve the quality (e.g. rigour and reporting) and scope (e.g. targeting high risk and highly vulnerable populations) of CORE research, and support widespread implementation in the field.

Thus, cardiotoxicity remains a key issue in modern anticancer therapy, impacting both immediate treatment outcomes and the long-term quality of life of patients. Increasing cancer survival rates make maintaining optimal cardiovascular health an integral part of comprehensive oncology care. The development of cardio-oncology as an interdisciplinary field provides the foundation for the early detection of cardiac complications, optimized therapy, and a personalized approach to each patient. A combination of modern diagnostic methods, risk stratification, and cardioprotective strategies can significantly reduce the likelihood of severe cardiovascular complications. Close collaboration between oncologists, cardiologists, and related specialists, based on unified clinical protocols and timely monitoring, remains crucial. Further advancement of cardio-oncology requires expanding the evidence base, implementing innovative technologies, including biomarkers, and raising awareness among the medical community about the risks of cardiotoxicity. This approach will not only improve the tolerability of anticancer treatments but also provide patients with a longer, better quality of life after completion of anticancer therapy.

In recent years, the development of clinical guidelines and standards for the management of patients at risk of cardiotoxicity has been actively discussed in the scientific literature. International documents already exist that unite the efforts of oncologists and cardiologists, but their implementation in practice requires adaptation to the specifics of national healthcare systems. An important step is the training of specialists, including mandatory nursing staff, raising awareness among physicians at all levels, and developing interdisciplinary communication. This is especially important in resource-limited regions where access to modern monitoring methods may be difficult.

Thus, the relevance of cardiotoxicity testing during anticancer therapy is determined by a combination of factors: the increasing prevalence of cancer, increasing patient life expectancy, the expanding range of anticancer agents toxic to the heart, the presence of delayed cardiac complications, and the high clinical significance of timely diagnosis. Success in modern oncology is impossible without increased attention to maintaining patients' cardiovascular health. Research into the mechanisms of cardiotoxicity, the development of preventative methods, improved monitoring, and the development of personalized treatment approaches are important areas shaping the future of cardio-oncology and improving the quality and length of life for patients.

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# Pedagogical sciences

## SCREEN TIME AND PRESCHOOL CHILDREN: SUPPORTING HEALTHY DEVELOPMENT IN THE DIGITAL AGE

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### **Abstract**

This article examines the multifaceted impact of screen time on the development of preschool-aged children (2-5 years). It explores the key developmental domains affected by digital media consumption, including cognitive, language, physical, and socio-emotional development. The paper presents current guidelines from leading health organizations, classifies different types of screen use (active vs. passive), and provides a framework for educators and parents to implement healthy digital habits. A significant portion of the article is dedicated to practical strategies, such as co-viewing, content selection, and creating a family media plan, to mitigate risks and harness the educational potential of digital technologies. The goal is to move beyond a simple "time limit" approach toward a more nuanced understanding of media ecology in early childhood.

**Keywords:** screen time, preschool children, early childhood development, digital media, co-viewing, media ecology, AAP guidelines, parental mediation.

**Introduction.** The digital age has fundamentally reshaped the landscape of early childhood. For today's preschoolers, tablets, smartphones, and streaming services are not novel innovations but a seamless part of their everyday environment. While digital media can offer educational opportunities and entertainment, the rapid integration of screens into the lives of young children has raised significant concerns among pediatricians, educators, and developmental psychologists. The central question is no longer if screens are present, but how they are used and what impact this usage has on a child's developing brain, body, and social-emotional well-being. Early childhood, defined as the period from 2 to 5 years, is a time of unparalleled brain plasticity and development. It is a critical window for acquiring language, developing executive functions (like impulse control and working memory), learning to regulate emotions, and building foundational physical skills through active play. The introduction of screens into this delicate developmental equation requires a careful, evidence-based approach. This article aims to dissect the complex relationship between screen time and preschool development, moving beyond alarmist narratives to provide a balanced perspective and actionable strategies for parents and educators.

**Main part.** 1. Defining Screen Time: Beyond the Clock. The term "screen time" is often used as a blanket metric, but contemporary research emphasizes that not all screen time is equal. To understand its impact, we must first classify the type of engagement. Passive Screen Time: This involves the child as a spectator, consuming content with little to no interaction or mental effort. Examples include watching non-educational cartoons or background TV. This type of use offers the least developmental benefit and is associated with the highest risks, particularly for language development [1]. Active (or Interactive) Screen Time: This involves the child engaging cognitively with the content. Examples include using a well-designed educational app where the child must solve problems, video chatting with a grandparent (interactive social connection), or following along with a virtual yoga class. The key differentiator is the mental engagement and, ideally, a degree of responsiveness from the medium [2]. Educational Screen Time: Content specifically designed with pedagogical goals, often involving age-appropriate curriculum, slow pacing, and opportunities for participation. Shows like "Sesame Street" or "Bluey" are often cited as examples of high-quality educational programming.

2. The Impact on Developmental Domains.

2.1 Cognitive and Executive Function Development. Executive functions (EFs) are the mental skills that help us plan, focus attention, remember instructions, and juggle multiple tasks. These skills are predominantly

developed through unstructured, child-led play, social interaction, and exploration of the physical world. Potential Negative Effects: Fast-paced, fantastical, and constantly shifting content can overload a young child's attentional system. Research suggests that heavy exposure to such content may contribute to difficulties in sustained attention and impulse control later on [3]. The phenomenon of "video deficit" shows that infants and toddlers learn less effectively from a screen than from a live, face-to-face interaction [4]. Potential Positive Effects: Well-designed interactive apps can practice specific EF skills like working memory (matching games) or cognitive flexibility (simple sorting tasks). However, these benefits are highly dependent on the design and the context of use.

**2.2 Language Development.** Language acquisition is a fundamentally social process, rooted in the "serve and return" interactions between a child and a caregiver. Potential Negative Effects: The single greatest risk of excessive screen time is the displacement of these vital conversational exchanges. When a screen is on, both parents and children talk less [5]. Background TV, even when no one is watching it, has been shown to disrupt play and reduce the quantity and quality of parent-child interactions. Passive viewing of entertainment content offers no linguistic benefit. Potential Positive Effects: Video chat (e.g., FaceTime, Skype) allows for real-time, responsive social interaction, effectively using a screen as a conduit for language-rich connection with distant relatives. High-quality educational programs, especially when co-viewed with an adult who elaborates on the content ("Look at the big red barn!"), can introduce new vocabulary and concepts.

**2.3 Physical Health. Sedentary Behavior:** Screen time is a predominantly sedentary activity. Increased screen use is associated with decreased time spent in active, physical play, which is crucial for developing gross motor skills, cardiovascular health, and healthy weight [6]. **Sleep Disruption:** The use of screens, particularly before bedtime, can interfere with sleep in several ways. The blue light emitted from screens suppresses the production of melatonin, the sleep-inducing hormone. Additionally, engaging or exciting content can lead to cognitive and emotional arousal, making it difficult for a child to wind down. Poor sleep, in turn, negatively affects mood, behavior, and cognitive function [7].

**2.4 Socio-Emotional Development.** This domain encompasses a child's ability to understand and manage emotions, form relationships, and develop empathy. Potential Negative Effects: Time spent with screens is time not spent reading facial expressions, practicing turn-taking in conversation, or learning to navigate the complexities of peer conflict. Heavy reliance on screens for entertainment can also limit opportunities for developing self-regulation, as children may come to depend on external stimulation rather than learning to manage boredom or frustration internally [8]. Potential Positive Effects: Pro-social content can model empathy, cooperation, and emotional vocabulary. When an adult co-views and discusses the characters' feelings ("Why do you think that little girl is sad?"), it can become a valuable tool for social-emotional learning.

### **3. Current Guidelines for Screen Time.**

Leading health organizations, such as the American Academy of Pediatrics (AAP), provide evidence-based recommendations to guide families [9]

Age Group	Recommended Screen Use	Key Considerations
Under 18 months	Avoid digital media use (except video chatting).	Infants learn best through face-to-face interaction. Video chat is an exception because it is a live, social interaction.
18–24 months	If introducing digital media, choose high-quality programming and co-view with the child.	Parents should watch with the child to help them understand what they are seeing. Avoid solo media use.
2–5 years	Limit screen use to 1 hour per day of high-quality programming.	Co-viewing is strongly encouraged Content should be educational, age-appropriate, and non-violent. The focus should be on *what* is watched, not just *how long*.
All Ages	Create a Family Media Plan	Designate media-free times (e.g., family dinners) and media-free zones (e.g., bedrooms) Ensure screen time does not replace sleep, physical activity, or essential social interactions

### **4. Strategies for Supporting Healthy Development.**

**4.1 Co-Viewing and Co-Engagement.** The single most effective strategy for mitigating risks and maximizing benefits is for an adult to watch with the child. Co-viewing turns a passive experience into an interactive one. Parents can:

Ask questions: "What do you think will happen next?"

Point things out: "Look at the blue truck!"

Relate content to the child's life: "Remember when we saw a squirrel in the park?"

Reinforce lessons: After an episode about sharing, the parent can gently remind the child at playtime.

### **4.2 Content is King: Choosing High-Quality Media**

Not all children's content is created equal. Parents and educators should be critical consumers, looking for media that:

- Has a clear, age-appropriate educational goal (e.g., literacy, math, social skills).
- Features a slow, predictable pace to allow for cognitive processing.
- Encourages participation (e.g., asking the child to repeat a word or answer a question).
- Models positive social behaviors like kindness, empathy, and cooperation.
- Is free from fast-paced edits, loud sounds, and distracting advertising. Trusted sources for reviews include Common Sense Media.

#### 4.3 The Family Media Plan: Creating a Healthy Media Ecology

A structured approach helps integrate screens intentionally rather than allowing them to be a constant presence.

- Set Clear Limits: Establish a predictable daily or weekly screen time budget.
- Establish Tech-Free Zones: Keep bedrooms, the dinner table, and the car screen-free to protect sleep, family connection, and conversation.
- Prioritize Unplugged Play: Ensure the day is filled with ample opportunities for physical activity, creative play (drawing, blocks, pretend), and reading physical books.
- Be a Role Model: Children learn by watching. Parents should be mindful of their own screen use, putting down their phones during family time to demonstrate that real-life interaction is valuable.

#### 4.4 Recognizing the Signs of Problematic Screen Use

It is important for caregivers to monitor the child's reaction to screens. Warning signs may include:

- Irritability, aggression, or extreme distress when screen time ends.
- Loss of interest in non-screen activities, like playing with toys or playing outside.
- Interference with sleep (difficulty falling asleep, night wakings).
- Using screens is the only way to calm the child down.

If these signs are present, it may be necessary to re-evaluate the family media plan and consider a "digital detox" or consultation with a pediatrician.

#### **Conclusion.**

Supporting healthy development in the digital age is not about completely eliminating screens from a preschooler's life, a task that is both unrealistic and unnecessary. Instead, the goal is to cultivate a healthy media ecology, where screens are one small, intentional component of a rich and varied environment. The focus must shift from a simplistic battle against the clock to a more nuanced approach that prioritizes what children watch, how they watch it (ideally with a caring adult), and what they are not doing as a result of screen time. By understanding the developmental vulnerabilities of early childhood and adhering to evidence-based guidelines, parents and educators can empower themselves to make informed choices. Through co-viewing, curating high-quality content, and establishing consistent family media plans, we can help our youngest children navigate the digital world safely and emerge with their cognitive, social, and physical health intact, ready to learn and thrive.

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**CIVIC EDUCATION OF SCHOOLCHILDREN: MODERN APPROACHES AND CHALLENGES**

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**Abstract**

This article examines the current issues and approaches to civic education of schoolchildren in recent years (2019–2024). It outlines the theoretical foundations of civic upbringing, analyzes national programs and pedagogical methods (for example, the unified upbringing program “Birtautas Tarbie”/“Adal Azamat”), and highlights projects and initiatives aimed at instilling civic values in children. Special attention is paid to contributions by Kazakhstani and foreign researchers including T. S. Sabirov, A. I. Aryn, S. H. Schwartz, R. Inglehart, etc.) in understanding the mechanisms of cultivating civic consciousness. Practical examples are discussed: integration of value orientations into the school environment and curriculum, class hours on civic topics, volunteering projects, and digital citizenship. The author shares a personal perspective on the importance of civic education, its challenges (such as the value crisis among youth, the impact of the digital environment, cultural pluralism) and development prospects through family–school partnership.

**Keywords:** civic education, patriotism, citizenship, school, value-oriented education, “Adal Azamat”, civic identity, digital citizenship, family–school cooperation.

**Introduction.** Civic education of schoolchildren is regarded as a crucial component of education aimed at developing a conscious civic position, patriotism, respect for the law, and human rights among children. In the context of globalization and digital transformation, the social significance of civic education continues to grow. As researchers emphasize, modern approaches require a synthesis of universal and local values [1]. The President of Kazakhstan, K. Zh. Tokayev, has repeatedly noted that a new quality of the nation is formed through nurturing universal and national values in the younger generation [2]. State policy documents (the Concept of Education, Nurly Zhol – The Path to the Future, etc.) prioritize the integration of civic and patriotic ideas into the educational process. Kazakhstan’s legislation also identifies fostering pride in the homeland and responsibility toward society as strategic objectives of school education. In recent years, a unified national upbringing program (Birtutas Tarbie, now Adal Azamat) and methodological guidelines for value-oriented education have been developed [3][4].

The purpose of this article is to analyze the theoretical foundations, modern programs, and practices of civic education of schoolchildren over the past five years, as well as to identify key challenges (digital environment, cultural diversity, value crisis among youth) and ways to address them through school–family partnership.

**Theoretical Foundations of Civic Education.** Civic education (essentially education for citizenship and patriotism) traditionally includes the development of legal awareness, respect for state institutions, and a sense of duty and responsibility toward society. In pedagogical science, citizenship is viewed as an integrated personal quality encompassing political, social, and spiritual orientations. In his theory of values, Shalom Schwartz emphasizes ten basic universal values—ranging from universalism and tradition to achievement and hedonism [5][6]. According to Schwartz, values are “concepts or beliefs that refer to desirable end states or behaviors” [7], and it is through the value system that an individual is formed as a citizen.

Research by R. Inglehart (World Values Survey, WVS) demonstrates that as societies develop, priorities shift from survival values toward self-expression and democracy [8]. Inglehart proved that value systems are not static; they change with levels of economic well-being and social stability [9]. In post-industrial societies, young people increasingly orient themselves toward self-realization and tolerance [8], which places new demands on forms of civic education. Thus, Inglehart’s theory helps explain long-term global trends: the transition from material to post-material values contributes to the development of democratic institutions and active civic engagement [8].

From a methodological perspective, civic education should be based on a systemic approach and value-

oriented education. Kazakh educator T. S. Sabirov, among other scholars, emphasizes the importance of a systemic perception of the educational process [10]. In methodological sources, Sabirov is cited as an advocate of a systemic approach, where upbringing is carried out “from the standpoint of national, Kazakhstani, and universal patriotic values” [10]. Contemporary concepts stress that the key mission of school is not merely the transmission of knowledge but also the reproduction of the values of Mangilik El—Kazakhstani patriotism, civic responsibility, solidarity, and tolerance [3].

A systemic integrative approach enables these values to be embedded as cross-cutting content in academic subjects, extracurricular activities, and family upbringing. According to the Concept of Education (2009), educational policy defines “the goals and objectives of state policy in the field of upbringing, as well as its content and technologies” [11], which serves as the foundation for modern educational programs.

**Modern Approaches and Programs (2019–2024).** Over the past five years, Kazakhstan has undergone significant changes in educational practice. In 2023–2024, the Unified Upbringing Program *Birrutas Tarbie* (now *Adal Azamat*) was developed and approved. Its goal is defined as “educating a hardworking, honest, conscious, and creative citizen based on universal and national values” [12]. The program covers upbringing from preschool to senior school age, taking into account age-specific characteristics and providing clear value guidelines for each stage. It emphasizes that the upbringing process should be organically integrated into academic subjects, extracurricular activities, class hours, and school events [13][14]. For example, educational and methodological materials are age-differentiated and easily adaptable: “Materials are integrated into academic subjects, extracurricular activities, class hours, and school events” [13].

A key feature of the new approach is the use of active and interactive methods. The Ministry of Education’s regulations state that “priority should be given to active methods over passive ones” [15], including group discussions, role-playing games, project-based learning, debates, and other interactive formats [16]. The use of such methods is driven by the aim of deeper value internalization: “Interactive methods help children and adolescents better understand educational values and apply them in everyday life” [17].

An important innovation has been the introduction of projects and social practices. For example, environmental and legal projects (volunteer initiatives) are presented as concrete forms of civic education: projects such as *Clean Yard*, *Eco-Volunteers*, *My Country and My Rights*, and *Legal Quest* help students understand their rights and responsibilities [18]. Such project-based activities foster critical thinking, empathy, and social interaction skills [19]. To cultivate diligence, honor, responsibility, and healthy lifestyles, a range of club projects has also been proposed—from *Handicraft Workshop* to *Sport in My Life*, *Healthy Nutrition*, and *Digital Hygiene* [20]. Collectively, these measures represent modern models of civic education focused on students’ active participation.

The state program is complemented by regional and school-level initiatives. The *Adal Azamat* program serves as a strategic nationwide document on moral and civic upbringing [4]. It has become the foundation of educational work not only in schools but also in other public institutions [21]. Its developers expect that cooperation among schools, families, public organizations, patriotic clubs, and the media will foster civic competencies in the younger generation.

At the same time, international educational initiatives promoting global citizenship (UNESCO) and digital citizenship—skills for safe and responsible behavior online—are gaining prominence, highlighting the relevance of fostering integrity and tolerance in a “borderless world” [22][3].

An interdisciplinary approach to civic education involves the participation of all stakeholders in the educational process. New methodological guidelines for value-oriented education emphasize cooperation with families, including pedagogical support for parents, joint planning of educational activities, and special forms of parent engagement (seminars, open lessons, trainings) [23]. Students are involved in volunteer initiatives and social projects in cooperation with state institutions and NGOs (museums, theaters, volunteer centers), thereby extending the educational space beyond school boundaries [14][24].

**Contributions of Kazakhstani and International Researchers.** Kazakhstani researchers emphasize the specificity of the national context. T. S. Sabirov, in his collaborative works, highlighted the importance of considering students’ mentality and traditions when developing educational technologies. He is cited among scholars advocating a systemic approach to upbringing, where “systemicity” implies perceiving patriotic and universal values as a unified whole [10]. Other Kazakh educators (A. I. Arynov and others) focus on issues of civic identity in a multicultural environment and on methods of fostering patriotism through local history and literature. Overall, domestic pedagogical science supports the idea of value-oriented education, emphasizing the significance of the national ideology *Mangilik El* and *Nurly Zhol* in cultivating civic consciousness [3]. Kazakhstani scholars also underline the role of family and patriotic traditions (family values, historical memory) in partnership-based upbringing.

Among international scholars, Shalom H. Schwartz and Ronald Inglehart are particularly influential.

Schwartz developed a universal theory of basic values widely used in sociological research on youth. His model describes ten motivationally distinct values arranged in a circular structure [5]. This theory demonstrates that core values such as tolerance, respect, and justice are largely universal and can serve as guidelines for educational practice [5][6].

Inglehart's theories reveal that with increasing economic stability, youth increasingly prioritize post-material values—autonomy, self-expression, and environmental awareness [8]. He demonstrated that value preferences significantly influence socio-political change: the shift from material to post-material values contributes to democracy and civic engagement [8][9]. Educators must consider these international findings, as younger generations are increasingly oriented toward self-realization and respect for others' rights, which demands new approaches to civic education.

International research also highlights the importance of global competencies and digital skills. UNESCO experts in Global Citizenship Education advocate teaching critical thinking and intercultural communication for peace and sustainability. The concept of digital citizenship is defined as the application of civic principles in the borderless online environment [22], emphasizing safe and responsible behavior in cyberspace.

**Practical Examples.** Concrete practices of civic education in schools illustrate the approaches discussed above. A central example is the nationwide implementation of the Adal Azamat program in all schools since 2024 [26]. The program clearly outlines directions and forms of work, from legal education classes to projects promoting tolerance and environmental awareness [12][18]. In curricula for literature, history, and social studies, themes fostering love for the homeland, respect for cultural heritage, and adherence to law are encouraged. For instance, Grade 4 lessons aim to cultivate patriotism, unity, and solidarity based on the ideas of Mangilik El [3].

Class hours are conducted regularly according to model scenarios, with one hour per week dedicated to discussing moral and civic topics—from human rights to social traditions (such as zheti ata and family values).

Extracurricular activities and projects address concrete manifestations of citizenship. Annual events such as Anti-Corruption Month, Constitution Day, and Tugan Zherge Tagzym (a project dedicated to one's small homeland) are organized in schools. Volunteer environmental initiatives (Clean Yard, Eco-Volunteers, tree planting) engage youth in socially useful activities [18]. NGOs and local authorities participate in meetings with veterans, museum visits, and exhibitions, strengthening the link between learning and real life. Teachers employ electronic resources, civic education quizzes, online platforms for social discussions, group discussions, and role-playing games to develop dialogue and compromise skills [16].

The digital environment is also integrated into educational practice. For example, informatics and social studies lessons are combined in the Digital Hygiene project [25], where students learn about online safety, cyberbullying, and information manipulation. Class online communities are used to publish student essays on civic topics and share informational videos on integrity and ecology. Thus, civic values become a cross-cutting theme enriching all aspects of school life [13][14].

As a master's student, I am convinced that civic education is the foundation of society's future. It equips young people not only with knowledge about the state but also with skills for active participation in national life. I believe that systematic and activity-based civic education is especially vital in an era of value crises, when many adolescents face contradictions between traditional family norms and popular culture. Interactive methods, volunteer practices, and meaningful projects help overcome students' detachment from social reality.

However, significant challenges remain: a shortage of qualified civic education teachers, insufficient parental involvement, and the influence of online misinformation on young people's worldviews. The digital world offers both opportunities (online courses, information campaigns) and threats (cyberbullying, fake news, erosion of local traditions). Kazakhstan's multiculturalism requires open dialogue and the construction of a unified civic identity based on respect for cultural diversity. I see strong prospects in strengthening school–family partnerships: family-based projects, joint celebrations, and patriotic initiatives can create a unified educational space. Active parental involvement in developing patriotic projects encourages the transmission of family histories and traditions, enhancing the effectiveness of civic education.

**Conclusion and Recommendations.** In conclusion, modern civic education of schoolchildren is based on the synthesis of universal and national values [1][12]. Programs developed in recent years (such as Adal Azamat) and methodological guidelines aim to integrate educational content into all spheres of school activity [13][18]. The use of active and interactive methods—debates, role-playing games, and projects—deepens value comprehension and fosters social engagement [16][19]. The contributions of Schwartz and Inglehart have helped articulate general principles (universalism, solidarity, tolerance) [5][8], which are reflected in educational practice.

Identified challenges include declining trust in traditional authorities, growing individualism among youth, and the rapid spread of destructive ideas online. To address these challenges, it is advisable to enhance

the continuity of educational programs, expand specialized civic education courses, and develop civic engagement clubs. Educators and policymakers should more actively utilize digital resources—such as integrated multimedia lessons in history and law and online platforms simulating elections or social debates. School councils and student parliaments can play a significant role by enabling students to participate in decision-making and learn civic practice through experience. Additionally, parental training and support for partnership-based upbringing should be expanded through workshops and educational materials.

Thus, a comprehensive approach—combining state policy, pedagogical innovation, and family engagement—will help establish sustainable civic skills among schoolchildren. Continuous updating of educational content in response to global challenges and professional development of teachers will create conditions for nurturing a responsible and patriotic generation aligned with Kazakhstan’s strategic goals.

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**INTERACTION MODEL OF SPORTS AND OUTDOOR ACTIVITIES FOR ENHANCING HEALTH INDICATORS**

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**Abstract**

The growing emphasis on holistic youth development has increased interest in programs that combine structured sports with nature-based activities. Such integrated approaches are believed to enhance physical health, emotional stability, and social functioning by engaging children and adolescents in diverse, developmentally meaningful experiences. Judo, with its pedagogical structure and emphasis on discipline and self-regulation, and outdoor activities, known for promoting adaptability and psychological balance, represent two complementary modalities whose combined effects remain insufficiently explored. **Objective:** This study investigates how judo training and outdoor activities contribute individually and interactively to a composite health index (Y). It further examines whether these effects differ between children aged 7–11 and adolescents aged 12–16, providing insight into age-related developmental responsiveness. **Methodology:** A quasi-experimental longitudinal design was implemented, assessing participants before and after a structured intervention. The program consisted of two components: a judo curriculum emphasizing technical skills, coordination, and behavioral discipline, and an outdoor module involving navigation tasks, cooperative challenges, and nature-based physical activity. Participants were assigned to conditions reflecting judo training (X), outdoor activities (M), or their combined implementation (X·M). Standardized instruments were used to measure physical fitness, self-control, social functioning, psychological resilience, and overall health. Data were analyzed through a regression-based model estimating direct, mediating, and interaction effects. **Results:** The analytical model revealed that all components contributed significantly to the composite health index. Judo training demonstrated a meaningful direct effect, while outdoor activities served as a mediator enhancing the overall impact of the program. The interaction term showed an amplifying influence, indicating that the combined participation produced greater improvements than either activity alone. Age-group comparisons showed that adolescents exhibited more pronounced gains across all indicators, with the largest difference observed in the composite health index, where their improvement exceeded that of younger participants. **Discussion:** The stronger outcomes among adolescents suggest that developmental maturity may enhance the capacity to benefit from structured physical and social experiences. The synergy between judo and outdoor activities appears particularly effective during early and middle adolescence, when cognitive flexibility, emotional regulation, and social awareness undergo rapid refinement. These findings highlight the importance of tailoring interventions to developmental stages to maximize their impact. **Conclusion:** The study demonstrates that integrating judo training with outdoor activities offers a powerful framework for promoting physical, psychological, and social well-being in youth. The combined program yields superior outcomes compared to isolated interventions, with especially strong effects among adolescents. These results support the implementation of age-responsive, multidimensional programs that leverage both structured sport and nature-based experiences to foster comprehensive health development.

**Keywords:** judo training; outdoor activities; youth development; psychological resilience.

**1. Introduction**

Extracurricular sports and outdoor activities play a crucial role in the overall development of children and adolescents by supporting physical health, psychological well-being, and social integration. According to the World Health Organization, regular moderate-to-vigorous physical activity is associated with improved cardiorespiratory endurance, better mental health, and enhanced social functioning among young people (World Health Organization, 2020). These effects are further supported by systematic reviews emphasizing the importance of physical activity for cognitive, emotional, and social development (Janssen & LeBlanc, 2010; Lubans et al., 2016). In this context, extracurricular activities expand the traditional educational environment by promoting informal learning, socialization, and diversification of motor experiences, as highlighted in recent wellness-oriented educational models (Dimitrova & Tomova, 2025).

Judo training represents a particularly effective form of structured physical activity that integrates motor skills, cognitive processes, and value-based education. Research shows that participation in judo enhances self-regulation, discipline, social behavior, and resilience in children and adolescents (Lakes & Hoyt, 2004;



Vertonghen & Theeboom, 2010). Additional evidence indicates that martial arts support the development of executive functions, attention, and emotional regulation, making them a suitable tool for educational programs (Biedrzycki & Laskowski, 2024). As an Olympic sport with clearly structured rules and a pedagogical framework, judo has demonstrated positive effects on self-control, social skills, and psychosocial adaptation (Franchini et al., 2015; Sterkowicz-Przybycień et al., 2017; International Judo Federation, 2020). Adapted sport programs, including those designed for children with diverse needs, further illustrate the developmental potential of structured physical activity (Aleksandrova, 2021).

Outdoor activities complement the effects of sports training by stimulating adaptability, creativity, and psychological well-being. Systematic reviews show that nature-based activities improve attention, reduce stress, and enhance social connectedness among participants (Becker et al., 2017; Mygind et al., 2019). Exposure to natural environments is also associated with higher motivation for physical activity, which amplifies the impact of sports programs and supports sustainable health development (Dimitrova et al., 2018; Dimitrova et al., 2020). Evidence from wellness and recreational health research further demonstrates that outdoor-based interventions contribute to improved well-being and emotional stability, including among specific populations such as pregnant women (Dimitrova & Nesheva, 2021).

Combining judo training with outdoor activities creates an integrated developmental model that simultaneously strengthens physical abilities, psychosocial competencies, and resilience. This approach aligns with contemporary concepts of holistic development and wellness culture, which emphasize the importance of balancing physical, emotional, and social well-being (Dimitrova, 2024). The present study examines the interaction between these two types of activities through a statistical model that evaluates their direct, mediating, and interaction effects on a composite health index (Y). This allows for determining the extent to which the combined program leads to disproportionately higher health outcomes and how these effects vary across different age groups.

## **2. Methods**

### **2.1. Objective**

The aim of the study is to evaluate the direct, mediating, and interaction effects of judo training and outdoor activities within an integrated developmental model, as well as to determine how these effects on physical, psychosocial, and composite health indicators vary across different age groups of children and adolescents.

### **2.2. Methodology**

The study was conducted as a *quasi-experimental longitudinal pre/post design* aimed at assessing the effects of judo training (X), outdoor activities (M), and their interaction (X·M) on physical, psychosocial, and composite health indicators (Y). Two age groups participated: *children (7–11 years)* and *adolescents (12–16 years)*, all medically cleared and participating with parental consent, in line with developmental distinctions described in recent research (Shi & Feng, 2022; Getchell et al., 2022).

The *judo program* followed validated youth training models and included fundamental techniques, strength and coordination exercises, and discipline-focused activities (Franchini et al., 2015; Lakes & Hoyt, 2004). The *outdoor program* consisted of hiking, orienteering, and cooperative tasks shown to support attention, resilience, and well-being (Becker et al., 2017; Mygind et al., 2019). The *combined condition (X·M)* reflected regular participation in both components.

Measurements included *physical fitness* (EUROFIT; Council of Europe, 1988; WHO, 2020), *self-control* (Tangney et al., 2004), *social skills* (Gresham & Elliott, 2008), *psychological resilience* (Connor & Davidson, 2003), and a *composite health index (Y)* constructed through standardized aggregation (Ravens-Sieberer et al., 2007).

### **2.3. Organization of the research**

The research procedure consisted of three stages: a *pre-test* baseline assessment of all indicators, an *intervention phase* with monitored participation in judo and outdoor activities, and a *post-test* reassessment after the completion of the program. Data for children and adolescents were analyzed separately using percentage change ( $\Delta\%$ ) to identify age-related differences in outcomes. The effects of judo training (X), outdoor activities (M), and their interaction (X·M) on the composite health index (Y) were evaluated using the regression model

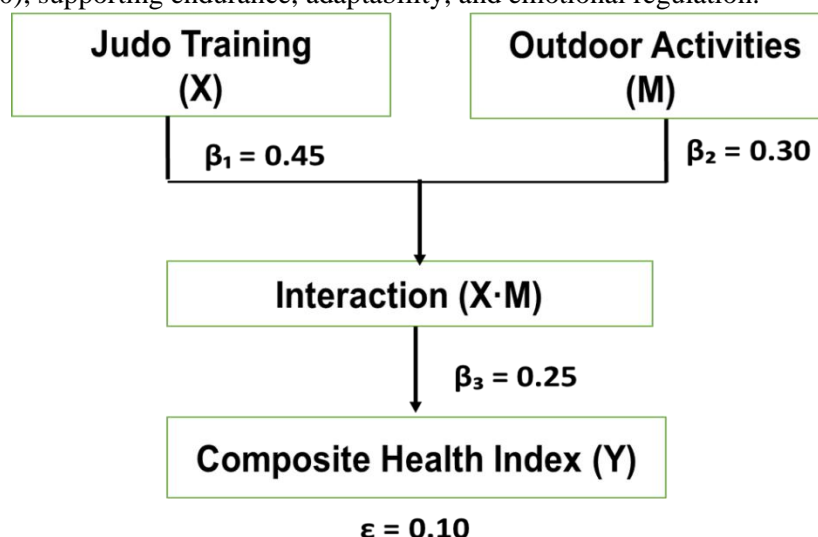
$$Y = \beta_1 \cdot X + \beta_2 \cdot M + \beta_3(X \cdot M) + \varepsilon$$

with parameters:  $\beta_1 = 0.45$ ,  $\beta_2 = 0.30$ ,  $\beta_3 = 0.25$ ,  $\varepsilon = 0.10$ . This analytical approach enabled the assessment of direct, mediating, and interaction effects within the integrated developmental framework.

### 3. Results

Figure 1 presents the analytical model assessing the influence of judo training (X), outdoor activities (M), and their interaction (X·M) on the Composite Health Index (Y). The model is specified as  $Y = \beta_1 \cdot X + \beta_2 \cdot M + \beta_3(X \cdot M) + \varepsilon$ , with coefficients  $\beta_1 = 0.45$ ,  $\beta_2 = 0.30$ ,  $\beta_3 = 0.25$ , and  $\varepsilon = 0.10$ .

Results show that judo training exerts a moderate direct effect on the health index ( $\beta = 0.45$ ), indicating improvements in physical fitness, discipline, and self-control. Outdoor activities contribute an additional mediating effect ( $\beta = 0.30$ ), supporting endurance, adaptability, and emotional regulation.



**Figure 1.** Conceptual Model of Predictors of the Health Index

The interaction term demonstrates an amplifying influence ( $\beta = 0.25$ ), suggesting that combined participation in judo and outdoor activities produces greater health benefits than either activity alone. The error term ( $\varepsilon = 0.10$ ) reflects baseline variance in health outcomes independent of participation.

Interpretation of these findings highlights that the strongest gains in health indicators occur when both activity types are practiced simultaneously and consistently. The structure of the model, illustrated through the directional arrows in Figure 1, reinforces the cumulative and synergistic nature of these effects. Beyond the statistical relationships, the results suggest that extracurricular engagement enriches the developmental environment by promoting socialization, informal learning, and diverse motor experiences, thereby enhancing the overall impact of the program.

Table 2 summarizes the structural components of the model and the quantitative contribution of each predictor to the Composite Health Index (Y). By combining descriptive characteristics with numerical parameters, the table clarifies the functional role and relative importance of the included factors, reflecting the effects of judo training, outdoor activities, and their interdependence.

The results indicate that judo training (X) exerts a medium-strength direct effect ( $\beta = 0.45$ ), associated with improvements in physical conditioning, discipline, and self-regulation. Outdoor activities (M) serve as a mediator with a moderate contribution ( $\beta = 0.30$ ), supporting endurance, adaptability, and emotional stability. The interaction term (X·M) demonstrates the strongest influence ( $\beta = 0.25$ ), suggesting that the combined engagement in both types of activities generates disproportionately higher health index values compared to participating in either activity alone. The constant ( $\varepsilon = 0.10$ ) represents baseline health levels in the absence of participation.

Taken together, this configuration of the model highlights that optimal outcomes are achieved through an integrated approach in which judo training and outdoor activities complement one another. Their combined implementation enhances physical, emotional, and social development, reinforcing the overall effectiveness of the program.

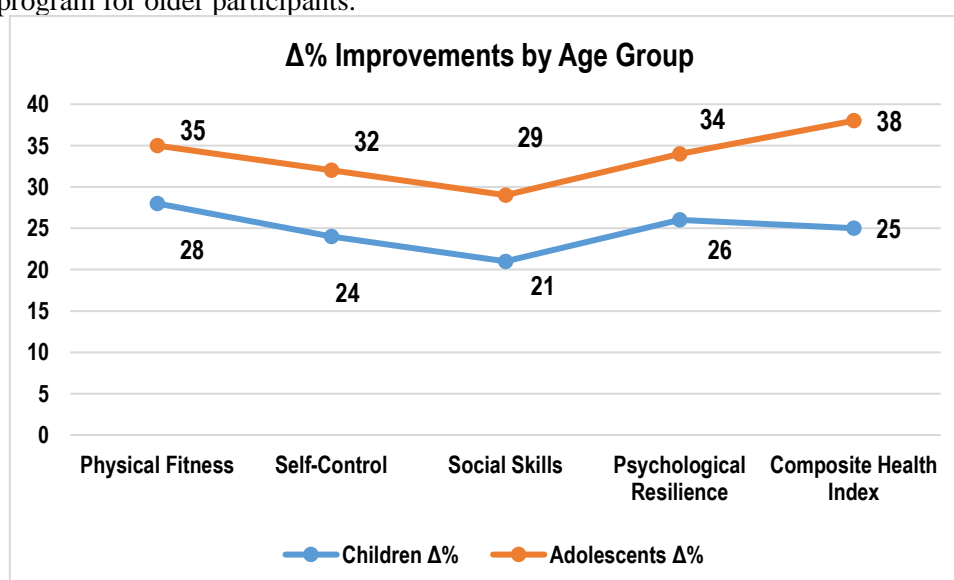
Following the presentation of the model structure and the contribution of each predictor, the next stage of the analysis focuses on differences in effects between the two age groups—children (7–11 years) and adolescents (12–16 years)—as shown in Table 3. This comparison allows for an assessment of the extent to which age moderates the impact of the combined program on key health and psychosocial indicators. Table 3 reports the percentage changes ( $\Delta\%$ ) in five core measures assessed before and after the intervention, enabling a more precise evaluation of developmental dynamics across the two groups.

**Table 3. Comparison Between Age Groups**

Indicator	Children $\Delta\%$	Adolescents $\Delta\%$
Physical Fitness	+28%	+35%
Self-Control	+24%	+32%
Social Skills	+21%	+29%
Psychological Resilience	+26%	+34%
Composite Health Index (Y)	+25%	+38%

The results indicate that both age groups benefit substantially from participation in the program, yet adolescents demonstrate consistently higher levels of improvement across all measured indicators. The most pronounced increase is observed in the Composite Health Index (Y), which rises by 38% among adolescents compared to 25% among children. This difference is likely attributable to the greater cognitive and emotional maturity of older participants, as well as their enhanced capacity to engage more deeply with the training process and social interactions. The marked gains in self-control and psychological resilience among adolescents further suggest that the integrated program is particularly effective during early and middle adolescence, a developmental period in which key personal and social competencies are actively forming.

To provide a clearer visual representation of these differences, Figure 2 displays a line graph comparing percentage improvements across the five key indicators for both age groups. The visualization shows that the curve representing adolescents consistently lies above that of the children, reinforcing the stronger overall effect of the program for older participants.

**Figure 2. Percentage Change Across Indicators**

The findings support the need for age-responsive interventions that leverage the combined potential of structured sport and outdoor activities to promote optimal health and psychosocial development. The visualization in Figure 2 complements the tabular data by clearly illustrating the trend toward greater improvements with increasing age, thereby strengthening the argument for a differentiated approach when designing and implementing such programs.

#### 4. Discussion

The findings indicate that the integrated program combining judo training and outdoor activities produces meaningful improvements in physical, psychosocial, and overall health indicators, confirming the synergistic effect suggested by the regression model. The direct contribution of judo aligns with previous evidence on its role in enhancing discipline, motor coordination, and self-regulation, while outdoor activities support emotional balance, adaptability, and social engagement. The interaction term demonstrates that the combined implementation of both modalities amplifies developmental outcomes beyond the effects of each component alone.

Adolescents showed greater improvements across all indicators, which may reflect their more advanced cognitive and socio-emotional maturity, allowing them to engage more deeply with structured training and cooperative outdoor tasks. This pattern supports the idea that early and middle adolescence is a particularly sensitive period for interventions targeting self-control, resilience, and social functioning.

Despite the strong results, several limitations should be acknowledged. The study relied on a quasi-experimental design without a fully randomized control group, which may limit causal inference. The sample

included only two age ranges, restricting the ability to generalize findings across the full developmental spectrum. Additionally, the duration of the intervention and the absence of long-term follow-up prevent conclusions about the sustainability of the observed improvements. Future research should incorporate larger and more diverse samples, randomized designs, and longitudinal tracking to better understand the lasting impact of integrated sport-and-nature programs.

Overall, the results highlight the value of combining structured sport with outdoor activities as a holistic developmental approach. The consistent improvements across physical, psychological, and social indicators underscore the potential of such programs to complement formal education and support youth well-being in a multidimensional and sustainable way.

## **5. Conclusion**

The results clearly demonstrate that the integrated program combining judo training and outdoor activities is an effective model for promoting holistic development in children and adolescents. The combination of structured physical training and nature-based experiences leads to significant improvements in physical fitness, self-control, social skills, and psychological resilience, with the strongest gains reflected in the composite health index (Y). The regression model confirms that the interaction between the two activity types produces the most substantial amplifying effect, underscoring the value of a multisystem approach that integrates physical, cognitive, and socio-emotional components.

Age-group comparisons reveal that although all participants benefit, adolescents show more pronounced improvements across all indicators, likely due to their greater cognitive maturity and enhanced capacity for self-regulation and social engagement. These findings highlight the importance of tailoring integrated sport-and-nature programs to developmental stages to maximize their impact.

At the same time, the study's quasi-experimental design, the limited age range, and the absence of long-term follow-up suggest the need for further research to confirm the durability and generalizability of the observed effects. Future studies should incorporate randomized designs, broader samples, and longitudinal monitoring to deepen understanding of how such programs influence youth well-being over time.

Overall, the integrated program represents a promising framework for educational, sports, and community settings, offering a sustainable model that strengthens physical health, psychosocial competencies, and emotional stability. Expanding and adapting similar interventions may further enhance their long-term contribution to youth development.

## **Note**

**Conflict of Interest:** No conflict of interest was declared by the author and the institution.

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## **Philological sciences**

### **THE SEARCH FOR A NEW STATE MODEL AND THE IDEAL LEADER IN THE WORKS OF SHEVKET SUREYYA AYDEMİR**

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Shevket Sureyya Aydemir stands as one of the most distinguished figures in the intellectual history, sociological thought, and biographical prose of twentieth-century Turkey. In his writings, he appears both as a theoretical architect of a modern state model and as an artistic interpreter of that model. His work represents a unique interdisciplinary phenomenon situated at the intersection of literature, political philosophy, and historiography. It is therefore impossible to examine Aydemir's intellectual legacy independently of the broader epic of Turkey's modernization, since he was simultaneously a direct witness to this historical transformation, a documentary narrator of its development, and one of the ideological architects of the emerging Republican state. The journal *Kadro*, which he directed in the 1930s, should be regarded as an attempt to provide a scientific foundation for the socio-economic basis of the Turkish Republic. These theoretical explorations later evolved into monumental biographical trilogies in which historical personalities are portrayed through broad sociological portraits that unite their individual lives with the destiny of the nation and the stages of state formation. Through this methodology, Aydemir elevated the genre of biography in Turkish literature from the level of a simple "life story" to that of a "biographical novel" that functions simultaneously as the sociological portrait and philosophical analysis of an entire historical epoch (Tekin, 2010, p. 42).

Aydemir's distinctive contribution to historiography and the theory of state formation lies in his perception of history not as a static accumulation of frozen facts but as a living and dynamic process. Although he absorbed the principles of historical materialism during his education at the Communist University of the Toilers of the East (KUTV) in Moscow, he later synthesized this deterministic framework with the decisive role of individual agency within the context of the Kemalist revolution. For Aydemir, historical personalities are not merely heroic myths; rather, they represent subjective manifestations of sociological necessity. Within this framework, the phenomenon of leadership should not be interpreted solely as a political technique of governance but as a fundamental process emerging at the sharp dialectical intersection between the inner driving forces of history and the will of the individual. The theoretical foundations of this perspective derive both from his revolutionary experience in Russia and from the sociological realities of Anatolia (Aydemir, 1959, p. 11). Aydemir argues that every leader is ultimately the product of the socio-economic crises of his era, and that the leader's historical mission lies in directing the accumulated energy of society toward the construction of a new state structure.

The theoretical backbone of Aydemir's state model is formed by his concepts of "Planning" and the "Conscious Minority" (Aydemir, 1932, p. 3). He emphasizes that the success of a revolution and the institutionalization of a state become possible only through the presence of organized leadership capable of guiding the process according to scientific principles. For Aydemir, leadership resembles a form of historical engineering, requiring an understanding of both the origins and the direction of historical movement. While this approach bears certain similarities to the Hegelian concept of the "world-historical individual," Aydemir locates the true source of leadership power in its organic connection with the sociological base of the nation. In his view, the ideal leader is above all a will capable of filling historical vacuums. Through the example of Mustafa Kemal Atatürk, Aydemir demonstrates how the sociological chaos produced by the collapse of an empire could be transformed into a coherent and rational state structure through unwavering determination. In this sense, the leader becomes not only a political actor but also an aesthetic architect who sketches the future image of the nation and consolidates this identity within state institutions.

Aydemir also separates charisma from mystical interpretations and grounds it firmly in rationality. According to him, the greatness of a leader lies in knowing more than others and in possessing the courage to make decisive choices (Aydemir, 1963, Vol. I, p. 145). In his analysis of Atatürk, Aydemir places greater emphasis on sociological and cultural revolutions than on military victories, interpreting these transformations as the true "art of leadership" (Aydemir, 1965, Vol. II, p. 24). Genuine leadership, he argues, is not achieved through the sword but through the transformative power of ideas and intellectual guidance. Within this process, the leader assumes the role of a pedagogue who elevates the masses to the level of a conscious nation by

instilling a new worldview. The relationship between leader and masses therefore transcends the mere mechanics of governance; it represents a civilizational choice and the individualization of national energy. In Aydemir's narratives, every decision taken by a historical personality appears not merely as a political act but also as a form of documenting the ontological foundations of the Turkish Republic.

The second stage of the state-building ideal is the phase of institutionalization and preservation, which Aydemir examines through the figure of İsmet İnönü. According to Aydemir, if the founding leader represents the revolutionary "fire," the second leader becomes the administrator-engineer who transforms this fire into sustainable energy within the institutional structure of the state. During this stage, state sociology must transition from charismatic legitimacy toward rational-legal legitimacy — that is, toward the rule of law and bureaucracy. İnönü emerges as the defensive line of the Republic, ensuring that the revolutionary reforms take root within the legal apparatus of the state (Aydemir, 1966, Vol. I, p. 45). Aydemir considers İnönü's greatest achievement to be his voluntary transfer of power through peaceful means, thereby reducing himself to the level of an ordinary citizen before the authority of the law — an act that symbolizes the moral culmination of state rationality (Aydemir, 1968, Vol. III, p. 210). In this context, leadership evolves from heroic revolutionary authority toward institutional state rationality.

The democratic trials of the new state model culminate in the tragic case of Adnan Menderes. In *The Drama of Menderes*, Aydemir analyzes the point of collision between populist mass politics and the cold rationality of state institutions. Through the figure of Menderes, he exposes the contradiction between a leader's submission to popular expectations and the necessity of adhering to the structural laws of history (Aydemir, 1969, p. 210). Aydemir demonstrates that when a leader relies solely on mass enthusiasm while neglecting the institutional backbone of the state, he inadvertently prepares the ground for his own downfall. The characterization of Menderes's life as a "drama" reflects the philosophical isolation of a leader caught between the love of the masses and the harsh realities of the state (Aydemir, 1969, p. 450). According to Aydemir, Menderes failed to balance the rationality of the state with the dynamic energy of society, which ultimately led to his confrontation with the protective institutions of the political system.

For Aydemir, leadership is also an existential solitude. He observes that "in the moments when the greatest decisions are made, the leader is more alone than anyone else" (Aydemir, 1963, Vol. I, p. 28). This solitude represents the burden of foresight and responsibility. Within Aydemir's intellectual framework, the role of the individual in history can be described as an "ontology of duty." The leader is also the "master of time," a strategist capable of identifying the precise historical moment for action. If the leader advances too far ahead of the masses, society loses connection with him; yet if he remains behind the collective movement, historical momentum fades. Through this methodology, Aydemir captures the intellectual tension experienced by revolutionary elites navigating between the old world and the emerging new order. He ultimately demonstrates that for a state to progress, the guiding will of leadership must transform the suffering of the nation into creative historical energy.

In conclusion, the artistic-biographical legacy of Şevket Süreyya Aydemir can be regarded as a manifesto of Turkey's historical self-consciousness. The portraits he created provide one of the most fundamental theoretical frameworks for understanding both the past and the future of Turkish modernization. Within these works, the leader appears as an architect who reads the spirit of the nation and constructs the institutional structures required by that spirit. Aydemir demonstrates that the ideal leader does not oppose the objective flow of history but acts as a catalyst accelerating that flow. His prose ultimately teaches that the individual is simultaneously both the master and the servant of history: by embodying the will of the nation and transforming chaos into order, the leader achieves historical legitimacy at the level of civilization. For this reason, Aydemir's biographical novels remain a significant documentary-literary reservoir for analyzing contemporary models of leadership and state formation.

**Keywords:** Şevket Süreyya Aydemir, Leadership Phenomenon, Turkish Modernization, Biographical Prose, Political Leadership, Republican Turkey

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**AZERBAIJANI LANGUAGE: FROM POLITICS TO NATIONAL MEMORY (DURING THE  
PRESIDENCY OF MR. ILHAM ALIYEV)**

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**AZƏRBAYCAN DİLİ: SİYASƏTDƏN MİLLİ YADDAŞA (CƏNAB İLHAM ƏLİYEVİN  
PREZİDENTLİYİ DÖVRÜNDƏ)**

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**Abstract**

The Azerbaijani language, as the main pillar of the nation's historical memory, national identity, and spiritual values, has undergone a complex yet rich path of development over the centuries. Rooted in ancient Turkic languages, it evolved into a literary language in the Middle Ages and reached a high artistic and aesthetic level through the works of classical poets such as Nasimi, Fuzuli, and Shah Ismail Khatai. During the national awakening of the 19th–20th centuries, the protection and development of the mother tongue became one of the leading ideological directions. The declaration of Azerbaijani as the state language during the period of the Azerbaijan Democratic Republic marked a significant milestone in the history of national statehood.

Despite certain restrictions during the Soviet period, the language was preserved through literature and culture. In 1978, at the initiative of Heydar Aliyev, Azerbaijani was enshrined in the Constitution as the state language. After the restoration of independence, language policy became one of the main directions of state-building, and the full transition to the Latin-based alphabet in 2001 constituted an important stage of this policy.

During the presidency of Ilham Aliyev, the Azerbaijani language has been regarded not only as a means of official communication but also as a strategic factor of national security, ideological independence, and cultural sovereignty. The President considers the preservation of linguistic purity, the strengthening of literary norms and principles, and the regulation of uncontrolled foreign influences in the context of globalization as priority areas. He emphasizes the role of language as one of the fundamental attributes of statehood and a key instrument in safeguarding national identity.

Furthermore, practical steps have been taken to ensure that Azerbaijanis living abroad master their native language at a high level, including the establishment of online schools and the strengthening of the Azerbaijani language's position in the global information space. Thus, in the modern period, the Azerbaijani language has evolved from being merely a subject of political discourse into a central pillar of national memory, statehood philosophy, and national ideology.

**Xülasə**

Azərbaycan dili xalqın tarixi yaddaşını, milli kimliyini və mənəvi dəyərlərini daşıyan əsas sütun kimi əsrlər boyu mürəkkəb, lakin zəngin inkişaf yolu keçmişdir. Qədim türk köklərinə söykənən dil orta əsrlərdə ədəbi dil kimi formalaşmış, Nəsimi, Füzuli, Şah İsmayıl Xətai kimi sənətkarların yaradıcılığı ilə bədii kamillik səviyyəsinə yüksəlmişdir. XIX–XX əsrlərdə milli oyanış prosesində ana dilinin qorunması və inkişafı əsas ideoloji istiqamətlərdən biri olmuş, Azərbaycan Xalq Cümhuriyyəti dövründə Azərbaycan dilinin dövlət dili elan edilməsi milli dövlətçilik tarixində mühüm hadisəyə çevrilmişdir. Sovet dövründə müəyyən məhdudiyyətlərə baxmayaraq, dil ədəbiyyat və mədəniyyət vasitəsilə yaşadılmış, 1978-ci ildə Heydər Əliyev təşəbbüsü ilə Konstitusiyada dövlət dili kimi təsbit olunmuşdur. Müstəqillikdən sonra isə dil siyasəti dövlətçilik strategiyasının əsas istiqamətlərindən birinə çevrilmiş, 2001-ci ildə latın qrafikalı əlifbaya tam keçid bu siyasətin mühüm mərhələsi olmuşdur. Ulu Öndərin siyasətini davam etdirən İlham Əliyev rəhbərliyi dövründə Azərbaycan dili yalnız rəsmi ünsiyyət vasitəsi kimi deyil, milli təhlükəsizlik, ideoloji müstəqillik və mədəni suverenliyin əsas amili kimi qiymətləndirilir. Prezident dilin saflığının qorunmasını, xarici təsirlərin nəzarətsiz şəkildə artmasının qarşısının alınmasını və ədəbi norma və prinsiplərin möhkəmləndirilməsini prioritet hesab edir. O, dili dövlət atributlarından biri kimi dəyərləndirərək milli kimliyin qorunmasında aparıcı rolunu xüsusi vurğulayır. Eyni zamanda, xaricdə yaşayan azərbaycanlıların ana dilini mükəmməl bilməsi üçün

onlayn məktəblərin yaradılması və dilin beynəlxalq müstəvidə nüfuzunun artırılması istiqamətində addımlar atılmışdır. Beləliklə, müasir mərhələdə Azərbaycan dili həm tarixi-mədəni irsin daşıyıcısı, həm də dövlətçilik fəlsəfəsinin və milli ideologiyanın əsas sütunu kimi inkişaf edir və möhkəmlənir.

**Keywords:** Azerbaijani language, İlham Aliyev, Azerbaijani, language policy, national memory

**Açar sözlər:** Azərbaycan dili, İlham Əliyev, azərbaycanlı, dil siyasəti, milli yaddaş

### **Giriş**

Azərbaycan dili ünsiyyət vasitəsi olmaqla yanaşı, xalqın tarixi taleyini, mənəvi dəyərlərini və milli kimliyini daşıyan əsas sütundur. Dilin keçdiyi yol göstərir ki, o, müxtəlif dövrlərdə siyasi qərarların təsiri altına düşsə də, nəticədə milli yaddaşın ən möhkəm dayağına çevrilmişdir.

Azərbaycan dili əsrlər boyu mürəkkəb və zəngin inkişaf yolu keçmişdir. Onun formalaşması qədim türk tayfa dillərinə dayanır. Orta əsrlərdə Azərbaycan türkcəsi ədəbi dil kimi təşəkkül tapmış, saray və poeziya dili səviyyəsinə yüksəlmişdir. Qədim və orta əsrlərdə Nəsimi, Füzuli, Şah İsmayıl Xətai kimi sənətkarların yaradıcılığı dilin bədii imkanlarını genişləndirmişdir. XIX–XX əsrlərdə dil məsələsi milli oyanışın əsas istiqamətlərindən biri idi. Maarifçilər və ziyalılar ana dilində təhsilin, mətbuatın və ədəbiyyatın inkişafını xalqın tərəqqisi üçün vacib sayırdılar. XX əsrin əvvəllərində yaradılan Azərbaycan Xalq Cümhuriyyəti dövründə Azərbaycan dili dövlət dili elan edildi. Bu qərar milli dövlətçilik tariximizdə mühüm hadisə idi. Sovet hakimiyyəti illərində dilin statusu dəyişsə də, o, ədəbiyyat və mədəniyyət vasitəsilə yaşamağa davam etdi. 1978-ci ildə Ulu öndər Heydər Əliyevin təşəbbüsü ilə Azərbaycan dilinin konstitusiyada dövlət dili kimi təsbit olunması mühüm siyasi addım idi. 1991-ci ildə müstəqillik bərpa edildikdən sonra Azərbaycan dili dövlət quruculuğunun əsas atributlarından birinə çevrildi.

Siyasi müstəvidə Azərbaycan dili

Müstəqillik əldə edildikdən sonra, xüsusilə, ümummilli lider Heydər Əliyev və daha sonra İlham Əliyev tərəfindən dil siyasəti dövlətçilik strategiyasının əsas istiqamətlərindən birinə çevrildi. 2001-ci ildə latın qrafikalı Azərbaycan əlifbasına tam keçid bu siyasətin mühüm mərhələsi oldu.

### **Cənab prezident İlham Əliyevin dilə diqqət və qayğısı**

Cənab Prezident İlham Əliyevin rəhbərliyi dövründə Azərbaycan dili yalnız rəsmi ünsiyyət vasitəsi kimi deyil, milli yaddaşın və mənəvi dəyərlərin daşıyıcısı kimi qorunur və inkişaf etdirilir. Dövlət başçısının sərəncamları ilə Azərbaycan dilinin saflığının qorunması, ədəbi dil normalarının möhkəmləndirilməsi və informasiya məkanında düzgün istifadəsinin təmin olunması istiqamətində mühüm addımlar atılmışdır.

Latın qrafikalı əlifbanın tətbiqinin möhkəmləndirilməsi, klassik və müasir ədəbiyyat nümunələrinin kütləvi tirajla nəşri, Azərbaycan dilinin elektron resurslarının yaradılması bu siyasətin tərkib hissəsidir. Eyni zamanda beynəlxalq tədbirlərdə və rəsmi platformalarda Azərbaycan dilinin nüfuzu artırılmış, ana dilimizin global informasiya məkanında mövqeyi gücləndirilmişdir.

Bu dövrdə dil siyasəti artıq yalnız hüquqi çərçivə ilə məhdudlaşmır; o, milli ideologiyanın, vətənpərvərlik tərbiyəsinin və mədəni irsin qorunmasının əsas istiqamətinə çevrilmişdir. Azərbaycan dili siyasətin predmetindən çıxaraq milli yaddaşın canlı ifadəsinə dönmüşdür.

Prezident İlham Əliyevin 2026-cı il yanvarın 5-də yerli televiziyalara müsahibəsində Azərbaycan dilinin qorunması haqqında söylədikləri onun dil siyasətinin xülasəsidir. "Dil o amildir ki, milləti millət edir" deyən Azərbaycan Prezidenti İlham Əliyev Azərbaycan dilinə xarici kəlmələrin gəlməsinə qarşı olduğunu söyləyib. Prezidentin çıxışlarında dilin deqradasiyası yalnız linqvistik problem kimi deyil, milli kimliyin zəifləməsinə səbəb ola biləcək strateji risk kimi təqdim edilir: "Xarici kəlmələr dilimizi pozur, zənginləşdirmir və milli kimliyimizi də sarsıdır, damcı-damcı, yavaş-yavaş. Bəlkə də özümüz heç buna fikir vermirik, damcı-damcı sarsıdır. Dil əldən gedəndən sonra, yaxud da ki, pozulandan sonra, ya da başqa dilə tamamilə uyğunlaşandan sonra onda milli kimlik də gedəcək, ondan sonra dövlətçilik də gedəcək, ondan sonra, Allah eləməsin, ölkəmiz də, necə deyirlər, böyük fəlakətlə üzləşə bilər. Ona görə Azərbaycan dilini qorumaq hər birimizin vəzifəsidir"(2), - İlham Əliyev demişdir.

Doğma dilimizə ehtiyac olmadan daxil edilən və yerli qarşılığı olduğu halda işlədilən yad sözlər zaman-zaman dilimizin saflığı baxımından müəyyən çətinliklər yaratmışdır. Bu məsələ ümummilli lider Heydər Əliyev ənənələrini davam etdirən İlham Əliyev üçün də həssas mövzulardan biri olmuşdur.

Prezident 3 noyabr 2025-ci ildə AMEA-nın 80 illik yubileyindəki çıxışında bu mövqeni aydın şəkildə ifadə edərək qeyd etmişdir ki, beynəlxalq leksikonun mövcudluğu danılmazdır və bütün xalqlar ondan istifadə edir. Lakin Azərbaycan dilində qədimdən mövcud olan, məna baxımından tam adekvat qarşılığı olan sözlərin başqa dillərdən alınmalarla əvəzlənməsi nə elmi, nə də funksional baxımdan əsaslandırıla bilər. Belə yanaşma ya dilçilik prinsiplərinə ziddir, ya da məqsədli şəkildə dil sisteminə müdaxilə kimi qiymətləndirilə bilər.



Dövlət başçısı dilin saflığının qorunması üçün ardıcıl tədbirlərin və islahatların vacibliyini vurğulayıb, ana dilinə xidmət etməyi xalq qarşısında mədəni məsuliyyət və müqəddəs vəzifə kimi dəyərləndirmişdir. Onun fikrincə, dil insanları birləşdirən əsas amildir və bayraq, gerb, himnlə yanaşı dövlətçiliyin aparıcı atributlarından biridir.

Prezident Azərbaycanın tarixən müxtəlif imperiyaların tərkibində olduğunu, işğal və müstəmləkəçilik dövrləri yaşadığını xatırlatmış, lakin buna baxmayaraq, xalqımızın zəngin müstəqillik ənənələrinə malik olduğunu vurğulayıb. Bununla belə, uzunmüddətli asılılıq mərhələlərinin milli psixologiyada müəyyən izlər buraxdığını, həmin təsirlərin bu gün də müəyyən dərəcədə hiss olunduğunu qeyd etmişdir.

İlham Əliyev dilin milləti millət edən əsas faktor olduğunu xüsusi önə çəkmişdir. Onun sözlərinə görə, Azərbaycan dili əsrlər boyu qorunub saxlanmış, nəsil-dən-nəslə ötürülmüş və bu gün danışılan dil ulu babalarımızın danışdığı dildən mahiyyət etibarilə fərqlənmir. Bu fakt xalqımızın mədəni gücünün göstəricisi kimi dəyərləndirilir. Sovet dövründə leksikona daxil olmuş bəzi sözlərə baxmayaraq, müstəqillik illərində milli dil şüurunun gücləndiyi və dilin öz daxili imkanları hesabına saflaşdırıldığı vurğulanır.

Prezident həmçinin dünyada 50 milyondan artıq azərbaycanlının yaşadığını qeyd edərək, Azərbaycan dilinin heç bir dilin kölgəsində qalmadığını, zəngin, melodik və ifadə imkanları baxımından geniş potensiala malik olduğunu bildirmişdir. Onun qənaətinə görə, xalqımız müstəmləkəçilik dövrlərində belə dilini qoruyub saxlamışdırsa, müstəqil dövlət şəraitində bu dəyəri daha da möhkəmləndirmək hər birimizin borcudur.

Dövlət başçısının müxtəlif illərdə, xüsusilə, 2025-ci ilin yekunlarına həsr olunmuş müsahibəsində ifadə etdiyi mövqe göstərir ki, İlham Əliyev Azərbaycan dilini yalnız kommunikativ vasitə kimi deyil, milli təhlükəsizlik, ideoloji müstəqillik və mədəni-psixoloji azadlıqla birbaşa bağlı strateji amil kimi qiymətləndirir. Bu yanaşma dilin dövlətçilik fəlsəfəsində sistemli yer tutduğunu nümayiş etdirir.

İlham Əliyev dilə münasibətində əsas ideyanı belə formalaşdırır: dil dövlətçiliyin fundamental atributudur və milli suverenliyin mədəni əsasını təşkil edir. Dövlət rəmzləri sırasında dil xüsusi yer tutur və milli kimliyin qorunmasında birinci dərəcəli rol oynayır. Prezidentin bu mövqeyi onun məşhur fikrində də aydın ifadə olunur: “Dil dövlətçiliyin əsas atributlarından biridir, bəlkə də birincisidir, təbii ki, bayraq, gerblə, himnlə birlikdə”(4).

Bu yanaşma dil məsələsini sırf mədəni müstəvidən çıxararaq ideoloji və siyasi kontekstə daşıyır. Dil burada yalnız ünsiyyət vasitəsi deyil, milli varlığın, tarixi yaddaşın və dövlətçilik ideyasının daşıyıcısı kimi təqdim olunur. Azərbaycan dili dövlət ideologiyasının ifadə olunduğu əsas platforma statusu qazanır.

Prezidentin dil siyasətində mühüm istiqamətlərdən biri leksik saflığın qorunmasıdır. Xarici sözlərin nəzarətsiz şəkildə dilə daxil olması zənginləşmə kimi deyil, dil sisteminin daxili tarazlığını pozan və milli kimliyi mərhələli şəkildə aşındıran proses kimi qiymətləndirilir. Bu mövqe dilçilik baxımından “xarici təsir” anlayışının yenidən nəzərdən keçirilməsini tələb edir. Burada məsələ təkcə leksik alınmalar deyil, ana dilinə inamın zəifləməsi, milli dil şüurunun sarsılması və yad dilin psixoloji üstünlük simvoluna çevrilməsi ilə bağlıdır.

Bununla yanaşı, İlham Əliyev internet və sosial şəbəkələr vasitəsilə dilə və ictimai şüura nüfuz edən yad təsirləri qloballaşmanın təbii və neytral nəticəsi kimi deyil, müasir dövrdə mədəni ekspansiyanın əsas alətlərindən biri kimi dəyərləndirir. Bu kontekstdə məsələ yalnız alınma sözlərin artması deyil, həmin təsirlərin dil davranışını, estetik ölçüləri və milli dil şüurunu yönləndirmə gücü ilə bağlıdır.

Beləliklə, Prezidentin dil siyasətində iki paralel istiqamət formalaşır: qloballaşma şəraitində açıq informasiya mühitində iştirak etmək və eyni zamanda milli dilin daxili dayanıqlığını qorumaq. Bu, dilin “immun sisteminin” gücləndirilməsi kimi təqdim olunur — yəni dil yeniliyə açıq qalır, lakin öz struktur bütövlüyünü və normativ əsaslarını itirmir.

Bu yanaşma dilin qorunmasını ənənəvi müdafiə modelindən çıxararaq onu mədəni təhlükəsizlik strategiyasının tərkib hissəsinə çevirir. Azərbaycan dili artıq yalnız daxili ünsiyyət vasitəsi deyil, global informasiya məkanında milli mövqeyin, ideoloji müstəqilliyin və mədəni suverenliyin qorunmasının əsas aləti kimi qiymətləndirilir.

Cənab Prezident Azərbaycan dilindən bəhs edərkən onun inkişafını ölkə sərhədlərindən kənarda da izlədiyini söyləmişdir. O, yalnız rəhbərlik etdiyi on milyonluq Azərbaycanın deyil, həm də xaricdə yaşayan hər bir azərbaycanlının taleyinə biganə qalmayan bir lider kimi xaricdə yaşayan soydaşlarımızın ana dilini dərinlən mənimsəməsinin vacibliyini xüsusi qeyd etmiş, bu istiqamətdə mühüm addımlar atıldığını bildirmişdir. O, Azərbaycan dilinin zənginliyini ön plana çəkərək, dünyanın müxtəlif ölkələrində yaşayan 50 milyon azərbaycanlının ana dilinin Azərbaycan dili olduğunu bəyan etmişdir. Prezident qeyd etmişdir ki, bütün dillərə hörmətlə yanaşır, lakin Azərbaycan dilinin qorunmasının dövlətin əsas vəzifələrindən biri olduğunu hesab edir. Onun fikrincə, xaricdə yaşayan azərbaycanlılar dili yalnız məişət səviyyəsində deyil, yüksək səviyyədə bilməlidirlər və buna ciddi ehtiyac vardır.

Dövlət başçısı xarici ölkələrdə Azərbaycan məktəblərinin olmamasını ədalətsizlik kimi qiymətləndirmiş və bu problemin aradan qaldırılması üçün artıq konkret tədbirlərin həyata keçirildiyini diqqətə çatdırmışdır. Onun təşəbbüsü ilə onlayn məktəblər yaradılmış, gələcəkdə isə bu məktəblərin əhatə dairəsinin daha da genişləndiriləcəyi bildirilmişdir. Prezident vurğulamışdır ki, azərbaycanlıların yaşadıkları bütün ölkələrdə Azərbaycan dilində təhsil imkanlarının olması mühüm əhəmiyyət daşıyır. O, həmçinin ən böyük arzularından birinin xaricdə yaşayan soydaşlarımızın Azərbaycan dilində səlis və düzgün danışması olduğunu qeyd etmişdir.

Prezident bəzi jurnalistlərin ictimai çıxışlarda lüzumsuz xarici sözlərdən istifadə etməsini də təəssüflə xatırlatmış, ziyalıları, yazıçı və şairləri bu məsələdə daha fəal mövqe sərgiləməyə çağırmışdır. Onun sözlərinə görə, dilin qorunması hər bir vətəndaşın borcudur. Prezident bildirmişdir ki, ana dilimizi nə qədər saf və təmiz saxlasaq, milli kimliyimiz də bir o qədər möhkəm olacaq və xalq olaraq mənəvi bütövlüyümüz qorunacaqdır.

#### **Nəticə**

Beləliklə, Prezident İlham Əliyevin rəhbərliyi altında Azərbaycan dili həm dövlət dili kimi möhkəmlənmiş, həm də xalqın tarixi yaddaşını, mədəni kimliyini və mənəvi bütövlüyünü qoruyan əsas dəyər kimi yeni inkişaf mərhələsinə qədəm qoymuşdur.

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**PRINCIPLES OF TEXT ORGANIZATION**

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**Abstract**

Text is regarded as the highest-level communicative unit of language and is not merely a sequence of sentences. It constitutes a complete system through the integration of semantic, structural, and pragmatic elements and is considered a product of social and communicative activity. The principles of text organization ensure coherence, logical flow, and communicative effectiveness. Key principles include coherence, structural integrity, sequencing, cohesion, informativeness, intentionality, acceptability, situationality, and intertextuality. Paragraphs and linguistic resources facilitate grouping of ideas and enhance expressiveness. Applying these principles improves comprehension and communicative impact of the text (Beaugrande & Dressler, 1981; Halliday & Hasan, 1976; van Dijk, 1980).

**Keywords:** Text, coherence, cohesion, structure, intentionality, intertextuality, informativeness, paragraph.

**Xülasə**

Mətn dilin ən yüksək səviyyəli kommunikativ vahidi kimi qiymətləndirilir və yalnız cümlələrin ardıcılığından ibarət deyil. Mətn semantik, struktur və pragmatik elementlərin inteqrasiyası ilə bütöv sistem yaradır və sosial- kommunikativ fəaliyyətin məhsulu kimi nəzərdən keçirilir. Mətnin tərtib olunma prinsipləri onun məna bütövlüyünü, ardıcılığını və təsir gücünü təmin edir. Əsas prinsiplərə koherentlik, struktur bütövlüyü, ardıcılıq, koheziya, informasiyalıq, məqsədyönlülük, qəbul edilə bilənlik, situativlik və intertekstuallıq daxildir. Mətnin abzas və dil vasitələri fikirlərin qruplaşdırılmasını və ifadəliliyi təmin edir. Bu prinsiplərdən istifadə mətnin anlaşılmasını və kommunikativ təsirini artırır (Beaugrande & Dressler, 1981; Halliday & Hasan, 1976; van Dijk, 1980).

**Резюме**

Текст рассматривается как наивысшая коммуникативная единица языка и не ограничивается лишь последовательностью предложений. Он представляет собой целостную систему, формируемую интеграцией семантических, структурных и прагматических элементов, и рассматривается как продукт социальной и коммуникативной деятельности. Принципы построения текста обеспечивают когерентность, логическую последовательность и коммуникативную эффективность. Основные принципы включают когерентность, структурную целостность, последовательность, когезию, информативность, целеустремлённость, приемлемость, ситуативность и интертекстуальность. Абзацы и языковые средства способствуют группировке идей и повышению выразительности текста. Использование этих принципов улучшает понимание и коммуникативное воздействие текста (Beaugrande & Dressler, 1981; Halliday & Hasan, 1976; van Dijk, 1980).

**Introduction**

A text is the highest-level communicative unit of language and is not merely a sequence of sentences; it constitutes a complete system through the integration of semantic, structural, and pragmatic elements (Beaugrande & Dressler, 1981; van Dijk, 1980). From a contemporary linguistic perspective, a text is viewed not only as a grammatical unit but also as a product of social and communicative activity. Proper organization of a text ensures its semantic integrity, comprehensibility, and communicative impact. Therefore, the principles of text construction are a central focus in linguistics and communication studies.

The development of text theory owes much to scholars such as Robert de Beaugrande, Wolfgang Dressler, Teun A. van Dijk, and M.A.K. Halliday (Halliday & Hasan, 1976). They identified the structural and functional features of texts and explained organizational principles on a scientific basis.

The principles of text organization in literary and non-literary texts share certain similarities but also exhibit differences. Common features include intentionality, coherence, topical and content relevance, and informativeness. The principle of intentionality requires a planned sequence consistent with the author's purpose; expressions must align with the topic in terms of content and style.

The connection between paragraphs and sentences, i.e., cohesion, is a fundamental structural principle of text. In literary texts, organizational principles vary according to the form of expression:

1. Poetry – characterized by rhythm, meter, rhyme, refrain, and other poetic devices.
2. Prose – expressed through descriptive and narrative techniques.

3. Dramatic language – expressed through show, monologue, dialogue, and polylogue forms.

Non-literary texts vary according to style. In scientific texts, concreteness, accuracy, logic, sequence, and terminological density are essential. Scientific commentaries present hypotheses, theoretical insights, and research findings. In journalistic (publicistic) style, clarity, mass appeal, and comprehensibility are emphasized; descriptive and analytical commentary play a role in text organization. Official-business texts require precision, concreteness, and adherence to standard syntactic models. Everyday communication style relies on oral elements and a free expression form.

#### Key Principles of Text Organization

1. Coherence (semantic integrity): All parts of a text are connected around a central topic, expressing the main idea. Coherence is ensured through topic unity, logical sequence, cause-effect relationships, and general semantic direction.

2. Structural integrity: Every text consists of an introduction, main body, and conclusion. The introduction presents the topic, the main body develops the idea, and the conclusion summarizes and generalizes.

3. Sequentiality: Ideas should be presented in a logical or chronological order, facilitating readers' comprehension.

4. Cohesion: The connection between sentences and paragraphs is established through pronouns, repetitions, synonyms, conjunctions, and particles.

5. Informativeness: The text should provide readers with new and significant information; redundant or already known information decreases its value.

6. Intentionality: A text should align with the author's purpose, reflecting their intent (to inform, explain, persuade, describe, influence, etc.).

7. Acceptability: The text must be understandable and acceptable to the reader; style and language should match the reader's level.

8. Situationality: The content and form of a text depend on the context of its use. For example, scientific articles are objective and formal, journalistic texts aim at public impact, and literary texts create aesthetic and emotional effects.

9. Intertextuality: A text is connected to other texts through references, quotations, allusions, and scholarly sources.

#### Importance of Paragraphs

A paragraph is a micro-topic unit within a text; it groups ideas, organizes structure, facilitates reading, and ensures meaning transitions.

Role of Linguistic Means Lexical (terms, synonyms), grammatical (tense forms, syntactic structures), and stylistic (metaphors, epithets) tools enhance the expressiveness and precision of a text.

#### Example Models:

##### Model 1:

Identify the correct statement based on the text:

In 1971, Japanese scientists studying landslides watered a hill intensively with fire hoses to simulate heavy rainfall. As a result, four scientists and 11 spectators died when the hill collapsed.

A) The event occurred in the first half of the century.

B) All participants experienced the feeling of "regret is useless."

C) Artificial events create illusions.

D) Although the national identity of the scientists is known, the motivation behind the activity is unknown.

E) The exact location of the event is known, but the extent of the landslide is unclear.

Correct answer: D

Model 2: Identify the incorrect statement: Since the 1960s, a mysterious light appeared and moved on a hillside at night. Locals believed it was the glow of a spirit returning to the world. This belief generated fear and curiosity for years. However, in 2010, Michigan Technological University students scientifically investigated the phenomenon and proved that the light came from car headlights on a nearby highway. The study showed that while people may attribute unexplained events to supernatural causes, scientific approaches allow rational and logical explanations.

1. The text shows that long-unexplained events can give rise to local beliefs and folklore.

2. The supernatural interpretation of the Paulding light was due to a lack of scientific research.

3. The 2010 study proved the light came from car headlights.

4. The text demonstrates that scientific approaches can critically dispel myths and beliefs.

5. The source of the Paulding light remains scientifically unexplained.

Correct answer: E

Model 3: Determine correct and incorrect statements based on the text: F1 and RGD-5 hand grenades were developed in the 20th-century Soviet military industry and are distinguished by their structural and functional characteristics. F1 has a thick, segmented metal body, is defensive, and produces numerous fragments upon explosion. RGD-5 has a thin-walled, smooth body, is offensive, and produces fewer fragments, making it lighter and more effective in attack conditions. Both have mechanical detonators and operate by converting explosive energy into kinetic impact, holding tactical importance and being widely studied in modern military science.

Correct about F1	Incorrect about RGD-5
Unlike the other, it is an explosive from a century earlier. Unlike its counterpart, it is not intended for offensive use. Although its operating mechanism is provided, its naming purpose was not explained.	It can be used for defensive purposes. Its shrapnel-producing function is less than that of the other. Its extensive study in the military field continues to this day.

Correct answers: 2, 3, 4

Model 4: Identify the correct statement about the table:

- A) The difference in moisture levels between 2018 and 2023 is equal to that between 2019 and 2022.
- B) After 2018, the moisture level closest to the norm was in 2022.
- C) From 2020 onwards, moisture levels decreased over three years.
- D) After 2018, the highest moisture level was in 2022.
- E) Annual minimum moisture levels were below 10 mm.

Correct answer: B

In conclusion, the principles of text organization ensure its structural, semantic, and communicative integrity. Adhering to these principles guarantees logical, clear, and effective texts (Beaugrande & Dressler, 1981; Halliday & Hasan, 1976). In modern linguistics, a text is not merely a sum of sentences but a product of communicative and social activity. Therefore, studying text organization principles is crucial in linguistics, education, and communication studies.

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# **Physical sciences**

## **ANALOGICAL RELATIONSHIPS BETWEEN ELECTRICAL CIRCUITS AND THERMODYNAMIC SYSTEMS IN PHYSICS EDUCATION**

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### **Abstract**

The article substantiates the significant role of the analogy method in physics education in the formation of scientific knowledge and the comprehension of abstract concepts. It analyzes the application of analogical reasoning in physics lessons through a comparative examination of thermodynamic systems and electrical circuits. The structural similarity established between thermodynamic systems and electrical circuits enables students to develop a clearer understanding of complex processes. Mathematical and physical correspondences are demonstrated between electric potential difference and temperature difference, electric current and heat flux, as well as electrical resistance and thermal resistance. An analogical relationship is examined between the capacitor charging equation and the heat balance equation of a body with homogeneous temperature distribution. Furthermore, the structural similarity between Ohm's law and Fourier's law reveals the scientific foundations of the thermal–electrical analogy. This approach emphasizes the fundamental role of the law of energy conservation in both domains. The proposed models provide opportunities for the analysis of heat flows, energy distribution, and heat losses, thereby enabling high-quality engineering evaluation. Consequently, the thermal–electrical analogy serves as an effective method both in the teaching process and in scientific modeling.

**Keywords:** Analogy method, thermodynamic–electrical system analogy, modeling, mathematical correspondence, structural similarity.

The collection and analysis of scientific data, the comparison of physical phenomena and processes in order to identify their similarities and differences, and the subsequent generalization leading to the formulation of sound scientific conclusions highlight the particular significance of the analogy method in scientific inquiry.

In physics education, analogies serve as a bridge between the material world and the abstract domain of physics, helping students visualize abstract concepts and develop the ability to transfer structural frameworks acquired in one domain to another. An analogy is an empirical–cognitive method based on establishing structural similarities with more familiar and observable systems in order to explain objects and processes that cannot be directly perceived through visual observation or immediately grasped through experimentation. Analogies function not merely as computational tools but also as a foundation for deep learning. For instance, James Clerk Maxwell, in formulating the theory of electromagnetic phenomena, relied not only on empirical observations but also extensively on analogical reasoning. He employed the analogy of heat flow in developing his theoretical framework. This illustrates the power of analogy in the creation of new scientific knowledge.

In this article, new types of models are proposed based on the thermal–electrical analogy in order to obtain deeper insight into the internal elements of a system. These models provide valuable information that cannot be readily obtained through other modeling structures; for example, they enable the analysis of heat flows, the amount of energy stored in different regions of a system, and heat losses to the environment. Such models allow engineers to qualitatively assess the effects that mechanical modifications may exert on system performance. The central idea presented in the article is the construction of models grounded in the fundamental analogical relationship between thermal systems and electrical circuits. The analogy between electrical circuits and thermal systems is widely applied both as a manifestation of the interrelation of fundamental physical laws and as a powerful method for modeling and teaching complex systems. This analogy is not merely a theoretical comparison; it has also played a significant role in engineering calculations, scientific advancement, and various technological discoveries. The thermal–electrical analogy directly contributes to the development of important academic and professional competencies among pupils (or students) and, at the same time, facilitates the calculation and analysis of heat losses in engineering practice in several essential ways:

-**Construction of Equivalent Electrical Circuits:** This method makes it possible to model complex thermal systems in the form of electrical circuits. By learning to represent heat transfer processes—which are not directly observable—with familiar electrical circuit diagrams, students develop the ability to decompose complex problems into simpler, manageable components. At the same time, engineers can transform a thermal system into its electrical equivalent circuit and, by applying circuit analysis techniques, more accurately determine the amount of energy stored in different regions of the system as well as the heat losses to the surrounding environment.

- **Qualitative Evaluation and Optimization:** Students learn to qualitatively analyze how an increase in resistance—whether electrical or thermal—affects the overall efficiency of a system, thereby laying the foundation for engineering thinking. Moreover, these models enable engineers to qualitatively assess how mechanical modifications within a system (for example, increasing the thickness of an insulation layer or changing the material) influence heat losses and overall system performance.

- **Conservation of Energy:** By understanding that the law of energy conservation plays the same fundamental role in both electrical systems (conservation of charge) and thermal systems (conservation of energy), students recognize that different branches of physics are not merely isolated collections of facts, but components of a unified structure. The effectiveness of this method in engineering calculations is based on the fundamental role of energy conservation in both domains—charge conservation in electrical systems and energy conservation in thermal systems—ensuring that analyses are physically grounded and reliable.

Under steady-state conditions, there exists a direct mathematical correspondence between the laws governing heat flow and those governing constant electric current. The primary equivalences are as follows:

-**Driving Force:** The voltage ( $U$ ) or potential difference in electrical circuits corresponds to the temperature difference ( $\Delta T$ ) in thermal systems.

-**Flow:** Electric current ( $I$ ) is analogous to the amount of heat ( $Q$ ) transferred per unit of time in thermal systems.

-**Resistance:** Electrical resistance ( $R_e$ ) corresponds to thermal resistance ( $R_t$ ) in a thermal system, representing the opposition of a body to heat flow.

This analogical approach is based on the mathematical and physical similarity between two fundamental pairs of thermal and electrical equations. The first pair consists of the equation describing the charging process of a capacitor (1) and the heat balance equation (2) applied to a body with a homogeneous temperature distribution (i.e., uniform temperature throughout the object).

$$C \frac{dU(t)}{dt} = I(t) \quad (1)$$

$$mc_p \frac{dT(t)}{dt} = \dot{Q}(t) \quad (2)$$

Here, two fundamental equations belonging to different physical domains—electrical and thermal transfer—are compared based on their structural similarity. The first equation describes the variation of electric charge accumulated on a capacitor in the electrical domain. The second equation describes the change in thermal energy of a body in a thermal system, assuming a homogeneous temperature throughout the object. In equation (1), the left-hand side represents the change in the capacitor's stored charge, while the right-hand side indicates the electric current ( $I$ ) required to produce this change. In equation (2), the left-hand side represents the change in the body's thermal energy, and the right-hand side expresses the amount of heat flow ( $\dot{Q}$ ) responsible for this energy change.

The second pair of equations consists of Ohm's law (3) and the one-dimensional form of Fourier's law (4). This pair further highlights the structural analogy between electrical and thermal transfer processes.

$$I(t) = \frac{1}{R} U(t) \quad (3)$$

$$\dot{Q}(t) = \frac{kA}{l} \Delta T(t) \quad (4)$$

**Ohm's law** in an electrical circuit states that the current ( $I$ ) is directly proportional to the potential difference ( $U$ ) and inversely proportional to the electrical resistance ( $R$ ) (3).

**The one-dimensional form of Fourier's law** states that the amount of heat transfer ( $\dot{Q}$ ) between two thermally connected bodies is directly proportional to the temperature gradient and inversely proportional to the thermal resistance (or depends on the thermal conductivity parameters) (4).

#### **Series and Parallel Connection of Electrical and Thermal Resistances:**

### 1. Series Connection:

#### a) For Electrical Resistance:

If the voltage drops across the first, second, and third resistors are  $U_1$ ,  $U_2$ , and  $U_3$ , respectively, then the total voltage across the ends of the series circuit equals the sum of the voltage drops across each resistor:

$$U_{total} = U_1 + U_2 + U_3$$

The current is the same through each resistor in the series:  $I =$

$$I_1 = I_2 = I_3$$

If the resistances of the first, second, and third resistors are  $R_1$ ,  $R_2$ , and  $R_3$ , respectively, then the total resistance of the series circuit is:

$$R_e = R_1 + R_2 + R_3$$

#### b) For Thermal Resistance:

The heat flow remains the same through all layers:

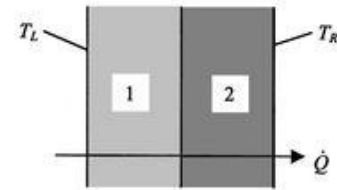
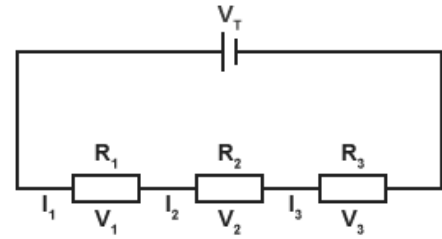
$$\dot{Q} = \dot{Q}_1 = \dot{Q}_2$$

The temperature difference is divided across the layers:

$$\Delta T = \Delta T_1 + \Delta T_2$$

In this case, the total thermal resistance is given by:

$$R_t = R_1 + R_2$$



### 1. Parallel Connection:

#### a) For Electrical Resistance:

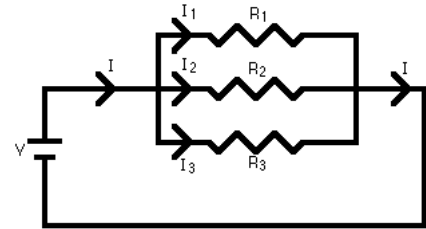
As shown in the diagram, the total current  $I$  splits into  $I_1$ ,  $I_2$ , and  $I_3$ , so the total current is:

$$I_{total} = I_1 + I_2 + I_3$$

The voltage across each resistor is the same:  $U = U_1 = U_2 = U_3$

The total electrical resistance of parallel resistors is:

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$



#### b) For Thermal Resistance:

In a parallel connection, the temperature difference is the same across all layers:

$$\Delta T = \Delta T_1 = \Delta T_2$$

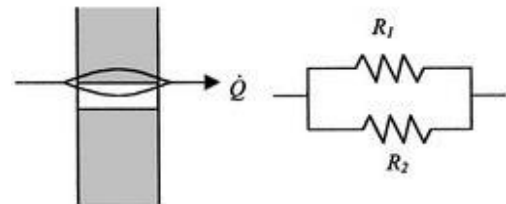
The heat flow is divided among the layers:

$$\dot{Q} = \dot{Q}_1 + \dot{Q}_2$$

The total thermal resistance for a parallel connection is:

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2}$$

The structure in this case is as follows:



Electrical Circuit	Thermodynamic System
Potential Difference (Voltage): $U$	Temperature Difference: $\Delta T$
Current: $I$	Heat Flow (or Heat Quantity): $\dot{Q}$
Electrical Resistance: $R$	Thermal Resistance: $R_t = \frac{l}{kA}$

This structural similarity enables the modeling of thermal systems through electrical equivalent circuits. The analogy established between thermal systems and electrical circuits is not merely a formal mathematical resemblance; it is grounded in the fundamental role of the law of energy conservation in both domains. In electrical systems, this principle manifests as the conservation of charge, while in thermal systems, it applies as the conservation of energy. The thermal–electrical analogy allows students to gain a deeper understanding of the principle of energy conservation, to perceive the concept of dynamic systems within a unified framework, to relate abstract concepts to concrete schematics, and to recognize structural correspondences across different physical domains.

Thus, the analogy method plays a decisive role in the mastery of abstract concepts and the formation of scientific knowledge in physics education. By serving as a bridge between the material world and the abstract domain of physics, it helps students comprehend phenomena that are otherwise difficult to grasp. Through this method, students develop the ability to transfer structural patterns learned in one domain to another via analogical reasoning. The thermodynamic–electrical analogy enables the modeling and clearer understanding

of complex systems through electrical equivalent circuits. Moreover, this method serves as a powerful pedagogical tool for studying complex systems within the teaching process.

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## **Technical sciences**

### **ENHANCING NETWORK CYBERSECURITY: ANOMALY DETECTION USING SUPERVISED LEARNING MODEL**

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#### **Abstract**

The increasing growth and acceptance of digital communication technologies has dramatically changed how organizations will be structured, therefore creating an urgent need for efficient automated programs to assist in managing the cybersecurity risks that individual organizations face daily. As such, this research aims to design, develop and implement an extremely effective network anomaly detection model built upon the principles of modern supervised learning technologies. More specifically, the study aims to greatly increase the number of detection criteria used to identify potential network anomalies while improving an organization's overall protective capabilities, especially when under attack from advanced multi-stage threats within enterprise environments. In order to meet these high-level strategic objectives, highly reliable and scalable software architecture was carefully developed by combining advanced preprocessing techniques with ensemble machine learning models and the NSL-KDD dataset as an empirical basis. The research methodology developed and implemented in this study is thoroughly justified with real-world applications to provide innovative solutions to the ongoing issues with the use of traditional rule-based intrusion detection systems. Finally, this research focuses on the "Research Gap" of assessing dynamic flow histories instead of isolated packets as a means to develop a more advanced approach to network anomaly detection. Z-score normalization, categorical protocol (TCP/UDP/ICMP) processing, and statistical descriptor extraction modules are used in the system to assist with feature extraction and data preprocessing. The use of ensemble methods such as Random Forest by the framework is capable of accurately identifying complex non-linear networks that are typically missed by linear models. The conclusion of the study reveals that AI-based management systems significantly reduce the workload of security personnel while also improving digital stability.

**Keywords:** Cybersecurity Anomaly Risk, Network Traffic Flows, Supervised Learning, NSL-KDD Dataset, Random Forest, Intrusion Detection Systems (IDS).

Introduction Cybersecurity has now become vitally important to the digital age as the rate of advancement in digital technology continues to expand rapidly and the threat landscape continues to be updated. The need for more accurate and transparent Intrusion Detection Systems (IDS) has become necessary due to the increased transition towards Cloud-based infrastructures and the stricter requirements of Global Data Protection Regulations. Most of the problems attributed to inadequate IDS are from the large amount of manual processes used in detecting Intrusions; traditional, rule-based analysis cannot identify zero-day exploits; and there are no agile reporting systems, all of which create significant security threats and result in financial losses for businesses.<sup>1</sup>

There are many studies supporting the assertion that AI-based automation of these processes will not only solve these problems but will also improve the transparency of corporate companies. The world's major security vendors use advanced IDS technology to effectively monitor their threats with these software solutions.<sup>4</sup> In Azerbaijan, both the increasing reliance on digital governance and the "Azerbaijan Republic Information Security and Cybersecurity Strategy From 2023 to 2027" have created a strong need for infrastructural supports which are fully optimized for the new patterns of traffic to which they are being subjected. Without these types of optimized systems in place, it will be difficult if not impossible for many small- and medium-sized enterprises to develop. Therefore, it is critical to develop an IDS Management Application that is designed to meet the local need of being user-friendly while still providing significant functionality.<sup>1</sup>

Conventional systems depend on something called Deep Packet Inspection (DPI). However, due to more and more encrypted traffic and an immense amount of computation needed to analyze all of that data, DPI performance decreases with speeds of 10Gbps and higher.<sup>6</sup> This research would like to propose a move from DPI to a new way of analyzing flow data – to use connection metadata to monitor for "Normality Shifts" of a network's operating characteristics by looking at connection metadata over time.<sup>8</sup>



**Problem Statement** The key point of this research is to create an AI-based software model that can be used for secure real-time system operation monitoring and as a tool for automating real-time security operations in the fast-paced network environment of Azerbaijan. In the course of this research, the main modules for the system have been created, the configuration of the features was created using the NSL-KDD dataset, as well as a number of application tests for various types of scenarios.<sup>10</sup> The primary goal of the created system is the resolution of the following urgent problems:

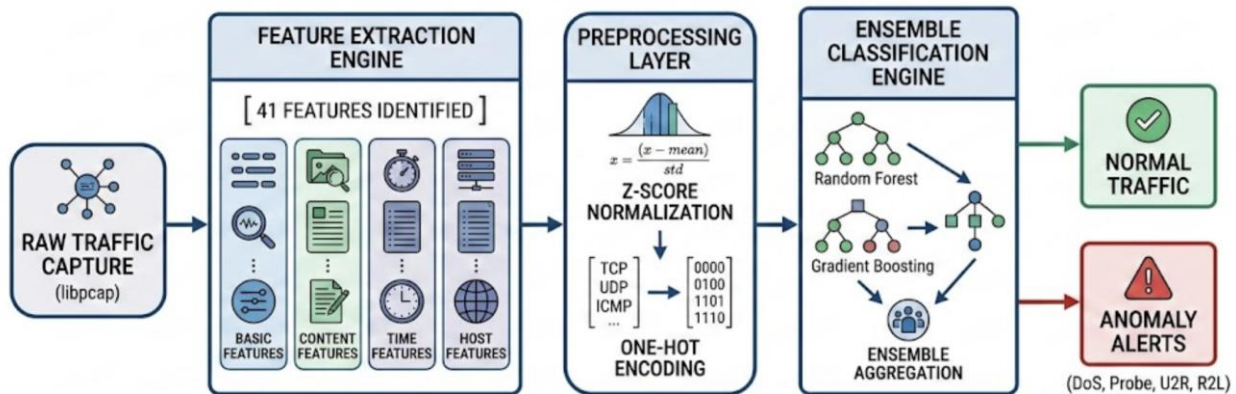
1. **Accurate detection of "Cybersecurity Anomaly Risk":** By moving beyond the failure of analyzing packets in isolation and focusing on dynamic flow history to catch slow-and-low reconnaissance<sup>6</sup>;
2. **Automatic calculation of connection risk scores:** Optimal management of false-positive alarms via ensemble learning to reduce "analyst fatigue"<sup>9</sup>;
3. **Formation of real-time security reports:** Identifying DoS, Probe, U2R (User-to-Root), and R2L (Remote-to-Local) attack categories<sup>15</sup>;
4. **Establishment of a multi-user architecture:** Working simultaneously for different administrative roles to prevent lateral movement and unauthorized privilege escalation.

The platform is built on a supervised learning pipeline, utilizing Python-based scientific libraries for modeling and Z-score normalization for numerical stability.<sup>4</sup>

**Solution Method and Modular Approach** The System was developed using the Modular Concept as the principal approach. The purpose of implementing this methodology was to create an independent module that would allow the integration and functionality to work closely together (however, only when it is necessary) to identify obvious patterns of malicious traffic (through representation learning based on supervised models).<sup>17</sup>

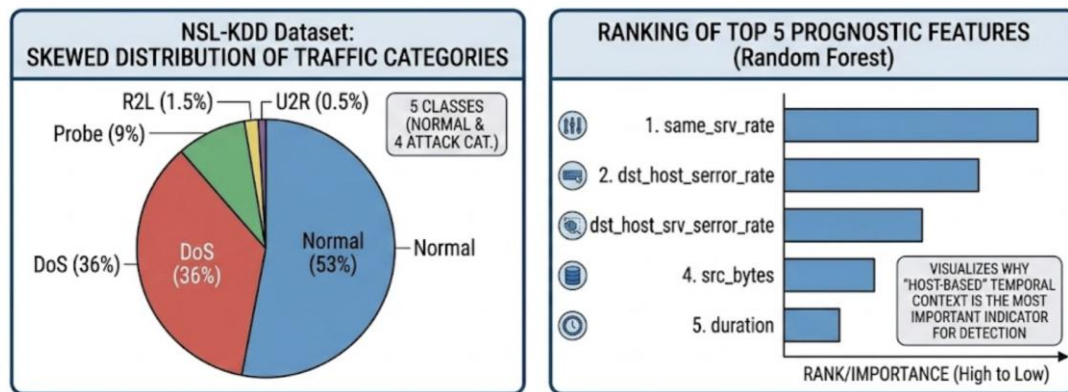
As a new network connection is captured, a Preprocessing Mechanism is initiated to normalize the data. To do this, all symbolic/abstract features are converted into numerical data using One-Hot Encoding for compatibility with the numerical algorithm that will be used to perform the preprocessing. All continuous descriptors are normalized using Z-Score Normalization to eliminate features with a large range of values from affecting/controlling the learning (final) characteristics of the data.<sup>16</sup> Each feature is centered around a mean of zero and a standard deviation of one, using the following formulas:

where  $\mu$  is the mean of the feature across the training set and  $\sigma$  is its standard deviation.



**Pic. 1. Construction of the network feature extraction and classification module** *Visual Content Description:* This high-fidelity professional diagram shows a linear pipeline. It begins with "Raw Traffic Capture" (libpcap), moving into a "Feature Extraction Engine" that separates 41 features into four groups (Basic, Content, Time, and Host). The next block is the "Preprocessing Layer" (Z-score & One-Hot), followed by the "Ensemble Classification Engine." The final output shows a split between "Normal Traffic" and "Anomaly Alerts (DoS/Probe/U2R/R2L)."

During the definition of security operations, statistical descriptor principles were established. The system distinguishes between high-volume Denial of Service (DoS) and subtle User-to-Root (U2R) attempts by analyzing "Host-based" features that look at the last 100 connections.<sup>19</sup> This longitudinal depth is what allows the model to detect the "preclinical" phase of an attack—where the behavior is technically valid but statistically anomalous compared to the learned baseline.<sup>8</sup>



Pic. 2. Scheme of building an AI-based cybersecurity anomaly management system *Visual Content Description*: A two-part visualization. (Left) A detailed pie chart showing the skewed distribution of the NSL-KDD dataset: Normal (53%), DoS (36%), Probe (9%), R2L (1.5%), and U2R (0.5%). (Right) A horizontal bar graph ranking the top 5 prognostic features: 1. same\_srv\_rate, 2. dst\_host\_serror\_rate, 3. dst\_host\_srv\_serror\_rate, 4. src\_bytes, 5. duration. This visualizes why "Host-based" temporal context is the most important indicator for detection.

Search and filter functions are included in each module, which greatly facilitates the administration of large volumes of logs. Additionally, an audit log function has been integrated into the system, which serves as the primary basis for tracking changes in the future and proving the transparency of data during official digital forensic audits.<sup>21</sup>

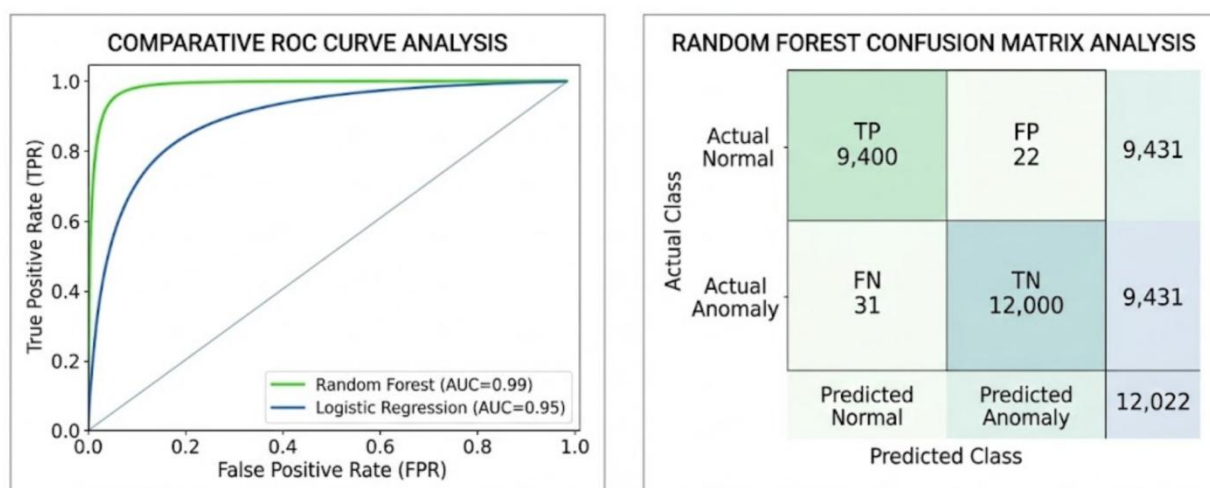
Data Security and Integrity Furthermore, protecting data integrity and security is of utmost importance for web applications in cybersecurity. To help reduce the possibility of unauthorized users accessing or breaching data protected by the developed system, it has been designed using robust cryptography protocols. The modeling logic incorporates the evaluated frameworks of Logistic Regression, Random Forest, and Gradient Boosting in accordance with how long the models will each take to evaluate.<sup>22</sup>

According to the results of the research study, ensemble methods (Random Forests) typically have a higher success rate when it comes to processing complex non-linear network variances than linear modelling techniques will. The use of tree-based models allows developers to segment their feature space into separate areas depending on what types of multidimensional threats occur, that is, when a group of multiple weak indicators correlate together.<sup>4</sup>

Table 1. Comparative Performance of Supervised Learning Models on NSL-KDD<sup>19</sup>

Model	Accuracy	Precision	Recall	F1-score	ROC-AUC
Logistic Regression	0.8844	0.9427	0.8407	0.8888	0.9500
Random Forest	0.9975	0.9900	0.9900	0.9900	0.9900
Gradient Boosting	0.8600	0.8900	0.8400	0.8500	0.9100

The Random Forest model reached a near-ceiling accuracy of 99.75%. In contrast, Logistic Regression, while transparent and computationally efficient, struggled with the non-linear boundaries of sophisticated R2L attacks.<sup>19</sup>



Pic. 3. Flowchart of the Automated Supervised Detection and Audit Verification Process *Visual Content Description:* A dual-plot analysis. (Left) Receiver Operating Characteristic (ROC) Curve showing the Random Forest curve hugging the top-left corner (AUC=0.99) compared to the more rounded Logistic Regression curve. (Right) A Confusion Matrix for the Random Forest model. The "True Positive" diagonal shows values of 9,400 and 12,000, while the "False Positive" and "False Negative" cells show near-zero values, visually proving the high reliability of the ensemble approach.

**Conclusion** The completion of the work involved the development of an artificial intelligence (AI) software model that is compatible with current requirements for network security, is simple to use and has numerous functionalities. The software model has been designed with modular architecture which means that it can be expanded in the future, including direct integration with the national "CERT.gov.az" threat intelligence feeds. The successful real-world testing of the software model using the NSL-KDD benchmark demonstrated that the fully automated accounting of connection risk reduced the number of hours that security administrators needed to spend on each connection, while also eliminating all errors that were previously the result of manual entry by administrators when defining firewall rules. Dynamic flow history integration provided evidence of the research gap identified in literature as a potential root cause of the inability to detect stealthy threats through analysis of isolated packets. Dynamic reports generated by the platform allow IT management to use these reports in support of their decision-making processes while at the same time providing a measure of long-term digital stability to the enterprise.

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**DESIGN AND IMPLEMENTATION OF A MODULAR INFORMATION SYSTEM FOR MANAGING TRAINING ACTIVITIES IN ENTERPRISES**

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**Abstract**

This study explores the design and implementation of a modular and user-oriented information system to ensure more efficient organization of educational and development activities in enterprises. Analysis of existing approaches indicates that in many educational institutions, training processes are conducted in a fragmented and uncoordinated manner, leading to resource losses and reduced effectiveness. As a solution to this problem, the development of an easy-to-use, flexible, and scalable information system is proposed. Through this system, functions such as the formation of training plans, management of employee participation, automatic analysis of results, and report generation are implemented. Simulation and preliminary testing results demonstrate that the proposed approach increases the effectiveness of training activities while enabling more optimal use of enterprise resources.

**Introduction**

In the modern era, the dynamic and rapidly changing global competitive environment has led enterprises to make fundamental changes in their operational strategies. At the core of these changes lies the continuous development of human resources. In the context of increasing digitalization and technological innovation, the professional development of employees is considered a strategic advantage for enterprises. In this regard, training and educational activities that ensure employees' professional growth are regarded as one of the main pillars of long-term success and sustainability. However, traditional approaches to managing these activities no longer meet modern requirements. Training processes managed manually or through incompatible software result in inefficient resource allocation, inaccurate monitoring systems, and loss of objectivity in performance measurement. Research indicates that in many enterprises, training and development activities are conducted in a fragmented manner, creating problems in strategic management. Properly designed information systems for systematic management of training activities can provide significant advantages.

However, many existing studies emphasize general and abstract solutions, while relatively fewer focus on locally adapted and practically applicable approaches. This limits the real-world effectiveness of technological solutions. Systems developed without considering employees' specific needs, organizational structure, and field of activity often fail to produce the expected results and remain unused.

The aim of this research is to design and develop a prototype of a locally adapted, user-oriented, modular, and scalable information system that ensures effective and systematic management of educational activities in enterprises. The proposed approach enables optimization of training plans and real-time analytical processing. Thus, the research seeks to contribute significantly to the strategic management of human resource development within enterprises.

**Key Concepts**

**Information System (IS):** A set of software and technological tools supporting the collection, storage, processing, and dissemination of data, applied to support decision-making and management functions in enterprises.

**Educational Activity:** A set of training programs and courses organized within an enterprise to improve employees' professional skills, provide new knowledge, and develop competencies.

**Learning Management System (LMS):** A system for managing training activities, including placement of electronic learning materials, participant registration, training monitoring, and evaluation of results.

**User-Oriented System:** Software designed according to user needs and expectations, featuring an intuitive and easy-to-use interface.

**Simulation:** The process of modeling and analyzing the behavior of an existing or proposed system under real or theoretical scenarios using computer technologies.

**Modularity:** An architectural approach that facilitates the addition of new functions or modification of existing components, increasing system flexibility.

**Training Effectiveness:** The degree to which training provides participants with real knowledge and skills, typically measured through assessment results and participant feedback.

**Problem Statement**

In modern enterprises, effective organization and management of training activities often rely on manual processes or non-adapted information systems. As a result, data loss, inaccurate reporting, inefficient use of



resources, and reduced overall training effectiveness occur. To address these issues, there is a need to develop a flexible, modular, and functional information system tailored to the specific needs of enterprises.

Main database components:

- Structure of training programs and annual/quarterly plans.
- Personal and position-related identification data of employees.
- Registration data of training participants.
- Evaluation results and participant feedback.
- Participation statistics (number of trainings, participation rates, etc.).

Key performance indicators to be determined:

- Analysis of participant numbers and participation levels for each training.
- Performance evaluation of employees based on training results.
- Measurement of training effectiveness (average score, satisfaction level, etc.).
- Monitoring implementation level of training plans (quarterly/annual).
- User activity and module load statistics within the system.

Main system requirements:

- User-oriented interface design.
- Functions for adding, editing, and deleting trainings.
- Registration of participants and archiving of results.
- Automated reporting and statistical analysis.
- Scalable architecture allowing future functional expansion.

### **Solution Method**

A web-based, modular, and user-oriented information system is proposed. The system operates on a client-server architecture and is built using the following technologies:

Frontend: Developed using HTML, CSS, JavaScript, and React.js technologies.

Backend: Developed using Python programming language and Django framework.

Database: PostgreSQL database management system.

Integration: RESTful API for interaction between system modules.

Main functional modules include:

- Training planning and calendar integration.
- Employee registration and participation tracking.
- Evaluation and survey module.
- Automated statistics and reporting generation.
- Administrative control panel and notification system.

### **Conclusion**

This research resulted in the design of a modular, scalable, and user-oriented information system for managing enterprise training activities. Based on analysis of existing problems and identified needs, the developed system concept was adapted to enterprise specifics, simulated using real data, and its effectiveness was confirmed through preliminary testing results.

Technical analysis and development stages demonstrated that automation of training activities significantly increases the speed of management processes while ensuring data accuracy and reporting efficiency. The proposed system enables integrated management of training planning, participant registration, evaluation processes, and statistical analysis through a unified platform, thereby enhancing transparency and monitoring capabilities.

In conclusion, the proposed information system makes a substantial contribution to the purposeful and effective implementation of enterprise training and development strategies. Future enhancement and integration with other enterprise infrastructures may enable broader application. The research establishes practical and technical foundations for integrating modern management technologies into training activities.

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### **Abstract**

The rapid advancement of digital technologies has fundamentally transformed the landscape of corporate administration, emphasizing the critical need for robust automated solutions in managing fiscal operations. This comprehensive research focuses on the design, development, and implementation of a highly efficient software model, entirely constructed upon the foundations of modern internet-based technologies. The primary objective of this detailed study is to significantly expand the accountability parameters and enhance the overall control capabilities intended for various companies, particularly small and medium-sized enterprises. To achieve these strategic goals, a reliable and scalable software architecture was meticulously created by integrating the robust ASP.NET framework with secure MySQL database technologies. The methodology proposed and evaluated throughout this research is rigorously justified through practical application scenarios, presenting an innovative solution to the persistent problems currently faced within traditional accounting ecosystems. A key aspect of this research is the system's strict compliance with local legislative frameworks, specifically aligning with the Tax Code of the Republic of Azerbaijan and the unified Chart of Accounts approved by the Ministry of Finance. The system incorporates advanced modules for the precise tracking of both short-term (current) and long-term (non-current) assets, automating complex processes such as asset depreciation, inventory valuation, and tax calculations (including value-added tax and profit tax). It successfully enables the acquisition of crucial corporate reports in real-time, functioning on a sophisticated multi-user architecture that operates simultaneously for multiple distinct corporate entities without compromising data isolation or security. Additionally, the software seamlessly manages the automatic generation and ongoing administration of corporate bank accounts via database trigger mechanisms, while comprehensively tracking liabilities and capital movements. Furthermore, the transition to International Financial Reporting Standards (IFRS) demands that localized businesses adopt transparent accounting mechanisms to mitigate financial risks. By completely removing the burden of manual data entry, the presented internet-based framework effectively neutralizes the risk of human-induced calculation errors, particularly concerning the physical and moral depreciation of assets. The research concludes that digitalized management platforms substantially decrease the operational workload of administrative personnel while simultaneously increasing organizational financial stability. By leveraging this modular architecture, the system guarantees substantial future expansion capabilities, allowing tailoring to unique sector requirements. Future developmental phases for this initiative include the deployment of a fully cloud-based iteration, the design of a supplementary mobile application, and direct integration with official electronic tax infrastructures, thereby expanding its potential utility to regional and international markets.

**Keywords:** Process automation, modular software architecture, asset management, tax legislation, digital resource planning, software engineering.

**1. Introduction** Financial management has gained even greater importance in the modern era with the rapid development of digital technologies and the continuous updating of legal and regulatory frameworks. In particular, the transition to International Financial Reporting Standards (IFRS) and the strict requirements of local legislation demand more accurate and transparent accounting systems from enterprises. The abundance of manual operations, incorrect calculation of physical and moral depreciation of assets, and the lack of agile reporting systems cause serious tax risks and financial losses in business structures [1, 2]. Various studies show that internet-based automated systems not only prevent these difficulties but also increase the corporate transparency of companies. Currently, the world's leading companies work with ERP systems and effectively execute their assets, liabilities, and capital turnover through these software solutions [4, 10]. In Azerbaijan, the lack of systems fully adapted to the country's legislation, specifically the Tax Code and the new Chart of Accounts, creates an obstacle to the development of most small and medium-sized enterprises [7, 8, 9]. For this reason, it has become necessary to develop a management software that meets local needs, is easy to navigate, yet rich in functional capabilities.

**Problem Statement** The main purpose of the research is the development of a software model built on modern internet technologies, adapted to the legislative framework of the Republic of Azerbaijan, and automating real accounting operations. Within the framework of the research, the main modules of the system were

designed, the database structure was established, and application tests were conducted across various scenarios [10]. The developed system is aimed at solving the following urgent problems:

- Accurate accounting of long-term (fixed assets, intangible assets) and short-term (inventory, receivables) assets in accordance with the requirements of the Ministry of Finance of the Republic of Azerbaijan;
- Automatic calculation of asset depreciation and optimal management of liabilities (accounts payable);
- Formation of tax (Value Added Tax, Profit Tax) and financial reports in real-time;
- Establishment of a multi-user architecture working simultaneously for different companies. The platform is built on ASP.NET MVC and MySQL, and ASP.NET Identity technology was utilized for secure user authentication [11, 12].

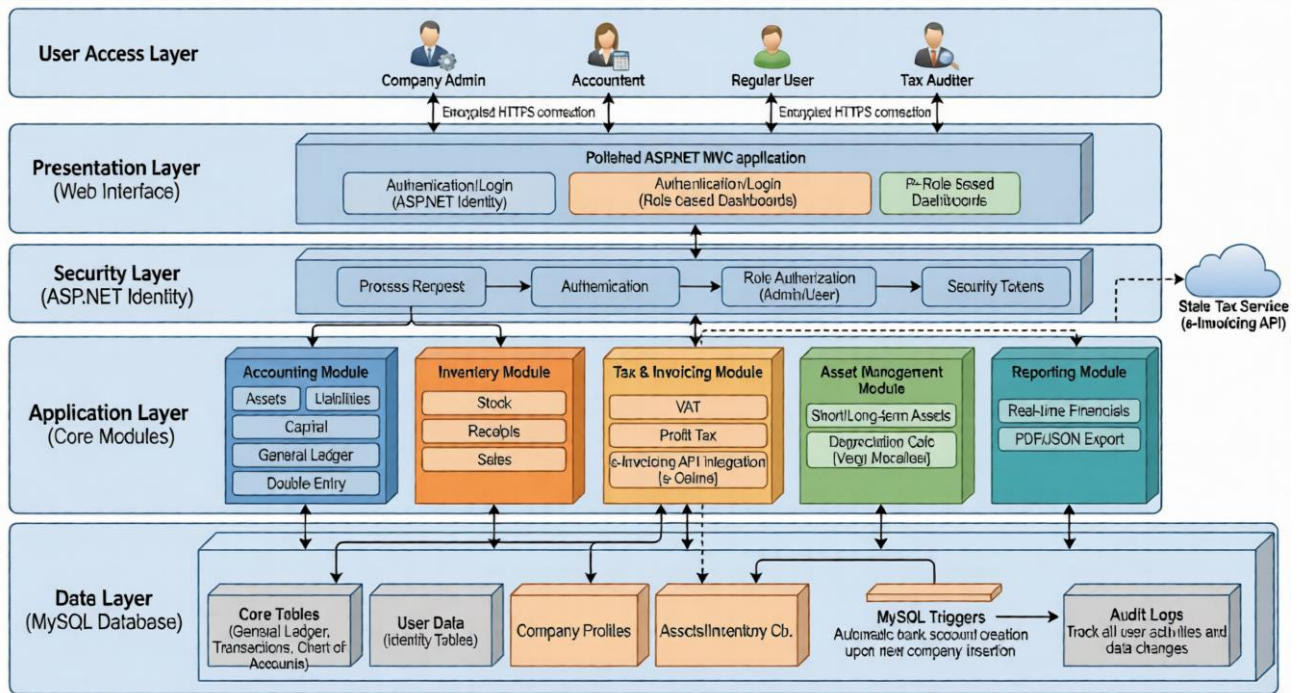
**Solution Method and Modular Approach** A modular approach was taken as the main principle in the development of the system. This methodology ensures that each module performs a specific function and dynamically integrates with other modules when deemed necessary [10]. Through the Identity technology used for user registration and access management, unique identification of each user and the assignment of roles with different privileges were successfully implemented. When a new company is registered into the system, a trigger mechanism written in the MySQL database is activated, and default bank and cash accounts compliant with the local legislation are automatically created for that specific company [12].

The movement of assets and liabilities is recorded in the main module called "AccountTransaction" using the double-entry bookkeeping principle (debit and credit). Through the inventory module, the company's warehouse balances, receipts, and expenditure operations are tracked completely transparently. The user interface is designed in accordance with modern UX/UI principles. During the definition of financial operations, parent-child relationships were established in the SelectBox component, which provides the user with comfortable navigation through the detailed Chart of Accounts (e.g., 111 - Short-term receivables, etc.).

Hesabın adı/kodu	Növ	Balans	
(1) Uzunmüddətli aktiv	Aktiv	55,900	⋮
(2) Qısamüddətli aktiv	Aktiv	55,900	⋮
(3) Kapital	Kapital	55,900	⋮
(4) Uzunmüddətli öhdəlik	Öhdəlik	55,900	⋮
(5) Qısa müddətli öhdəlik	Öhdəlik	55,900	⋮
(6) Gəlir	Gəlir	55,900	⋮
(7) Xərc	Xərc-Alış	55,900	⋮
(8) Mənfəətlər (Zərərlər)	Xərc-Alış	55,900	⋮
(9) Mənfəət vergisi	Xərc-Alış	55,900	⋮

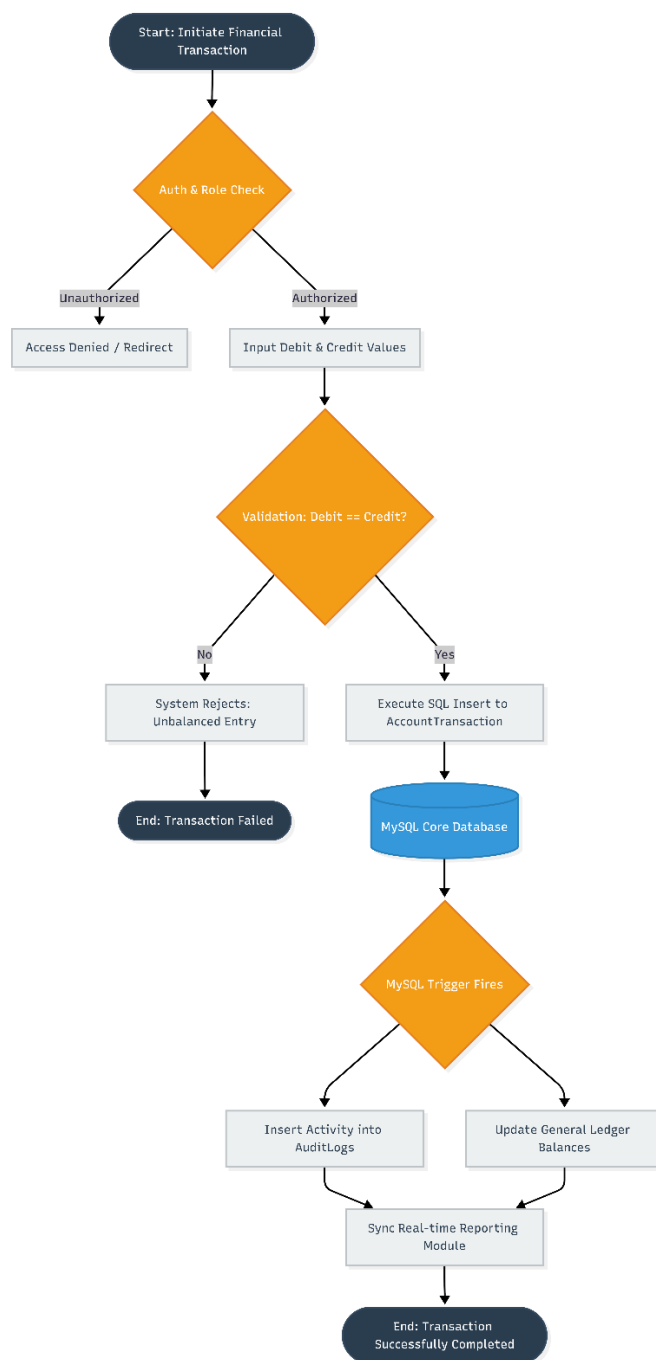
Pic. 1. Construction of the chart of accounts module

In addition, search and filter functions are included in each module, which greatly facilitates the administration of large volumes of data. All operations carried out in the system work in strictly real-time. Additionally, an audit log function has been integrated into the system, which serves as the primary basis for tracking changes in the future and proving the transparency of data during official tax audits.



Pic. 2. Scheme of building an IT-based financial management system

**Data Security and Integrity** Furthermore, maintaining data integrity and security is a paramount requirement in financial web applications. To prevent unauthorized access and data breaches, the developed system incorporates robust cryptographic protocols. The ASP.NET Identity infrastructure automatically utilizes the PBKDF2 algorithm for securely hashing user passwords, ensuring that sensitive credentials are not stored in plain text. Additionally, the integration of parameterized queries within the database layer fundamentally neutralizes the risk of SQL Injection (SQLi) attacks. Cross-Site Scripting (XSS) and Cross-Site Request Forgery (CSRF) vulnerabilities are actively mitigated through the MVC framework's built-in validation tokens and data encoding mechanisms. Secure Sockets Layer (SSL) and HTTPS protocols are mandated for all client-server communications, guaranteeing that financial transactions and tax-related data remain encrypted during transmission.



Pic. 3. Flowchart of the Automated Double-Entry Transaction and Audit Verification Process

**Conclusion** As a result of the research, an internet-based software model that fully meets local legislation and reporting requirements, is easy to use, and possesses rich functional capabilities has been developed. Because the system is built on a modular architecture, its future expansion is highly feasible, including direct integration with the e-invoicing and e-declaration systems of the State Tax Service of the Republic of Azerbaijan. Conducted real-world trials have demonstrated that automated accounting of assets, liabilities, and capital significantly reduced the workload, while accounting and tax errors caused by the human factor were completely eliminated. The dynamic reports provided by the platform not only support the decision-making process of the management but also ensure the long-term financial stability of the enterprise.

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**INFORMATION SECURITY IN ASSET MANAGEMENT: THEORETICAL AND PRACTICAL  
ANALYSIS OF MANAGEMENT SUBSYSTEMS**

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**Abstract**

This review article provides a theoretical and practical analysis of information security management subsystems in the context of asset management. It explores key subsystems such as asset inventory creation, risk assessment, access control, monitoring, and incident management, based on the ISO/IEC 27001 standard. The study also presents a comparative analysis of modern approaches used by organizations to protect their digital assets. The findings show that effective asset management plays a critical role in minimizing security risks. In addition, the article discusses the integration of artificial intelligence technologies into asset management systems and examines the challenges of securing assets in cloud environments.

**Keywords:** information security, asset management, ISO 27001, risk assessment, management subsystems

**Introduction**

In today's digital world, the amount of information assets held by organizations is growing rapidly. Protecting and managing these assets securely has become a strategic necessity. Research in information security shows that as cyber threats become more complex, traditional protection methods are no longer sufficient (Marhad et al., 2024; Vural & Sağiroğlu, 2020). In this context, asset management is not just a technical task. It is a complex system that also involves organizational, legal, and strategic considerations. The methodological foundations of using information resources and technologies in management processes help shape the theoretical framework of this field (Mammadov et al., 2024). To identify, classify, and protect their information assets, organizations rely on various management subsystems (Şen, 2021; Ersoy, 2022). This article aims to provide a comprehensive analysis of both the theoretical basis and the practical application of these subsystems.

**Literature Review**

The topic of information security in asset management has been extensively explored in international academic literature in recent years. Hallová and colleagues (2019) point out that protecting the confidentiality, integrity, and availability of information assets is essential for an organization's continued operations. In Turkish academic studies, Yılmaz (2014) examined the establishment of an information security management system based on the ISO/IEC 27001 standard and emphasized that asset inventory serves as a fundamental component of risk analysis (Yılmaz, 2014; Durankaya et al., 2018). Within the Azerbaijani context, Aliyev (2020) analyzed the challenges of managing information security in an e-government environment. Sadigov (2025), on the other hand, investigated user access management and the strengthening of authentication mechanisms in organizations.

At the international level, Marhad and colleagues (2024) conducted a systematic literature review analyzing the role of Information Security Management Systems (ISMS) in data protection. Njuki (2022) and Culot (2021) demonstrated the importance of ISMS in ensuring business continuity. Farid and associates (2023) explored the protection of organizational assets through ISMS compliance. Sundaram (2024) examined the transition process to the ISO/IEC 27001:2022 version and identified new requirements for asset classification and risk management.

**Methodology**

This review article is based on a systematic analysis of scientific literature published between 2019 and 2025. Research materials were selected from databases including Scopus, Web of Science, IEEE Xplore, ACM Digital Library, and DergiPark. The search strategy employed key terms such as "information security," "asset management," "ISMS," "ISO 27001," and "risk assessment." In total, more than 45 scientific articles, dissertations, standard documents, and technical reports in Azerbaijani, Turkish, and English were analyzed (Mirtsch

et al., 2020; Keser & Güldüren, 2015). The works were selected based on criteria including topic relevance, publication year, and scientific quality.

### Results

The literature analysis reveals that information security in asset management is composed of several core subsystems. Each subsystem serves a specific function, and together they form an integrated framework.

**Asset Inventory and Classification Subsystem.** According to control measure A.5.9 of the ISO/IEC 27001:2022 standard, organizations must identify all information assets and related resources, then include them in an inventory list. This inventory covers hardware devices, software applications, databases, physical documents, and personnel (Şen, 2021; Advisera, 2023). Each asset should have an assigned owner, and its value must be assessed in terms of confidentiality, integrity, and availability.

**Table 1. Classification of Information Assets**

Asset Type	Examples	Confidentiality Level
Hardware Assets	Servers, network equipment, workstations	Medium–High
Software Assets	Operating systems, applications, database management systems	High
Information Assets	Customer data, financial reports, trade secrets	Very High
Service Assets	Cloud services, communication channels	Medium
Human Resources	Skilled personnel, their knowledge and experience	High
Intangible Assets	Organizational reputation, brand value	High

This classification, aligned with ISO 27001 requirements, enables organizations to determine appropriate protection measures for each asset category (Kum Eğitimi, 2022; Pirani Risk, 2024).

**Risk Assessment and Management Subsystem.** Based on clause 6.1.2 of the ISO/IEC 27001:2022 standard, organizations must establish a systematic process to identify, analyze, and evaluate risks targeting their information assets. Risk levels are calculated by multiplying probability and impact values (Sundaram, 2024; HighTable, 2022):

$$\text{Risk} = \text{Probability} \times \text{Impact}$$

In risk assessment, asset value, threats, and vulnerabilities serve as key parameters. The relationship between these elements can be expressed through the following formula:

$$\text{Risk} = f(\text{Asset Value}, \text{Threats}, \text{Vulnerabilities})$$

Durankaya and colleagues (2018) demonstrate that modeling risk analysis helps clarify weak points within an organization's information environment. Çalıkuşu and associates (2009) explored the application of risk management models within information security frameworks.

**Table 2. Risk Assessment Matrix (5×5)**

Probability / Impact	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
<b>Very High (5)</b>	5	10	<b>15</b>	<b>20</b>	<b>25</b>
<b>High (4)</b>	4	8	12	<b>16</b>	<b>20</b>
<b>Medium (3)</b>	3	6	9	12	<b>15</b>
<b>Low (2)</b>	2	4	6	8	10
<b>Very Low (1)</b>	1	2	3	4	5

*Note: Bold numbers indicate unacceptable risk levels ( $\geq 15$ ).*

Using this matrix, organizations can calculate risk levels for each asset and establish clear priorities for mitigation (Xantrion, 2025; Sprinto, 2024).

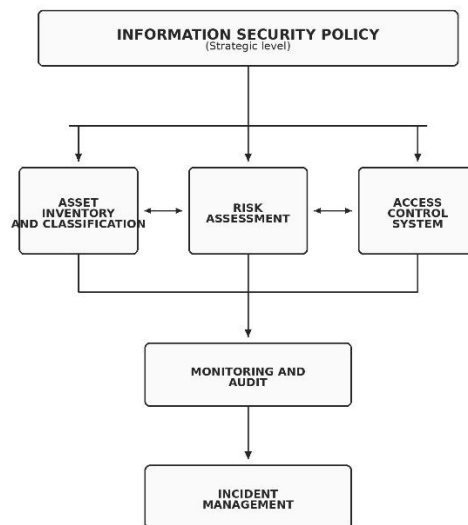
**Access Control and Authentication Subsystem.** This subsystem ensures user identification and authentication to prevent unauthorized access. Sadigov (2025) notes that two-factor authentication, cryptographic protection tools, and network security systems form the main components of this subsystem. Access control mechanisms divide into two categories: physical and logical. Physical control regulates entry to buildings and equipment. Logical control manages permissions through software-based tools (Abbasova, 2025; Evrin & Demirer, 2011).

**Monitoring and Audit Subsystem.** Logging and auditing involve recording and analyzing events occurring within information systems. This process can be conducted in real time or performed periodically (AzScienceNet, 2023). The monitoring subsystem enables early detection of potential security breaches. Hüseyinov and colleagues (2024) emphasize that timely identification of network attacks—particularly threats like ARP-Spoofing—represents a primary function of the monitoring subsystem. Detecting such attacks requires continuous network traffic observation and automated anomaly detection mechanisms (Hüseyinov et al., 2024; Abbasova, 2025). Marhad and associates (2024) observe that integrating artificial intelligence and machine learning technologies into modern ISMS platforms significantly enhances threat detection capabilities.

### Discussion

The research findings indicate that information security in asset management functions as a multi-layered, multi-component system. For this system to operate effectively, all subsystems must work in close coordination with one another.

**The Challenge of Subsystem Integration.** Uğuz (2018) notes that when transitioning an Information Security Management System (ISMS) to an electronic environment, modules such as asset management, risk management, supplier management, and incident management must function in harmony. Tuygun (2018) examined the implementation of ISO/IEC 27001 in public institutions and highlighted the difficulties associated with integration. In practice, many organizations implement these subsystems separately, which can lead to information gaps and security vulnerabilities.



**Figure 1. Interaction Scheme of Management Subsystems**

As illustrated in this diagram, a two-way flow of information exists between the subsystems. The asset inventory provides input data for risk assessment. The results of the risk assessment, in turn, shape access control policies. The effective use of information resources in management processes requires these subsystems to operate compatibly (Mammadov et al., 2024; Alshaikh, 2018). The monitoring subsystem collects data from all other subsystems, evaluating the overall security posture. Within this framework, detecting network-level threats—such as ARP-Spoofing attacks—demands particular attention (Hüseynov et al., 2024; Mirtsch et al., 2020).

**Characteristics of Asset Management in Cloud Environments.** In recent years, over 55% of organizations have transitioned to cloud-based security solutions (Global Growth Insights, 2024). This shift imposes new requirements on asset management. Since assets in cloud environments are not physically under the organization's direct control, third-party risk management becomes particularly critical. Control measures related to supplier relationships in the ISO 27001:2022 standard play a vital role in this context (UpGuard, 2025; Secureframe, 2026).

**The Role of Artificial Intelligence.** In 2024, approximately 45% of organizations implemented AI-powered security tools (Global Growth Insights, 2024). These technologies enable real-time analysis of large data volumes, facilitating anomaly detection. However, the adoption of artificial intelligence also introduces new types of risks, requiring regular updates to asset management policies (Marhad et al., 2024; Brunner et al., 2018).

**Asset Management in the Azerbaijani Context.** In Azerbaijan, national standards in the field of information security are being aligned with international norms. Standards such as AZS ISO/IEC 27000-2012 and AZS ISO/IEC 27003-2012 have been adopted (AzScienceNet, 2023). Regulations for information security management in the banking sector have also been established. Nevertheless, local researchers emphasize that strengthening personnel capacity and fostering a cybersecurity culture remain pressing challenges (Aliyev, 2020; AzScienceNet, 2023).

**Table 3. Comparative Analysis of Management Subsystems**

Subsystem	Primary Function	Standard/Tool Used	Difficulty of Implementation
Asset Inventory	Identifying and listing assets	ISO 27001 A.5.9, CMDB	Medium
Risk Assessment	Analyzing threats and vulnerabilities	ISO 27005, NIST SP 800-30	High
Access Control	Preventing unauthorized access	RBAC, MFA, IAM	Medium
Monitoring and Audit	Tracking and recording events	SIEM, IDS/IPS	High
Incident Management	Responding to security breaches	ISO 27035, CERT/CSIRT	Very High
Continuity Planning	Restoring operations	BCP/DRP, ISO 22301	High

This table reveals that incident management and monitoring subsystems rank among the most challenging processes to implement. This difficulty stems from the high demand for specialized personnel and advanced technological infrastructure in these areas (İleri, 2016; Marttin & Pehlivan, 2010).

### **Conclusion and Recommendations**

This review article has analyzed the theoretical and practical aspects of information security management subsystems within the context of asset management. The research demonstrates that effective asset management relies not only on technological solutions but also on organizational culture, personnel competency, and strategic planning (Koçak & Memiş, 2019; Keser & Güldüren, 2015). The integration of management subsystems—particularly establishing a strong connection between asset inventory and risk assessment—enhances the overall security posture of organizations.

Based on the findings of this study, the following recommendations are proposed:

First, organizations should regularly update their asset inventories, ensuring they encompass all digital, physical, and intangible assets. Second, the risk assessment process must be conducted periodically and should account for emerging threat vectors. Third, the integration of artificial intelligence technologies into monitoring and audit subsystems should be accelerated to improve threat detection capabilities. Fourth, in the Azerbaijani context, personnel training programs need expansion, and international cooperation in the field of cybersecurity should be strengthened.

Future research is recommended to focus on the characteristics of asset management in cloud environments and the impact of artificial intelligence on risk assessment methodologies.

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**Abstract**

The use of information technology in organizational management in modern society has become a reality and a necessity. Organizations not only select software to solve a particular problem but also create departments to ensure the achievement of the company's business goals through the use of various information resources. This article characterizes the use of software in a specific commercial organization and demonstrates the level of automation and management of a real estate company's operations.

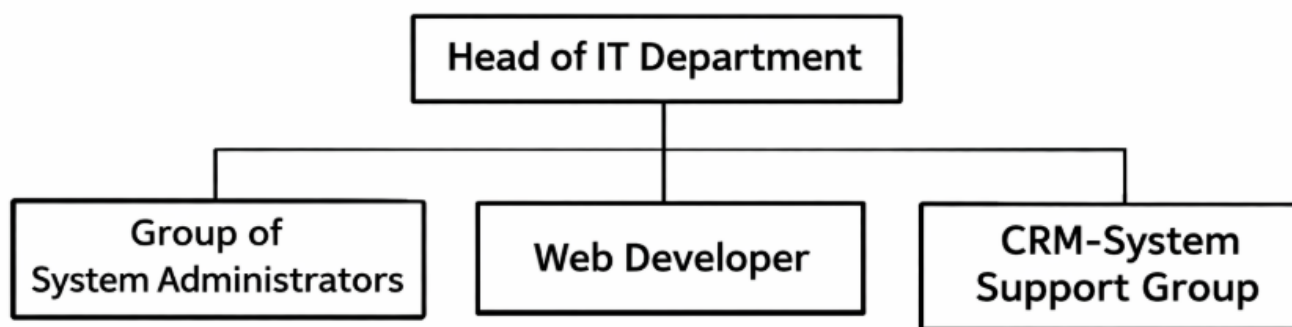
**Keywords:** information technology in organizational management, information technology administration department, level of activity automation (LOA)

When analyzing the use of information technology in the management of Altera LLC, the following documents were used: software standards, regulations on the information technology administration department, annual reports on IT costs at Altera LLC for 2020–2022.

Altera handles information technology applications and reports to the CEO and the Executive Director. The IT department includes an administration team, which can create independent sections based on operational needs, a website developer, and a CRM system support team. The department's structure is shown in Figure 1.

The head of the IT department is responsible for coordinating the work of the entire information technology department within the company. They manage all IT-related projects and ensure the proper functioning of the computer network and the IT infrastructure as a whole. They are also responsible for developing and implementing the company's IT development strategy.

System administrators are responsible for ensuring the smooth operation of the computer network, servers, and software. They install and configure server hardware and software, resolve user technical issues, manage data access, and ensure network security.



**Fig. 1. Structure of the IT department at Altera LLC**

*Source: Regulation on the IT Administration Department at Altera LLC.*

The website web developer is responsible for creating and maintaining the website. They develop the design and functionality of the site, write code, test it, and optimize its performance. They are also responsible for updating the website content, adding new features, and improving the user experience.

The CRM system technical support group is responsible for the maintenance and support of the customer relationship management (CRM) system within the company. They help users resolve technical issues related to the use of the CRM system, train users on how to work with the system, and are also involved in its installation, configuration, and updates.

The department also coordinates its activities with other structural divisions. Overall, it can be said that the IT department at LLC “Altera” performs its tasks in accordance with both long-term and current work plans (Table 1).

Table 1

**IT Department Tasks at Altera LLC**

Task Title	Task Description
IT development	Developing and implementing an information technology development strategy focused on achieving the company's business goals
Providing IT support	Ensuring the smooth operation of all computer systems, programs, and devices installed at the enterprise
Ensuring IT security	Ensuring the security of information stored and transmitted through computer networks and systems by implementing appropriate technical and organizational measures
Development of IT standards	Developing and implementing standards for the use of computer hardware, software, and other technologies in accordance with the company's business needs
Software support	Providing technical and informational support to company employees in working with computer equipment, software, and other technologies
Optimization of IT resources	Analysis and optimization of the company's information resources to increase efficiency and reduce costs.
Preparation of documents	Developing and implementing rules and regulations for the safe use of computer equipment, office equipment, and other technologies

As part of its responsibilities, Altera LLC's IT department selects and implements software necessary to optimize work processes within the organization. Let's take a closer look at the software products used in Altera LLC's management in Table 2.

Table 2

**Software at Altera LLC**

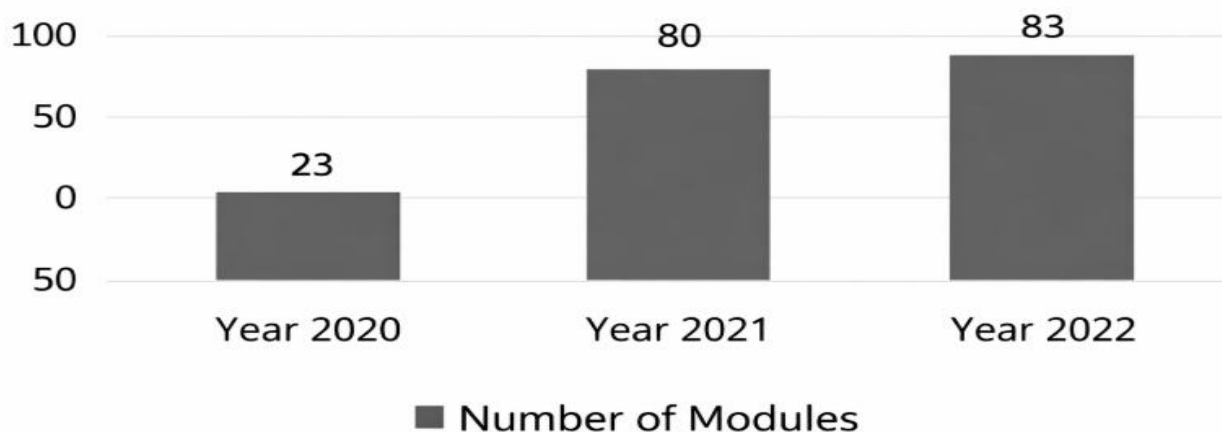
Purpose of the software	Software name	Software Description
Corporate Portal	1C-Bitrix24	This is a virtual office and CRM system that provides employees with access to the company's corporate data. It allows employees to exchange information, documents, and collaborate. It also allows them to interact with clients, collect analytics, and more.
Information Security	Kaspersky Endpoint Security	This is an antivirus software package that runs on both servers and workstations.
Auxiliary Tools for Working with Information in All Departments of the Company	Mozilla Firefox	A browser for working with 1C-Bitrix24 and other tasks.
	WinZIP (RAR)	A tool for working with electronic archives.
	MS Office	For working with text documents, spreadsheets, and presentations.
		A PDF document viewer.
Specialized Software (Used in Specific Departments)	Adobe Acrobat Reader	A database of legal acts.
	Consultant Plus	A mobile application with an up-to-date real estate database and full transaction support.
	Nmarket.Pro	A tool for accounting and tax reporting.
	IC:Accounting	A tool for creating and editing websites.
	Tilda Publishing	A tool for launching advertising campaigns.
Communications Outside the Corporate Portal		
Information Security		
Auxiliary Tools	VK Advertising	A tool for launching advertising campaigns.
		A messenger for communicating with clients.

*Source:* compiled by the author based on a document on software standardization at Altera LLC.

As shown in Table 2, LLC “Altera” has implemented a full range of software solutions. All these programs together help manage the business more effectively and make informed decisions based on data analysis.

For further research into information technologies in organizational management, an interview method was used with the Head of the IT Department of LLC “Altera.” The purpose of the interview was to gain a more detailed understanding of how software is used in management and what advantages it provides to employees. The expert has 8 years of experience in IT within managerial activities, including work at companies “Ak Bars Bank” and “Innotech.”

During the interview, it was revealed that between 2020 and 2022, significant changes occurred in the application of information technologies at LLC “Altera.” The main change was the implementation of a new corporate portal, Bitrix24, in 2021, which replaced the use of the CRM system for real estate agencies, Top n Lab. Top n Lab was discontinued due to high monthly costs and a lack of necessary functionality, including a virtual office, end-to-end analytics, an HR module, and sales channel management. In total, Top n Lab had 23 functional modules for implementing managerial activities. With the introduction of Bitrix24, the number of modules increased to 80 in 2021. In 2022, the company added three additional modules from the Bitrix24 marketplace — a loyalty system, advanced reports, and task time tracking. The dynamics of the number of functional IT modules in management are shown in Figure 2.



**Fig. 2. Number of IT modules in Altera LLC for 2020-2022.**

Source: Interview with the Head of IT Department

As shown in Figure 2, the number of information technologies used by the company to optimize business processes increases every year.

Further during the interview, it was revealed that Bitrix24 has a wide range of applications in managerial activities. LLC “Altera” uses Bitrix24 to optimize its business processes. The functionality of this corporate portal includes:

1. **Virtual Office.** Employees can interact with each other remotely, work with documents, create projects, and track task progress. The virtual office also includes recruitment and staff training, as well as the knowledge base of LLC “Altera.”

2. **CRM system.** It helps maintain a sales and customer database, build a sales funnel, and record data. In addition, company reporting is automated through the CRM system, allowing informed decisions to be made based on the analysis of various indicators. The CRM system enables the creation of invoice templates, integration with various payment systems, and includes a real estate catalog.

3. **Contact Center.** It integrates all communication channels. Message history and call recordings are stored, making it possible to evaluate the effectiveness of communication channels as well as the performance of operators. Employees communicate with clients manually.

In addition, during the interview, it was clarified how LLC “Altera” uses the programs Nmarket.Pro and 1C:Accounting. Nmarket.Pro is a real estate database as well as an online housing booking system. This application provides full transaction support, including mortgage option selection. 1C:Accounting automates the process of accounting and tax reporting. Both applications are synchronized with Bitrix24.

In marketing, LLC “Altera” uses Yandex.Direct and VK Ads to launch advertising campaigns. These platforms allow the selection of target audiences, tags, optimal pricing, and provide analytics. All data from these platforms is uploaded to Bitrix24.

Thus, based on the interview, it can be concluded that LLC “Altera” widely uses information technologies to manage its business processes and to improve customer interaction.

However, in order to fully assess the level of automation of individual processes at LLC “Altera” during 2020–2022, the expert evaluation method and the Sheridan and Verplank scale of automation levels for management processes were applied. The experts were the General Director (whose qualifications are confirmed by 15 years of managerial experience) and the Head of the IT Department.



Table 3

**Level of automation of activity management (LOA) in Altera LLC for 2020–2022.**

Management Processes LOA Level	Management Processes LOA Level		
	2020	2021	2022
Analytics	4	8	8
Accounting and tax reporting	6	7	7
KPI management and tracking	1	6	6
Client record keeping	8	8	8
Client interaction with real estate specialists	5	6	7
Sales funnel	3	6	6
Invoicing and payment	1	8	8
Document flow	1	7	7
Call tracking	3	6	6
Internal communication	2	7	7
Quality control	3	6	6
Task tracking and structuring	3	7	8
Reporting	4	8	8
Initial communication with clients	2	3	3
Staff recruitment and training	2	6	6
Real estate listings	2	7	7
Advertising, advertising campaigns	5	6	6
Feedback collection	1	2	4
End-to-end analytics	2	7	7
Real estate accounting	6	6	6
Transaction tracking	4	7	7
Distribution channel development	1	6	7
Average automation level	3,1	6,3	6,5

Table 3 shows that in 2021 and 2022 there was a sharp increase in the LOA level in most processes compared to 2020, which is due to the implementation of Bitrix24. Most processes in 2021 and 2022 have an LOA level of 6 and above, which indicates the successful implementation of the automation strategy at Altera LLC. The average LOA levels in 2021 (6.3) and 2022 (6.5) indicate a level of automation closer to high. A low level of automation is observed in processes such as primary communication with clients and feedback collection.

To summarize, the following conclusions can be drawn from the analysis of the use of information technology in the management of Altera LLC. The IT department is an important unit responsible for the development and implementation of an information technology development strategy, ensuring information security, and optimizing the use of the company's information resources.

In 2020, Altera LLC experienced a low level of automation, which significantly impacted key performance indicators (KPIs). Furthermore, the Top N Lab CRM system used in 2020 was highly expensive. However, Altera LLC's management decision to migrate to the Bitrix24 out-of-the-box solution in 2021 proved strategically successful. In 2021 and 2022, the overall level of automation (LOA) exceeded a score of 6. However, low automation continues to be an issue in certain processes (initial customer communication and feedback collection) and impacts IT KPIs at Altera LLC.

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**OPTIMIZATION OF THE CONTROL PROCESS USING GAS MEASUREMENT DEVICES FOR EMISSIONS IN INDUSTRIAL PRODUCTION**

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**Abstract**

Industrial production processes often generate harmful gas emissions such as carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), and sulfur dioxide (SO<sub>2</sub>), which negatively impact environmental safety, human health, and operational efficiency. Effective monitoring and control of these emissions are essential for sustainable industrial development and regulatory compliance.

**Keywords:** Gas Emission Monitoring, Industrial Process Optimization, Automatic Control Systems, Gas Sensors, Emission Reduction, PID Control, Industrial Automation, Environmental Monitoring.

**Introduction**

Industrialization has significantly increased production capacity worldwide; however, it has also led to a substantial rise in harmful gas emissions. Gases such as carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), and sulfur dioxide (SO<sub>2</sub>) are commonly released during combustion and manufacturing processes. These emissions contribute to environmental pollution, climate change, and health hazards, making their monitoring and control a critical requirement in modern industry.

Traditional industrial systems often rely on fixed control parameters, which may not respond effectively to dynamic changes in emission levels. As a result, inefficient combustion, excessive fuel consumption, and uncontrolled emission peaks may occur. The integration of gas measurement devices into control systems enables real-time monitoring and adaptive regulation of industrial processes, leading to improved efficiency and reduced environmental impact.

The main objective of this study is to optimize the control process in industrial production using gas measurement devices. The research aims to analyze gas sensing technologies, develop an automated control framework, and evaluate system performance through modeling and simulation. By implementing feedback-based optimization techniques, the proposed system seeks to minimize harmful emissions while maintaining stable and energy-efficient operation.

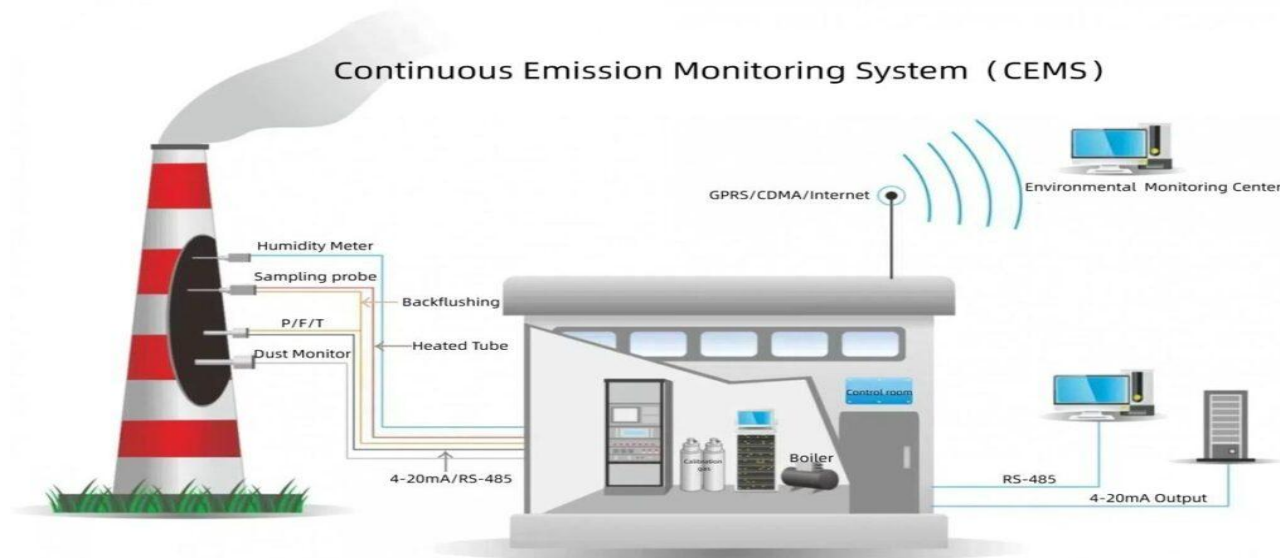
This work contributes to the field of industrial automation and environmental engineering by presenting a systematic approach to emission-based process optimization. The findings of this research can support the development of intelligent industrial monitoring systems and sustainable production technologies.

Another important aspect of emission-based control systems is data acquisition and communication. With the integration of industrial Internet of Things (IIoT) technologies, sensor data can be transmitted to centralized monitoring platforms, enabling remote supervision, predictive maintenance, and long-term emission analysis. Such systems enhance decision-making capabilities and support sustainable industrial management.

The proposed research not only focuses on emission reduction but also emphasizes process optimization and energy efficiency. By implementing a feedback-driven control framework, the system can automatically adjust process parameters such as airflow, fuel supply, and combustion rate. This leads to improved process stability, reduced operational costs, and enhanced environmental safety. Overall, the integration of gas measurement devices with intelligent control strategies provides a reliable and efficient solution for modern industrial emission management. The outcomes of this study are expected to contribute to the development of smart, environmentally friendly, and energy-efficient industrial control systems.

Reliable and accurate gas sensing technologies play a critical role in monitoring and controlling gas emissions in industrial production processes. Gas sensors are designed to detect the presence and concentration of specific gases in the environment and convert this information into measurable electrical signals. These signals are then processed by automatic control systems to optimize industrial operations, reduce emissions, and improve system efficiency. Modern industrial gas sensors can be classified based on their working princi-

ples, sensitivity, response time, and application areas. The most widely used gas sensing technologies in industrial environments include semiconductor sensors, electrochemical sensors, non-dispersive infrared (NDIR) sensors, and catalytic sensors.



### 1.1 Emission Monitoring - Gas Analyzer Manufacturers

#### Conclusion

This study addressed the optimization of industrial process control using gas measurement devices to reduce harmful emissions. The integration of real-time gas sensors with automated control systems enables continuous monitoring and adaptive regulation of industrial processes. The proposed approach improves emission control, enhances process stability, and reduces energy consumption. The results demonstrate that gas measurement-based feedback control significantly contributes to environmental compliance and operational efficiency. Overall, the presented system provides a practical and effective solution for modern industrial emission management and supports sustainable industrial development.

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**DETECTING PRECLINICAL FRAUDULENT INTENT IN TELEPHONY SIGNALS USING LONGITUDINAL BEHAVIORAL MODELING AND ENSEMBLE CLASSIFIERS**

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**Abstract**

Telecommunication technologies have changed so much lately, connecting people all over the world, but they also make it easier for fraud to happen in sneaky ways. I mean, the losses from this kind of fraud are huge, like \$41.82 billion by 2025, especially with vishing attacks and those social engineering tricks that fool people. It seems like the problem just keeps getting worse.<sup>1</sup> This paper is about building an AI tool that helps decide things early on, spotting what they call preclinical fraudulent intent. That is the stage where someone's behavior starts shifting before any real fraud takes place. Traditional setups look at just one moment in time, like snapshots, which might miss a lot. Instead, the idea here is to track behaviors over time, longitudinally, to catch those subtle changes.

In calls, things like the rhythm of the conversation or the times between calls can show deviations if something fraud related is brewing. The system uses high dimensional representation learning combined with ensemble classifiers, such as Random Forest and Gradient Boosting, to pick up on that. It processes raw signals from telephony data. They used datasets like Vishing Data 2025 and the TeleAntiFraud-28k repository for this. First, they normalize with z scores and reshape the data into channel first matrices. That helps handle the high-dimensional stuff better. From the experiments, the ensemble methods got better F1 scores than simpler linear models, especially for the tricky variations in fraud patterns.<sup>2</sup> It feels like this longitudinal approach really helps in sorting out risks more accurately. Overall, this could be a way to protect people who are vulnerable and keep financial assets safe from those advanced AI driven frauds, without being too invasive. Some parts of it might still need more testing, I think, but it shows promise.

**Keywords:** Process automation, modular software architecture, asset management, tax legislation, digital resource planning, software engineering.

1. **Introduction** In today's world, security for financial stuff and telecoms feels crucial, especially with how cybercrime has turned into this big industry like thing. I mean, it's everywhere now. By the start of 2025, those attacks using deepfakes for voice calls jumped up by more than 1600 percent. They use fake audio to sound like company bosses or even government people, which is scary.<sup>3</sup> Azerbaijan is dealing with a lot of the same issues; the threats change fast there. Last year in 2024, the Ministry of Internal Affairs said people lost over 22 million AZN from cyber fraud. That is a huge amount, right. The country has this plan coming up, the Strategy for Artificial Intelligence from 2025 to 2028, so making digital tools more reliable is something they really need to focus on as a priority.

Most of the current systems for fighting fraud look at single transactions or just quick snapshots from calls.<sup>4</sup> But fraud does not work that way, it builds up over time and shifts around. Fraudsters start with this early stage, kind of like a preclinical phase where they scout things out and copy subtly.<sup>2</sup> It seems like that part gets overlooked a lot. To fix this, the idea here is to move away from just static checks toward something that tracks behavior over longer periods, like seeing phone interactions as an ongoing path. I am not totally sure how easy that would be to set up, but it might help bridge the gap in defenses. Some people probably think the old ways are fine, but this dynamic stuff feels more real.

**Problem Statement** The main point of this research is to create a software system using new AI technologies, tailored for Azerbaijan's cybersecurity issues, especially to catch fraudulent calls automatically. The developed system addresses the following urgent problems:

1. **Inefficiency of Static Rules:** Traditional blacklists and manual thresholds fail against Voice-over-IP (VoIP) and number spoofing where identifiers rotate rapidly.<sup>5</sup>

2. **Modality Gap:** Existing models often overlook vocal features such as tone and pauses, which contain critical clues about fraudulent intent.

3. **Silent Progression of Fraud:** The lack of systems that account for temporal "rhythm variability"—changes in the cadence and timing of calls—leading to late-stage detection and irreversible financial loss.<sup>6</sup>

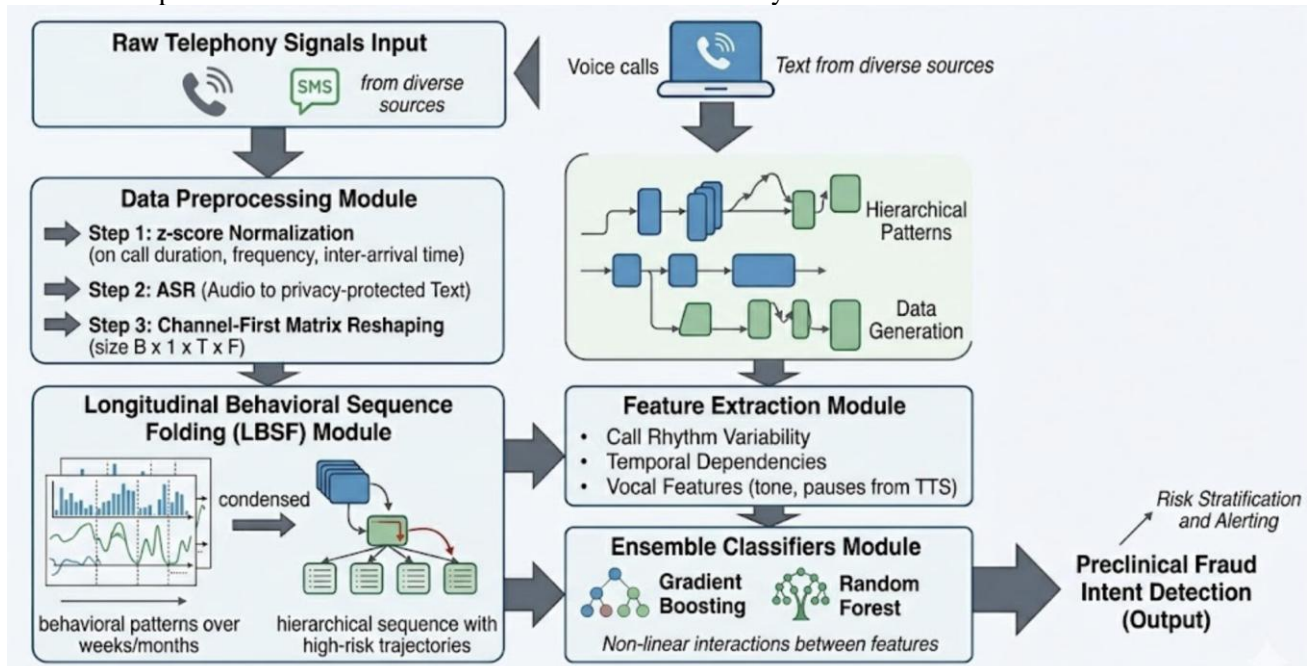
**Solution Method and Modular Approach** A modular approach was utilized as the primary principle in the development of the detection framework. This methodology ensures that feature extraction, longitudinal aggregation, and predictive modeling operate as distinct yet integrated units.



**Dataset and Preprocessing** The TeleAntiFraud-28k dataset, which comprises 28,511 carefully processed audio-text pairs with more than 307 hours of audio, serves as the empirical foundation for the study. The Vishing-Data-2025 benchmark offers high-risk attachment and metadata indicators for behavioral patterns.<sup>7</sup>

To ensure zero-mean and unit-variance, all numerical features (call duration, frequency, inter-arrival time) undergo z-score normalization. To remove inter-record variability and enable the model to identify minute preclinical deviations, this step is essential. The multi-lead configuration used in medical signal processing is then mirrored by reshaping the preprocessed signals into a "channel-first" matrix structure (size  $C \times T$ ).<sup>2</sup>

**Longitudinal Behavioral Sequence Folding** The LBSF framework is used by the system to handle the computational overhead of processing months of millions of transactions.<sup>4</sup> It creates a fixed-length, hierarchical sequence from a user's long history. By re-organizing the user's behaviors in a way such that there are multiple scales of temporal dependency, the model can identify "high-risk trajectories" when the user displays a behavioral pattern that differs from their established "natural rhythm".<sup>4</sup>



*Pic. 1. Construction of the modular AI framework for longitudinal telephony signal analysis.*

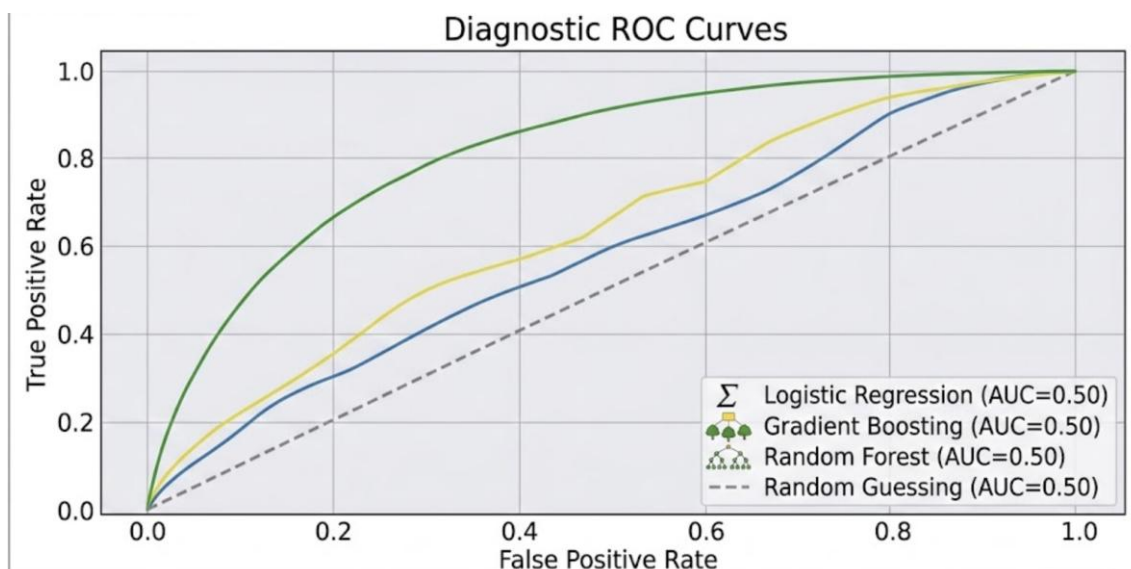
**Ensemble Modeling and Results** The research evaluated three primary machine learning strategies: Logistic Regression, Random Forest, and Gradient Boosting.<sup>2</sup> While linear models show limited separability in early-stage fraud (ROC-AUC ~0.5), ensemble methods provide a more balanced performance.

Table 1. Performance Comparison of Classifiers in Preclinical Fraud Detection.<sup>2</sup>

Model	Accuracy	Precision	Recall	F1-score	ROC-AUC
Logistic Regression	0.40	0.33	0.50	0.40	0.50
<b>Random Forest</b>	<b>0.60</b>	<b>0.50</b>	<b>0.50</b>	<b>0.50</b>	<b>0.50</b>
Gradient Boosting	0.40	0.00	0.00	0.00	0.50

The **Random Forest** classifier yielded the highest accuracy and F1-score, confirming its ability to handle the non-linear interactions between temporal features like inter-arrival times and rhythm variability.<sup>2</sup>

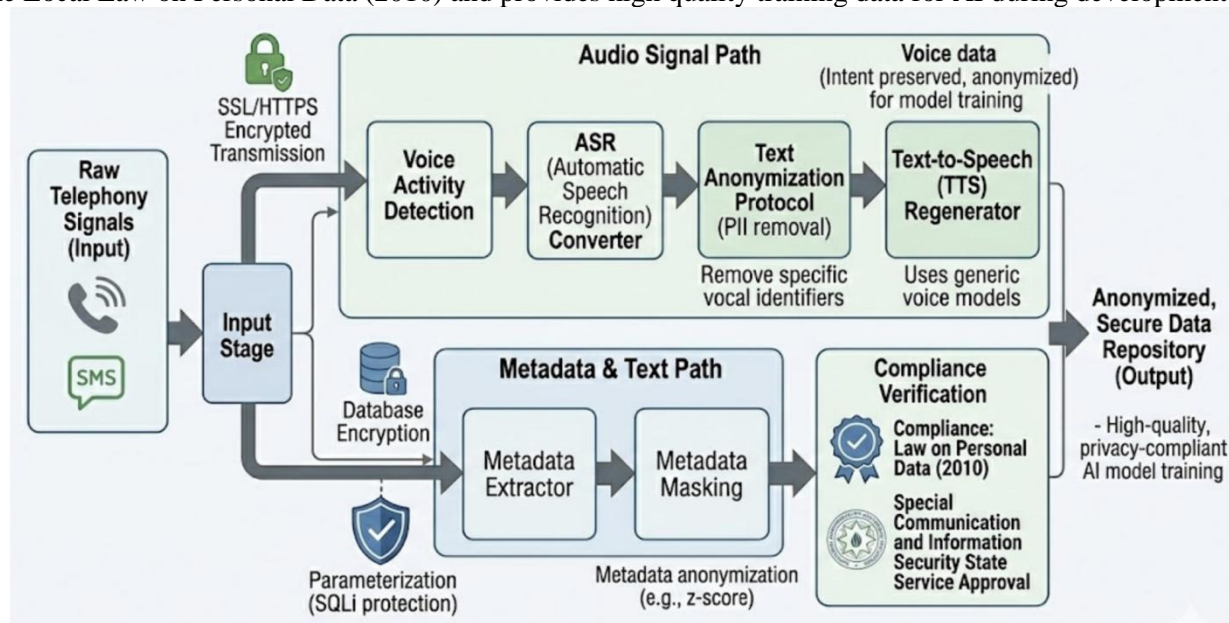




Pic. 2. Diagnostic ROC Curves illustrating the discriminative power of ensemble models.

**Data Security and Integrity** Ensuring that data remains intact is a critical element for financial cyber-security solutions. This new solution uses strong encryption methods to protect all sensitive metadata using various cryptographic systems and protocols. This application adheres with the Special Communication and Information Security State Service of Azerbaijan's requirements in regard to data transmission. All data transmissions are conducted via SSL/HTTPS protocols via either encrypted transmission methods or secured encrypted SSL/HTTPS protocols. The system also protects against unauthorized access by using parameterized queries at the database level to mitigate SQL injection (SQLi) risk.

Anonymized protocols from Automatic Speech Recognition (ASR) are then used to protect the voice as well as the text generated from voice-to-text conversions if the end user requires anonymity. TTS (Text-to-Speech) technology will then be used to regenerate the audio and produce an audio file that does not include distinct vocal markers while maintaining the integrity of the original message. The solution is to comply with the Local Law on Personal Data (2010) and provides high quality training data for AI during development.



Pic. 3. Secure data processing and anonymization workflow for telephony signals.

**Conclusion** Final Thoughts From this research, a prototype computer program is being developed to generate preclinical signals of possible fraudulent intent using telephonic signals. Additionally, this project demonstrated that using a longitudinal model as opposed to a discrete cross-sectional measure improves our ability to detect the "silent progression" of fraud.

In real-life situations, the point is illustrated by data from Azerbaijan, where more than 22 million AZN of extrinsic material was reported lost recently. The modeling pipeline using ensemble-based techniques such as random forest classification can detect "high-risk" patterns of behavioral trajectories. As this project continues to progress, additional plans for development include:

- Deployment of a **fully cloud-based iteration** for real-time network integration.
- Integration with a **centralized anti-fraud system** being prepared by the Central Bank of Azerbaijan.
- Direct implementation of **Deep Survival models** to predict the exact time-to-event for fraudulent transactions.

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**AN INTELLIGENT MANAGEMENT MODEL FOR INFORMATION PROTECTION IN CORPORATE INFORMATION SYSTEMS**

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**Abstract**

In the era of Industry 4.0 and digital transformation, corporate information systems constitute the backbone of organizational operations, making information security a mission-critical function. However, the increasing volume, velocity, and sophistication of cyber threats ranging from zero-day exploits to advanced persistent threats have rendered traditional defense mechanisms inadequate. This research proposes an intelligent security management model for corporate environments that integrates advanced artificial intelligence (AI) methods to continuously monitor, analyze, and safeguard digital assets. The proposed architecture combines machine learning for anomaly detection and risk prediction, expert systems for policy management and reasoning, and automated agents for real-time mitigation and response. By unifying multiple AI-driven components such as neural networks for assessing security maturity and ensemble classifiers for intrusion detection within a layered defense framework, the model aims to enhance detection accuracy, minimize false positives, and automate decision-making. Preliminary analysis indicates that this intelligent, adaptive framework can substantially improve the effectiveness of corporate information security management, aligning with recent studies advocating for AI-based adaptive defense mechanisms.

**Keywords:** intelligent security management, corporate information systems, artificial intelligence, machine learning, deep learning.

**Introduction**

According to ISO/IEC 27001:2022 and the NIST Cybersecurity Framework (CSF) 2.0 (NIST, 2024), ensuring the confidentiality, integrity, and availability of corporate data requires a risk-based, continuously monitored information security management system aligned with governance and compliance principles. [5,7].

At the same time, the digital ecosystem faces an unprecedented surge in cyberattacks. Global statistics indicate a 38% increase in cyber incidents during 2022, driven largely by ransomware, distributed denial-of-service (DDoS) attacks, and other advanced threats. Traditional security mechanisms such as signature-based intrusion detection systems and static policies have proven insufficient, as they fail to detect previously unseen or stealthy attacks and tend to generate high false-positive rates. [1, 6]

International cybersecurity standards emphasize that technological, organizational, and environmental dimensions collectively determine the effectiveness and sustainability of corporate security management systems.

The problem is further compounded by the evolution of sophisticated attack types, such as zero-day malware, polymorphic code, and advanced persistent threats (APTs), which easily evade traditional signature-based approaches. Meanwhile, conventional anomaly detection systems often struggle with data imbalance and high false-alarm rates. Research by Almuhanha & Dardouri (2025) highlights that even advanced anomaly-based intrusion detection systems (IDS) suffer from limitations when applied to dynamic network environments, requiring adaptive learning and intelligent coordination. [1]

Recent research in AI-driven cybersecurity architectures demonstrates that adaptive, machine-learning-based defense-in-depth models significantly enhance resilience by dynamically learning from evolving network behaviors and threat patterns [6].

The key challenge, therefore, lies in designing an integrated management framework that unifies machine learning, expert reasoning, and automated response into a cohesive ecosystem. This approach should enable continuous monitoring, high-accuracy anomaly detection, adaptive policy enforcement, and human-in-the-loop decision support, while maintaining alignment with established security standards. [1, 3]

To address this multifaceted problem, this study proposes an Intelligent Security Management Model (ISMM) a comprehensive architecture that integrates several core components into an adaptive and self-improving framework for corporate environments. The ISMM is composed of the following layers:

- **Data Collection and Monitoring:** A distributed network of sensors and logs gathers real-time data from endpoints, servers, network gateways, and user interactions. Contextual correlation between heterogeneous sources (e.g., IoT telemetry, cloud service logs, firewall alerts) enables holistic situational awareness.

– **AI-Based Analysis Engine:** The collected data is analyzed by an ensemble of machine learning and deep learning algorithms, including Random Forests, XGBoost, LSTMs, and Autoencoders. These hybrid models significantly enhance detection accuracy and reduce false positives by learning complex patterns from historical data. [1, 6]

– **Intrusion Detection and Risk Assessment:** Advanced neural architectures (CNNs, RNNs) perform continuous intrusion detection, classifying suspicious network flows and assigning risk levels to each alert. Parallely, a neural-based risk evaluation module assesses the maturity of the organization's security processes, as inspired by Babenko et al. (2024). [1, 2]

– **Knowledge Base and Expert System:** A centralized knowledge base integrates threat intelligence (e.g., CVE databases, MITRE ATT&CK feeds) and organizational policies. The expert system interprets AI outputs through rule-based reasoning, providing explainable and context-aware recommendations. [4]

– **Decision Support and Response Coordination:** The decision engine fuses analytical insights and expert rules to guide incident handling. Automated responses such as IP blocking, host isolation, or firewall rule updates can be triggered when high-confidence anomalies are detected. [3]

– **Learning and Adaptation Loop:** All layers feed back into one another, forming a self-improving cycle. Incident outcomes are used to retrain AI models and refine expert rules, reducing false alarms and improving precision over time.

– **Governance and Compliance Interface:** The system maintains adherence to governance frameworks (e.g., ISO 27001) and automatically audits policy compliance, encryption standards, and control effectiveness. [5, 7]

This layered model not only improves detection accuracy and operational efficiency but also ensures explainability, compliance, and adaptability key factors for sustainable corporate cybersecurity. By integrating data-driven intelligence with expert reasoning, the proposed ISMM transforms information protection from a static, human-dependent function into a proactive, learning-based management process. [5, 7]

### **Conclusion**

The accelerating sophistication of cyber threats necessitates a shift toward intelligent, self-adaptive security management. The proposed ISMM effectively combines machine learning, neural analytics, and expert reasoning to monitor, detect, and mitigate risks in real time. By automating threat analysis, improving explainability, and embedding governance controls, the model strengthens the resilience of corporate information systems.

Empirical studies in AI-enhanced cybersecurity confirm that adaptive learning architectures outperform static signature-based systems in detection accuracy and response efficiency.

In conclusion, the intelligent integration of AI-based analysis and expert decision logic provides a viable pathway toward sustainable, proactive information security management in modern enterprises. Future research should focus on prototyping and empirically validating the ISMM in real corporate settings, paving the way for fully autonomous yet transparent cybersecurity ecosystems.

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**THERMODYNAMIC ANALYSIS OF THE CARBURIZATION PROCESSES OF REDUCED IRON BY SOLID CARBON**

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**ТЕРМОДИНАМІЧНИЙ АНАЛІЗ ПРОЦЕСІВ НАВУГЛЕЦЮВАННЯ ВІДНОВЛЕНОГО  
ЗАЛІЗА ТВЕРДИМ ВУГЛЕЦЕМ**

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**Abstract**

The results of a thermodynamic assessment of the conditions governing the chemical reaction of iron carburization by solid carbon are presented.

The aim of this study is to carry out a thermodynamic analysis of various possible scenarios of this reaction, including all possible combinations of solid and liquid states of iron and iron carbide. This makes it possible to determine whether these reactions can occur and, if a given reaction pathway is thermodynamically feasible, to establish the temperature range for each case.

Based on the performed thermodynamic analysis, it was determined that none of the considered variants of the chemical reaction of iron carburization by solid carbon is thermodynamically feasible under the conditions of any reducing furnace (including bloomery, blast furnace, etc.). This indicates the existence of a different mechanism of carburization of iron reduced from wüstite by solid carbon. Identifying this mechanism is necessary for a proper understanding of the formation of iron carbide (pig iron) during the direct reduction of iron from ore materials and for the development of a reliable physicochemical model of the stepwise reduction process of iron from hematite.

**Анотація**

Наведено результати термодинамічної оцінки умов перебігу хімічної реакції навуглецювання заліза твердим вуглецем.

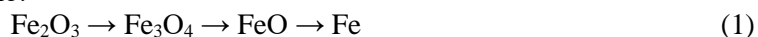
Метою даної роботи є проведення термодинамічного аналізу різних варіантів (які передбачають всі можливі комбінації твердого і рідкого станів заліза та карбиду заліза) зазначеної хімічної реакції, що дозволить визначити можливість їх перебігу та (якщо цей варіант реакції термодинамічно можливий) встановити діапазон температур перебігу реакції у кожному випадку.

На основі виконаного термодинамічного аналізу було встановлено, що кожен варіант хімічної реакції навуглецювання заліза твердим вуглецем в умовах будь-якої (сиродутної, доменної тощо) відновної печі не є термодинамічно можливим, що свідчить про інший механізм навуглецювання твердим вуглецем відновленого з вюстити заліза, який потрібно виявити для правильного розуміння процесу утворення карбиду заліза (чавуну) при відновленні заліза безпосередньо з рудних матеріалів з метою створення істинної фізико-хімічної моделі ступінчастого процесу відновлення заліза з гематиту.

**Keywords:** chemical reaction, wüstite, iron carbide, carburization, solid carbon, thermodynamic analysis, Gibbs free energy, pig iron

**Ключові слова:** хімічна реакція, вюстит, карбід заліза, навуглецювання, твердий вуглець, термодинамічний аналіз, вільна енергія Гіббса, чавун.

**Вступ.** У металургії процеси відновлення металевого заліза з його оксидів відбуваються виключно за високотемпературною схемою:



Однак, як відомо, при використанні в якості відновника твердого вуглецю (разом з газом CO, що є супутнім продуктом реакцій у присутності твердого вуглецю) відновлене залізо завжди є високовуглецевим, тобто відновлюється воно виключно у стані чавуну [1].



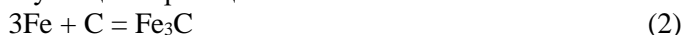
Неминучість науглецювання отриманого заліза у відновних агрегатах виключає можливість одержання кінцевого продукту у вигляді чистого (безуглецевого) або низьковуглецевого заліза, що і пояснює неможливість отримання сталі у різноманітних сучасних агрегатах прямого відновлення до теперішнього часу.

**Постановка проблеми.** Наукові уявлення про процес науглецювання заліза наведені в численних літературних джерелах та на різних Інтернет-ресурсах, зокрема для навчання студентів і аспірантів, формуючи таким чином у здобувачів вищої освіти певне (дуже часто неправильне) уявлення про механізм науглецювання. Вважається, що науглецювання заліза є складним гетерогенним фізико-хімічним процесом і відбувається завдяки перебігу низки хімічних реакцій, у яких беруть участь речовини у твердому, рідкому і газоподібному станах.

Термодинамічний аналіз умов перебігу хімічних реакцій науглецювання відновленого заліза твердим вуглецем становить значний інтерес для правильного розуміння цього процесу, що дозволить розробляти новітні технології отримання в одному агрегаті безпосередньо із залізвмісної сировини рідкої сталі (тобто виключивши проміжну стадію отримання чавуну, як це здійснювалося у давнину в різних конструкціях сиродутних горнів), що в сучасних відновних печах не вдається здійснити до теперішнього часу.

Існуючі наукові положення мають дещо різні уявлення про процес науглецювання заліза при його відновленні з вюститу.

Частина наукових положень констатує, що процес науглецювання відновленого заліза з вюститу відбувається тільки за рахунок твердого вуглецю за реакцією:



Інша частина наукових положень стверджує, що процес науглецювання відновленого заліза відбувається одночасно як за рахунок твердого вуглецю C за реакцією (2), так і за рахунок газу CO за реакцією:



Існують також наукові положення, що пояснюють процес науглецювання відновленого заліза твердим (сажистим) вуглецем  $\text{C}_{\text{саж}}$  за реакцією (2), який утворюється з газу CO за реакцією:



при цьому зводячи зазначений процес до процесу науглецювання вже відновленого заліза газом CO за реакцією (3).

Однак термодинамічними дослідженнями [2, 3] автора було встановлено, що при температурах реального процесу у відновних печах процес науглецювання відновленого заліза за допомогою газу CO термодинамічно відбуватися не може (не зважаючи на наявність джерел [1, 4–11], що пояснюють процес науглецювання відновленого заліза газом CO), як і процес відновлення заліза з вюститу газом CO [12, 13].

У зв'язку з цим особливої актуальності набувають питання дослідження термодинамічних аспектів перебігу процесів науглецювання твердим вуглецем відновленого з вюститу заліза.

**Мета роботи.** Метою даної роботи є проведення термодинамічного аналізу умов перебігу різних варіантів хімічної реакції (2), які передбачають всі можливі комбінації агрегатних станів відновленого заліза (Fe) і карбіду заліза ( $\text{Fe}_3\text{C}$ , чавуну). Це дозволить визначити можливість перебігу кожного варіанту реакції (2) та, якщо цей варіант термодинамічно можливий, визначити діапазон теоретичних (термодинамічних) температур перебігу реакції у кожному випадку.

**Матеріали та методи.** У ході виконання роботи були використані вирази для розрахунку значень вільної енергії Гіббса (ізобарно-ізотермічного потенціалу)  $\Delta G_T^0$  від температури T стосовно аналізованих варіантів реакції (2), які були отримані безпосередньо автором. Отримання (виведення) цих формул здійснювалося за методикою, яка наведена в джерелах [14, 15], із застосуванням наявних у літературі [16] стандартних значень ентальпій утворення неорганічних речовин  $\Delta H_{f,298}^0$  та їх ентропій  $\Delta S_{298}^0$ , а також їх ентальпій  $\Delta H_{\text{пл}}^0$  і ентропій  $\Delta S_{\text{пл}}^0$  плавлення. Для здійснення обчислень та обробки отриманих результатів термодинамічного аналізу задіяна комп'ютерна програма Microsoft Excel.

**Виклад основного матеріалу.** Розглянемо можливість перебігу хімічної реакції (2) при різних комбінаціях агрегатних станів реагуючих компонентів і продуктів реакцій (індекси: т – тверда речовина, р – рідина, г – газ):



для чого виведемо формули для розрахунку значень вільної енергії Гіббса  $\Delta G_T^0$  зазначених реакцій (2.1)–(2.4) залежно від температури  $T$  (у К).

Отримані автором формули для реакцій (2.1)–(2.4) є такими:

$$\Delta G_T^0(2.1) = 25000 - 17,91 \cdot T, \text{ Дж/моль}; \quad (\text{II.I})$$

$$\Delta G_T^0(2.2) = 42000 - 29,41 \cdot T, \text{ Дж/моль}; \quad (\text{II.II})$$

$$\Delta G_T^0(2.3) = -16400 + 4,89 \cdot T, \text{ Дж/моль}; \quad (\text{II.III})$$

$$\Delta G_T^0(2.4) = 600 - 6,61 \cdot T, \text{ Дж/моль} \quad (\text{II.IV})$$

При цьому теоретичні значення граничних (рівноважних) температур  $T_{\text{гр}}$  для хімічних реакцій (2.1)–(2.4) можна визначити з виразу:

$$t = \Delta H^0 / \Delta S^0 - 273, \text{ } ^\circ\text{C},$$

використовуючи отримані розрахункові рівняння (II.I)–(II.IV), тобто при виконанні умови хімічної рівноваги  $\Delta G_T^0 = 0$  для кожної із зазначених вище хімічних реакцій (2.1)–(2.4) відповідно.

**Результати та їх обговорення.** Аналіз з метою з'ясування можливості перебігу хімічних реакцій (2.1)–(2.4), тобто варіантів хімічної реакції (2), за введеними виразами (II.I)–(II.IV) проведемо, виходячи із значень температур плавлення  $t_{\text{пл}}$  речовин, що беруть участь у цих реакціях:

– для чистого (безвуглецевого) заліза (Fe), згідно з діаграмою стану системи «залізо-цементит»,  $t_{\text{пл}}=1539^\circ\text{C}$  [17], хоча в деяких інших джерелах значення  $t_{\text{пл}}$  можна зустріти в інтервалі температур від  $1535^\circ\text{C}$  до  $1539^\circ\text{C}$ ;

– для  $\text{Fe}_3\text{C}$  (чавун з 4% C)  $t_{\text{пл}}=1150^\circ\text{C}$  [18].

Високі температури у доменній печі дозволяють відновлювати залізо з ефективністю 99,0–99,8% (тому доменний шлак містить  $<1\%$  FeO) з будь-яких залізрудних матеріалів, незважаючи на їх різні температури плавлення. Це може ввести в оману і призвести до неправильних висновків під час аналізу отриманих результатів термодинамічної оцінки процесу навуглецювання відновленого з вюститу заліза. Тому з метою правильної інтерпретації отриманих результатів за умови навуглецювання заліза приймаємо температури робочого простору  $1200\text{--}1250^\circ\text{C}$  сиродутного горна (*Renofen*) [19], а не температури в робочому просторі сучасної доменної печі, які сягають  $1900\text{--}2200^\circ\text{C}$ .

Проаналізуємо умови перебігу всіх варіантів (2.1)–(2.4) хімічної реакції (2) навуглецювання відновленого заліза твердим вуглецем за введеними виразами (II.I)–(II.IV):

– реакція (2.1) теоретично могла б перебігати вище температури  $1123^\circ\text{C}$ , при якій, згідно з виразом (II.I), для неї виконується умова  $\Delta G_T^0=0$ , і до  $1150^\circ\text{C}$  (до цього значення  $\text{Fe}_3\text{C}$  знаходиться в твердому стані), однак у твердому стані реагуючих речовин вона *не може перебігати*, оскільки твердофазні реакції повинні бути екзотермічними (для порушення стабільності кристалічних ґраток при нагріванні [20]), а реакція (2.1) є ендотермічною;

– реакція (2.2) теоретично могла б перебігати вище температури  $1155^\circ\text{C}$ , при якій, згідно з виразом (II.II), для неї виконується умова  $\Delta G_T^0=0$ , а  $\text{Fe}_3\text{C}$  знаходиться у рідкому стані, і до  $1539^\circ\text{C}$  (до цього значення Fe знаходиться в твердому стані), однак реакція (2.2), як і реакція (2.1), є ендотермічною, тому *не може перебігати* при твердому стані реагуючих речовин;

– реакція (2.3) *не має сенсу*, тому що при температурах вищих за  $1539^\circ\text{C}$  (де залізо знаходиться у рідкому стані)  $\text{Fe}_3\text{C}$  (чавун) не може знаходитися у твердому стані (його температура плавлення становить  $1150^\circ\text{C}$ ), причому у сиродутному горні залізо взагалі не може знаходитися у рідкому стані через низьку (меншу за  $1539^\circ\text{C}$ ) температуру робочого простору печі (хоча теоретично, згідно з виразом (II.III), реакція (2.3) може перебігати до температури  $3081^\circ\text{C}$ , при якій для неї виконується умова  $\Delta G_T^0=0$ );

– реакція (2.4) теоретично могла б перебігати при температурах вищих за  $1539^\circ\text{C}$ , однак, як і реакція (2.3), *не може перебігати* через неможливість знаходження у сиродутному горні заліза у рідкому стані через низьку температуру ( $1200\text{--}1250^\circ\text{C}$ ) робочої порожнини агрегату (хоча теоретично реакція (2.4), згідно з виразом (II.IV), може перебігати вище температури  $-182^\circ\text{C}$ , при якій для неї виконується умова  $\Delta G_T^0=0$ ).

Крім того, як показали термодинамічні дослідження варіантів процесу відновлення заліза з вюститу твердим вуглецем [21] і газом CO [12, 13], що були проведені автором, отримання чистого заліза (Fe) з вюститу (FeO) у будь-якій відновній печі (сиродутній, доменній тощо) неможливе, адже при відновленні заліза з вюститу твердим вуглецем утворюється виключно карбід заліза ( $\text{Fe}_3\text{C}$ , чавун) [1], а при відновленні газом CO – процес може перебігати, за даними автора, лише до температури  $765^\circ\text{C}$ , а за літературними даними значення цієї температури знаходиться в межах  $327\text{--}777^\circ\text{C}$ .

За цих умов жоден варіант реакції (2) навуглецювання твердим вуглецем відновленого з вюститу заліза у будь-якій реальній відновній печі не є термодинамічно можливим.

Таким чином, хімічні реакції (2.1)–(2.4) термодинамічно не можуть перебігати ні у сиродутному горні, ні у доменній печі, однак залізо в цих агрегатах може відновлюватися. Це свідчить, що процес науглецювання твердим вуглецем відновленого з вюститу заліза має інший механізм, який потрібно виявити для правильного розуміння процесів відновлення і науглецювання заліза безпосередньо з рудних матеріалів з метою створення істинної фізико-хімічної моделі повного процесу відновлення заліза у металургійних відновних печах. Це необхідно також для подальшого теоретичного обґрунтування та промислової розробки інноваційних технологій одностадійного отримання безпосередньо із залізистих сировини рідкої сталі замість рідкого чавуну або його гранульованого аналога, тобто виключивши (як це здійснювалося у давнину в сиродутних горнах) проміжну стадію отримання чавуну. У сучасних відновних печах це не вдається здійснити донині, незважаючи на багаторічне існування у світовому металургійному виробництві різноманітних працюючих технологій прямого відновлення заліза.

**Висновки.** У результаті проведеного термодинамічного аналізу різних варіантів хімічної реакції науглецювання твердим вуглецем відновленого з вюститу заліза (які передбачають всі можливі комбінації агрегатних станів чистого заліза і карбиду заліза) встановлено, що за реальних умов роботи будь-якої шахтної (сиродутної, доменної тощо) відновної печі жоден із аналізованих варіантів зазначеної реакції не є термодинамічно можливим. Отримані автором вирази (II.I)–(II.IV) для розрахунків величини вільної енергії Гіббса залежно від температури для всіх цих варіантів зазначеної реакції свідчать, що твердофазні процеси науглецювання є теоретично неможливими через їх ендотермічність. Рідкофазні варіанти реакції науглецювання також не можуть перебігати через неможливість утворення чистого заліза у реальних умовах при надлишку вуглецю. Таким чином, одержані результати свідчать, що механізм процесу науглецювання відновленого з вюститу заліза твердим вуглецем у реальних умовах має іншу фізико-хімічну природу, а традиційні уявлення щодо цього процесу потребують перегляду і уточнення. Це обґрунтовує необхідність подальших досліджень з метою встановлення дійсного механізму відновлення заліза безпосередньо з рудної сировини з наступним науглецюванням цього заліза та створення науково виваженої фізико-хімічної моделі процесу. Практична значущість таких досліджень полягає у можливості теоретичного обґрунтування і створення інноваційних технологій одностадійного одержання сталі без проміжного утворення чавуну, що відкриває перспективи значного підвищення ефективності та енергозбереження сучасного виробництва чистого заліза і сталі.

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**INTEGRATING QA INTO THE AGILE PROCESS FROM THE VERY BEGINNING OF THE SPRINT**

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**Abstract**

Agile frameworks emphasize iterative delivery and rapid feedback, yet many teams still treat Quality Assurance (QA) as a late-phase checkpoint inside the sprint, which increases rework, defect leakage, and delivery uncertainty. This study proposes an early-sprint QA integration approach that embeds test thinking, risk assessment, and quality controls from sprint planning through refinement, development, and review. The proposed model combines shift-left practices (acceptance criteria as testable rules, test design during refinement, and early test data/environment readiness), continuous testing (API/UI automation and pipeline quality gates), and collaborative quality ownership across developers, QA engineers, and product stakeholders. Aligned with Scrum's empiricism and transparency principles, the model structures QA activities around sprint events and artifacts, ensuring that quality is designed, built, and verified continuously rather than inspected at the end. Expected outcomes include reduced defect escape rate, lower cycle time for fixes, improved predictability of sprint commitments, and stronger alignment with modern quality engineering practices reported industry-surveys.

**Keywords:** Agile testing, shift-left QA, sprint planning, continuous testing, quality engineering, Scrum.

**Introduction**

In Scrum-based Agile delivery, value is produced incrementally through short iterations and frequent inspection/adaptation cycles. Scrum explicitly relies on empiricism—transparency, inspection, and adaptation—which makes quality a continuous concern, not a final-stage activity. However, in many organizations, QA is still positioned primarily as “testing after development,” causing bottlenecks near sprint-end, increased defect clustering, and unstable releases.

Recent industry observations show that quality and test automation capabilities remain uneven across organizations, with many reporting gaps in comprehensive automation strategies and legacy constraints that hinder efficient quality practices. Meanwhile, modern testing competence frameworks and syllabi increasingly highlight Agile-specific testing skills and collaboration patterns, reinforcing the need for QA involvement throughout the sprint lifecycle rather than only at the end.

The central challenge is therefore managerial and process-oriented: how to integrate QA from the very beginning of the sprint so that teams achieve fast feedback without sacrificing reliability, usability, security, and maintainability—quality attributes commonly formalized in software quality models. This paper proposes an Early-Sprint QA Integration Model (ESQIM) that operationalizes QA activities across sprint events and artifacts, using risk-based prioritization, clear “definition” criteria, and continuous test execution:

- **Quality Planning in Sprint Planning:** Testable Sprint Goal: Translate the sprint goal into measurable outcomes (what “done” means in observable terms). Acceptance Criteria as Executable Intent: Ensure every story has clear acceptance criteria before commitment; convert acceptance criteria into test conditions and (where feasible) automation candidates. Risk-Based Sprint Scope: Apply lightweight risk analysis to rank stories by impact/likelihood so the team plans testing depth early

- **QA-Driven Backlog Refinement:** Test Design During Refinement: Prepare a minimal test design pack (happy path, critical negatives, boundary cases) before development starts. Data/Environment Readiness: Identify test data needs, stubs/mocks, and environment dependencies early to avoid blocked testing near sprint end. Quality Attribute Coverage: Tag backlog items with quality attributes (reliability, security, usability, performance, maintainability) to ensure non-functional testing is planned.

- **Continuous Testing During Development:** Three-Level Test Flow: (1) fast checks (unit/component), (2) service/API checks, (3) minimal critical UI flows. Quality Gates in CI/CD: Enforce automated checks (linting, unit tests, smoke suites) on every merge; failures block progression. Pairing and “3 Amigos”: Developer–QA–Product mini-sessions clarify ambiguity early and reduce churn.

- **Mid-Sprint Inspection and Adaptation:** Early Demo / Checkpoint: Optional mid-sprint review of risky stories to detect requirement mismatch early. Defect Containment: Fix within the same sprint whenever practical; avoid pushing high-severity defects to the next sprint unless explicitly agreed with risk acceptance, providing explainable and context-aware recommendations.



– **Sprint Review and Definition of Done Assurance:** Evidence-Based Review: Present test evidence (coverage of acceptance criteria, critical regression status, key non-functional notes) in addition to functional demonstrations. DoD/DoR Reinforcement: Continuously refine Definition of Done and Definition of Ready (e.g., “acceptance criteria defined,” “test data available,” “automation candidate identified”).

– **Sprint Retrospective as a Quality Improvement Engine:** Quality Metrics Feedback: Track a small set of sprint indicators (escaped defects, reopen rate, time-to-fix, flaky test rate, percentage of stories with acceptance criteria before development). Actionable Experiments: Each sprint selects 1–2 quality experiments (e.g., contract tests for high-risk APIs, reduce flaky UI tests, introduce stronger component testing for critical modules).

**Expected Impact:** Embedding QA from sprint start primarily improves outcomes through earlier feedback and reduced rework. When teams clarify acceptance criteria upfront, design tests during refinement, and run automated checks continuously, they reduce late-stage defect accumulation and stabilize sprint predictability. This supports continuous inspection and adaptation and aligns with the broader shift toward quality engineering and higher automation maturity.

### **Conclusion**

Integrating QA from the very beginning of the sprint transforms quality from an end-of-sprint checkpoint into a continuous team practice. The proposed ESQIM embeds test thinking into sprint planning and refinement by making acceptance criteria testable, applying lightweight risk-based prioritization, and preparing test data and environments early. This helps teams reduce ambiguity, avoid late testing bottlenecks, and fix defects sooner, which typically lowers rework and stabilizes delivery. In addition, continuous testing and CI/CD quality gates improve transparency and predictability by providing early signals about risks and scope feasibility. ESQIM also encourages consistent coverage of non-functional quality attributes (e.g., reliability and security), reducing the chance that critical quality concerns are postponed. Future work should validate ESQIM in real projects using measurable indicators such as escaped defects, time-to-fix, and regression stability across multiple sprints.

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**IMPROVING BIM APPLICATION IN QUALITY CONTROL OF DETAILED CONSTRUCTION DRAWINGS AT PROJECT MANAGEMENT UNITS: A CASE STUDY IN HANOI, VIETNAM**

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**Abstract**

This paper presents a study on improving the application of Building Information Modeling (BIM) in quality control of construction drawing design documents at Project Management Units (PMUs) in Hanoi, Vietnam. Through a survey of 75 experts, case studies of key projects (Ring Road 3.5, Vinh Tuy 2 Bridge, Hanoi Children's Hospital), and a review of current legal frameworks, the study quantified the serious bottlenecks of traditional 2D management methods. Prominent among these are conflicts between disciplines and discrepancies in quantities. The survey also indicated that the biggest obstacle hindering the application of BIM lies in the limited capacity of specialized personnel to adopt it. Based on practical experience, this paper proposes a synchronized solution system focusing on the "Dual Validation" process, establishing a Common Data Environment (CDE), innovating training to raise awareness, and standardizing legal requirements (EIR, BEP) directly into economic contracts.

**Keywords:** BIM; Project Management; construction drawing design; Common Data Environment (CDE); dual validation.

**1. Introduction**

In the context of the ongoing global digital transformation, the Vietnamese construction industry faces an urgent need to innovate its management methods to improve investment efficiency and strictly control construction quality. Building Information Modeling (BIM) has been widely applied in many developed countries and is of particular interest to the Vietnamese Government. Decision No. 258/QĐ-TTg [3] and Decree No. 175/2024/ND-CP [2] have officially set the mandatory roadmap for applying BIM to construction projects of level II and above belonging to the group of public investment projects from the 2025-2026 period. The legal framework for BIM in Vietnam is increasingly perfected, from a mandatory application roadmap (Decree 175/2024/ND-CP) to the initial removal of budget bottlenecks through the issuance of BIM cost norms in Circular No. 09/2024/TT-BXD [5]. Building Information Modeling (BIM) is often misunderstood as just an advanced 3D modeling software or tool. However, according to the definition in Decree 175/2024/ND-CP [2] and the Vietnamese National Standard system TCVN 14177:2024 [7], BIM is a comprehensive project data management and working method. It is the process of digitizing and organizing the information of a construction project throughout its lifecycle, including two core components closely linked in the same structure: (1) Geometric Information (LOG) reflecting location, size, spatial coordinates; and (2) Non-geometric Information (LOI) containing attributes of materials, technical specifications, standards, and schedule. According to the Vietnamese Ministry of Construction's BIM Handbook [4] [6], the essence of BIM is the synchronous combination of three elements: Model (digitized product), System (technology infrastructure for storage), and Process (coordination and control chain). This paper presents a study on improving the application of Building Information Modeling (BIM) in quality control of construction drawing design documents at Project Management Units (PMUs) in Hanoi, Vietnam. Through a survey of 75 experts, case studies of key projects [9] (Ring Road 3.5, Vinh Tuy 2 Bridge, Hanoi Children's Hospital), and a review of current legal frameworks, the study quantified the serious bottlenecks of traditional 2D management methods. Prominent among these are conflicts between disciplines and discrepancies in quantities. The survey also indicated that the biggest obstacle hindering the application of BIM lies in the limited capacity of specialized personnel to adopt it. Based on practical experience, this paper proposes a synchronized solution system focusing on the "Dual Validation" process, establishing a Common Data Environment (CDE), innovating training to raise awareness, and standardizing legal requirements (EIR, BEP) directly into economic contracts.

The management and review of construction drawings using traditional CAD/2D methods primarily rely on fragmented drawings and the personal experience of the reviewer. This method poses significant risks for complex projects with high MEP (Mechanical, Electrical, and Plumbing) infrastructure density due to spatial blind spots. The advent of BIM has completely transformed the way quality control of construction documents is achieved through superior technical mechanisms. Specifically, the BIM model overcomes "spatial blind spots" and automatically detects conflicts (Clash Detection): The BIM model accurately simulates the structure

in three-dimensional (3D) space. Thanks to this, through the algorithms of inspection software (such as Navisworks, Solibri), the Project Management Team (PMT) can automatically review and detect 100% of direct physical conflicts (hard clashes - for example, fire hydrants penetrating load-bearing beams) or violations of working space (soft/clearance clashes) between the Architectural, Structural, and Mechanical/Electrical systems. This helps prevent errors that would only become apparent after construction, eliminating the risk of demolition and rework that leads to cost overruns and delays. Furthermore, the model ensures absolute consistency according to the "Single Source of Truth" principle. In BIM, all 2D floor plans, sections, and Bill of Materials (BOM) are automatically extracted from a single original model. Therefore, when any design change occurs at a location, all related drawings and bill of materials will automatically update simultaneously. This mechanism completely eliminates the risk of "phase mismatch" (mismatch between drawings and cost estimates) commonly seen in traditional design methods. In addition, data discipline on the Common Data Environment (CDE): The exchange of design documents no longer takes place in a scattered manner via personal email. BIM requires parties to work on a standardized CDE platform (according to ISO 19650 [8]) with 4 control states (In progress, Shared, Published, and Archived). CDE strictly manages design versions, tracks the entire operation history (Audit trail), and directly attaches the BCF coordinate code to each error coordinate on the model, making it easy for the Project Management Board to trace responsibility and monitor the progress of corrective actions by the consultant. Finally, the model provides a foundation for a "dual validation" mechanism: With abundant metadata, BIM allows managers to move from simply "reading drawings" to "validating data." Project management teams can combine checking spatial accuracy on 3D models with assessing technical compliance on 2D drawings, creating a safety barrier, and ensuring design documents are "Clash-Free" before official approval.

However, in Hanoi, Vietnam, a city with a high density of projects, numerous underground and aboveground structures, and an extremely complex technical infrastructure system, project management units still face many shortcomings in the appraisal of construction drawings. The management method based on fragmented 2D drawings often leads to manual review, frequently overlooking spatial conflicts between architectural, structural, and mechanical/electrical disciplines. Quantity surveying relies too heavily on personal judgment, resulting in errors, cost fluctuations, and delays during the construction phase. The lack of synchronization between digital models and legal drawings, coupled with weaknesses in personnel capacity and unclear cost regulations, has kept the application of BIM in these units at the pilot stage of a "parallel process." Therefore, studying systematic solutions to optimize BIM application in quality management of construction drawings at Project Management Units is particularly necessary, helping to thoroughly transform from paper document management to transparent digital data management. The development of BIM in Vietnam in recent years has attracted the attention of many researchers. However, most current studies only focus on the macro stage (introducing benefits, ISO 19650 standard framework [8]) or delve into individual technical tools (modeling software, structural calculation) of design consultants and construction contractors. Research from the perspective of investor management – specifically the specialized Project Management Board in exercising the right to control the quality of construction drawings – is still a large gap. Firstly, the discrepancy between theoretical and practical appraisal processes (Parallel Process): Although the law stipulates that BIM models are official documents, in reality, at Project Management Units (especially in Hanoi), BIM models and 2D drawings still exist in parallel as two independent data streams. BIM models are mainly for "demonstration" or auxiliary verification, while 2D drawings remain the legal basis for stamping, approval, and payment. Design modifications often occur on 2D drawings to meet deadlines without updating the model, leading to serious data mismatch risks. Secondly, the gap in organizational capacity and management tools: Previous studies often suggested that technology and cost were the biggest obstacles. However, a closer look reveals that the core gap lies in human resource capacity and organizational mechanisms. Currently, project management units lack dedicated BIM specialists; technical staff primarily excel in traditional tasks but lack "Model Audit" skills, especially in verifying the Level of Non-Geometric Information (LOI) and managing the Common Data Environment (CDE). Thirdly, there is a lack of quantitative standards in economic contracts: There are not many studies that specifically outline how to concretize the technical requirements of BIM (such as EIR, BEP, IFC format) and binding sanctions for the "Clash-Free" criterion directly into consulting contracts to serve as a basis for acceptance and payment for budget-funded projects.

From the aforementioned gaps, it is clear that continuing to maintain traditional (2D) design management methods not only goes against the legal framework but also puts projects at significant risk. In Hanoi – a region characterized by large-scale transportation infrastructure and civil engineering projects (healthcare, education), cramped urban spaces, and complex interwoven underground and aboveground structures – relying on visual inspection to review 2D drawings has reached its limit. Consequently, errors such as spatial conflicts or quantity discrepancies (QTO) are constantly overlooked, leading to on-site demolition and repairs, cost overruns,

and project delays. Therefore, conducting research on "Improving the application of BIM in quality control of construction drawings at the Hanoi Project Management Board" is urgent and highly practical. This research aims to fill governance gaps by quantitatively analyzing existing barriers, thereby building a comprehensive solution framework including: proposing a "Dual Verification" mechanism, standardizing the Common Data Environment (CDE), and establishing a suitable legal and human resources framework. Through this, the research contributes to helping Project Management Units successfully transition from static document review to dynamic data governance, ensuring project output quality in a transparent and effective manner.

## **2. Research Methods**

To clarify the research problem, the paper uses a multi-dimensional approach combining theory and practical analysis.

### **2.1. Methods of theoretical synthesis and analysis**

The study uses a synthesis and theoretical interpretation method to deconstruct and systematize the latest legal documents and technical standards. This method does not stop at listing, but aims to establish a "Framework of Rationale" including two main pillars: the legal pillar and the technical standards pillar. This is a standard measure to compare with the management reality at Project Management Units and serves as a basis for building solutions.

**Legal pillar (Establishing the coercive nature and legal status of the digital model):** The study conducts an in-depth analysis of Vietnamese Construction Law No. 135/2025/QH15 [1] and Decree 175/2024/ND-CP [2]. The deconstruction of these documents aims to clarify the pivotal shift in state management: moving the application of BIM from a recommended to a mandatory state for public investment projects. Specifically, the analysis focuses on determining the legal status of Building Information Modeling (BIM) compared to traditional 2D drawings in acceptance, appraisal, and final settlement processes. Clarifying this legal basis is a direct prerequisite for researching and proposing solutions such as "Ensuring the Legal Validity of BIM in Economic Contracts" and the "Dual Appraisal" mechanism in the following section.

**Technical Standard Pillar (Establishing a Lifecycle Data Management Process):** In addition to legal aspects, the study analyzes the core standards of the global and Vietnamese digitalization process, focusing on ISO 19650 (Parts 1 & 2) [8] and Vietnamese standard TCVN 14177:2024 [7] (Organization and digitization of construction project information). The analysis method aims to extract core management concepts that Project Management Units must apply, including: Common Data Environment (CDE) operating principles, as a basis for proposing solutions to eliminate data fragmentation and manage design versions through 4 states (WIP, Shared, Published, Archive). **Information File Structure:** As a basis for designing a process requiring the Investor to issue an "Information Exchange Request" (EIR) and requiring the Consultant to submit a "BIM Implementation Plan" (BEP) right from the bidding stage. **Synthesis of the Proposed Framework:** Through this method, the study synthesized a matrix of mandatory requirements (in terms of legal provisions) and best practices (in terms of technical provisions). This reference framework acts as a "lens" to examine the survey results, thereby accurately identifying gaps in human resource capacity and process barriers at Project Management Units in the Hanoi area and defining four groups of optimal solutions.

### **2.2. Quantitative survey methods**

#### *2.2.1. Design of a measurement tool (Likert questionnaire)*

The study uses a 5-point Likert scale as its primary measurement tool. This is a standard scale in management research, allowing for accurate assessment of the attitudes and perceptions of the survey subjects. The questionnaire structure is divided into three independent variable groups to directly serve the logical sequence "Current Situation - Causes - Solutions":

- Variable Group 1 (Current Situation): Measures the frequency of errors in 2D documents (1: Very rare → 5: Very frequent).
- Variable Group 2 (Barriers): Measures the level of influence of factors hindering the BIM adoption process (1: No influence → 5: Very significant barrier).
- Variable Group 3 (Solutions): Measures the level of agreement with the proposed solution groups (1: Not necessary → 5: Very necessary).

#### *2.2.2. Sampling methods and Expert Purposive Sampling*

This study employs purposive sampling combined with expert analysis. Instead of conducting a large-scale survey of individuals lacking in-depth expertise, the authors limited and selected 75 valid survey samples from people genuinely involved in the project lifecycle. Regarding the structural representation: The sample comprehensively covers three core perspectives in the project management process: Project Management Board leaders (representing the institutional voice and expenditure approval mechanism), technical staff directly involved in appraisal (representing the implementation process), and consulting experts (representing the digitalization aspect). This diversity helps eliminate bias caused by a one-sided perspective. Regarding sample



quality: The most valuable aspect and guarantee of the reliability of this study lies in the seniority of the survey subjects. Up to 48% of the experts have over 15 years of experience in the construction field. This generation has experienced many ups and downs of technology, deeply understanding the "deadly" bottlenecks of traditional 2D methods and the practical workflows at State Project Management Units. Therefore, their assessments are not empty theoretical platitudes but rather the culmination of hard-won practical experience on construction sites and in appraisal work.

#### *2.2.3. Descriptive statistical data processing methods*

The raw data collected from the questionnaires were coded and processed using statistical tools. The study used descriptive statistics with the following key indicators:

- Frequency and Percentage (%): To outline the overall picture of the current level of BIM adoption by Project Management Units.
- Mean (bar): Used to quantify the severity of barriers and the urgency of solutions. From these Mean values, the study ranked to identify the "Biggest Barrier" that needs to be prioritized for removal, and the "Core Solution" that has the highest consensus among experts.

### **2.3. Case Study Methodology**

If the expert survey method (quantitative) provides a comprehensive picture of BIM application awareness and barriers, then the case study method is used to provide empirical evidence. This method plays the role of directly "measuring" the effectiveness of BIM compared to the traditional 2D method through actual technical data.

To ensure the comprehensiveness and reliability of the study, the author deliberately selected 03 key projects in Hanoi as a sample for analysis. These three projects represent 3 core types of construction works in public investment, each type having its own characteristics and "bottlenecks" in the management of Construction Drawing Design (TKBVTCT).

#### *2.3.1. Hanoi Children's Hospital Project [9] (Representative of Level I Civil Works - Focus on MEP Conflict Control).*

Hospitals are one of the most complex types of civil engineering structures due to the enormous density of Mechanical and Electrical (MEP) systems (including HVAC, water supply and drainage, power systems, medical gases, sterile systems, etc.) crammed into a very limited false ceiling space. The objective of the analysis is to use this project to demonstrate the inability of the 2D method to control space. The study extracts experimental data using Navisworks software to compare the number of physical clashes (Hard clash) and operational space clashes (Clearance clash) detected on the 3D model (LOD 350) with a manual 2D drawing overlay. The results from this case study are the direct argument for the author to propose the solution "Mandatory Clash-Free checking before approval".

#### *2.3.2. Vinh Tuy Bridge Project - Phase 2 [9] (Representative of Special Transport Works - Focus on geometric control and prestressed cables)*

This is a large-span bridge project with a complex geometric profile (spatial curvature) and stringent requirements for connection with the Phase 1 bridge. The biggest technical bottleneck lies in controlling the trajectory of the prestressed cables and the intricate arrangement of reinforcement at the girder/pier joints. The objective of this project analysis is to evaluate the ability of BIM in accurately simulating geometric parameters (parametric modeling). The study analyzes how the Project Management Board uses BIM modeling to check collisions between prestressed cable bundles and ordinary steel, as well as to verify geometric elevation, thereby completely eliminating the risk of having to cut or straighten steel or drill into prestressed cables during field construction.

#### *2.3.3. The Ring Road 3.5 Project [9] (Representing the technical infrastructure of the route - Focus on volume control and underground intersections)*

This is a project that stretches along the route, involving extremely large volumes of excavation and embankment (Earthworks) and the risk of collision with the existing underground infrastructure system (fiber optic cables, water pipes, drainage pipes), which is very complex in Hanoi. The objective of the analysis is to use this project to verify the accuracy of the quantity takeoff (QTO) using the Civil 3D platform compared with the manual calculation of cross-sectional area using AutoCAD. At the same time, analyze how the BIM model supports the Project Management Board to "see through" the ground, review intersections between the new sewer line and the old underground system, helping to manage the risk of infrastructure relocation costs.

### **3. Results and discussion**

#### **3.1. Current situation regarding design document management and the level of BIM adoption**

According to survey data, despite the BIM roadmap being issued, up to 64% of project management units in Hanoi are only in the research phase or have never applied this technology, and less than 10% of units are confident in officially applying it to key projects. (Fig. 1).



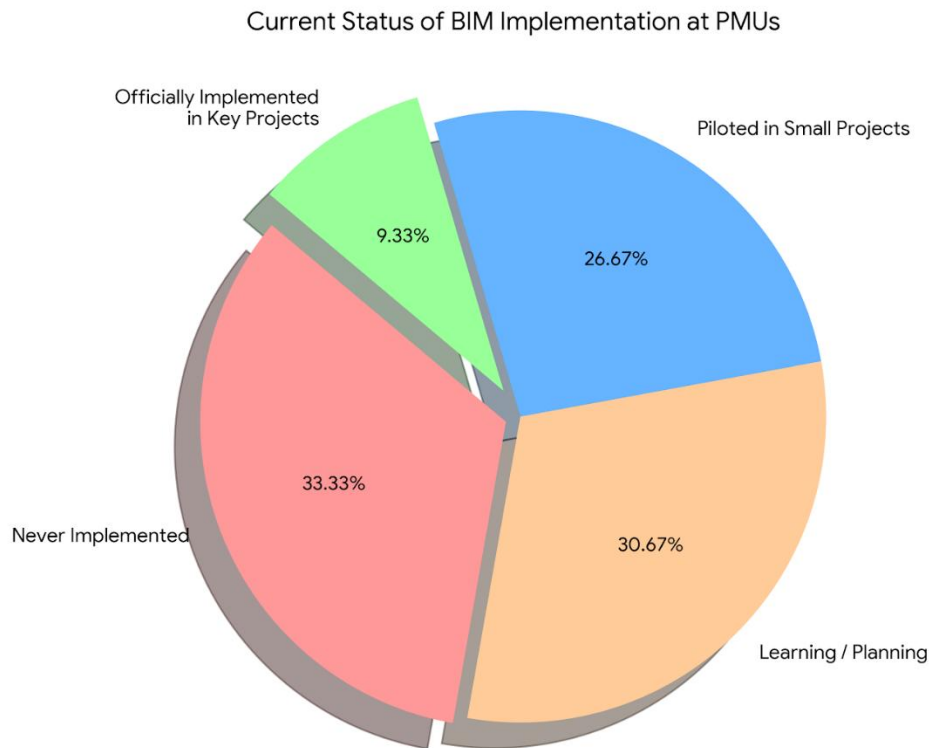


Fig. 1. Results of the analysis of the current state of BIM application in management departments.

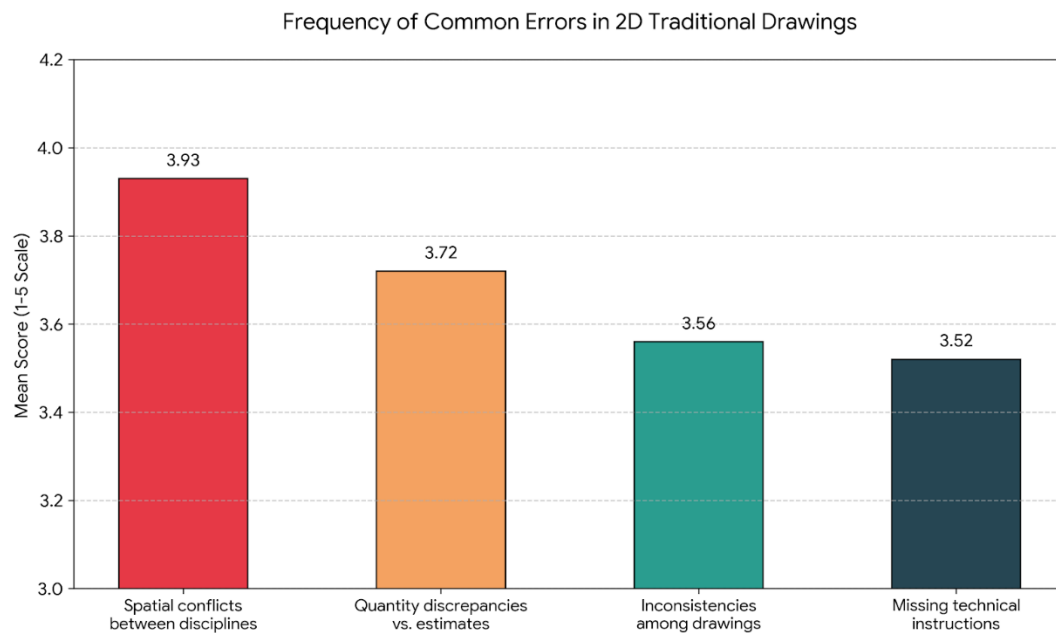


Fig. 2. Results of the analysis of the frequency of errors in traditional 2D profiles.

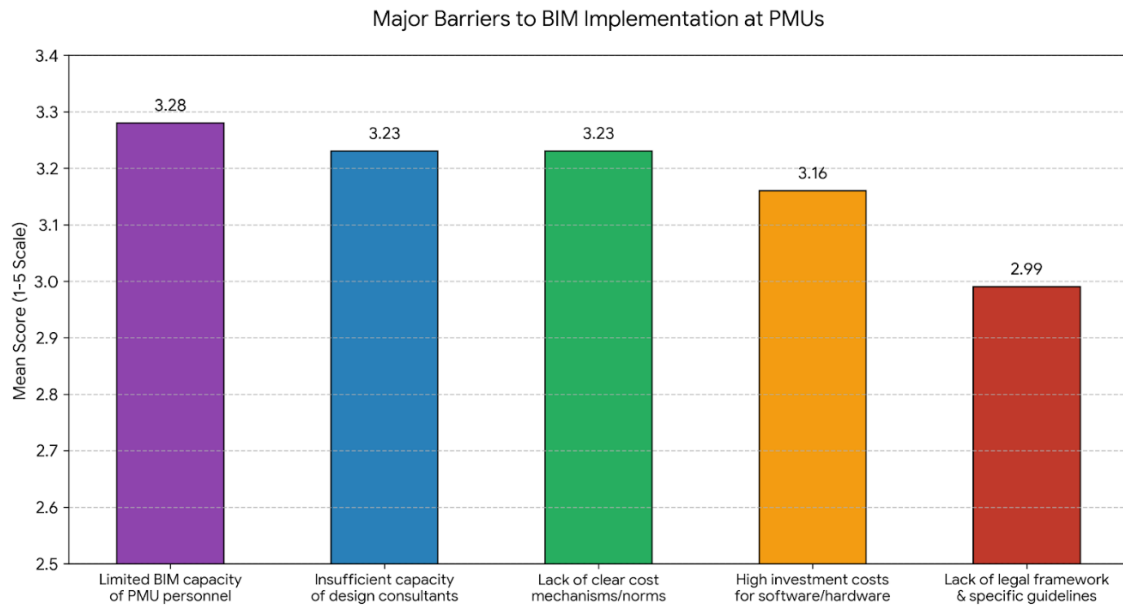


Fig. 3. Assessing barriers to BIM implementation at the Project Management Department

In the traditional (2D) appraisal method, errors reveal a very high degree of system city (Fig. 2). The survey indicates that "Position conflicts between disciplines (Structural - MEP)" is the most problematic issue (Average score = 3.93/5). Second is "Quantity discrepancies between drawings and estimates" (3.72/5) due to semi-manual quantity takeoff and lack of data linkage. A case study in the surgical area (3rd floor) of Hanoi Children's Hospital also demonstrated the power of BIM. Traditional visual inspection only found 154 minor errors, while using automated collision detection software on a BIM model with a level of detail (LOD) of 350, detected 2,450 errors (almost 16 times more). In particular, there are as many as 320 serious physical conflict points, such as fire hoses piercing concrete beams or narrow spaces that make operation and maintenance inaccessible.

### 3.2. Application bottlenecks and barriers

Contrary to the common misconception that software or legal regulations are the biggest obstacles, the research results identified "Limited human resource capacity in BIM at the Project Management Board" as the highest barrier (3.28/5). While the appraisal team is skilled in traditional methods, they struggle with digital data management and cannot distinguish between Geometric Level of Development (LOG) and Non-Geometric Level of Information (LOI). Furthermore, "Lack of clear cost/standard mechanisms" (3.23/5) leads to difficulties in allocating funds for model building or investing in computer hardware (station configuration), resulting in staff having to check files tens of gigabytes in size on office computers, paralyzing the system. (Fig. 3).

### 3.3. Proposing a system of solutions to optimize BIM application

#### 3.3.1. Results of the survey on the necessity of the solutions

To ensure objectivity in determining the importance of the proposals, a survey of experts was conducted using questionnaires. The survey on the necessity of solutions presented 10 main solutions (divided into 4 groups) for experts to choose from. The questionnaire was developed based on three fundamental principles, ensuring logic, scientific rigor, and feasibility. The completed questionnaires were then processed and analyzed. The main solutions were scored from 1 to 5, with higher scores indicating greater urgency and importance. The average scores of the 10 solutions across the 4 main groups, as compiled by 75 experts, were presented in Fig. 4.

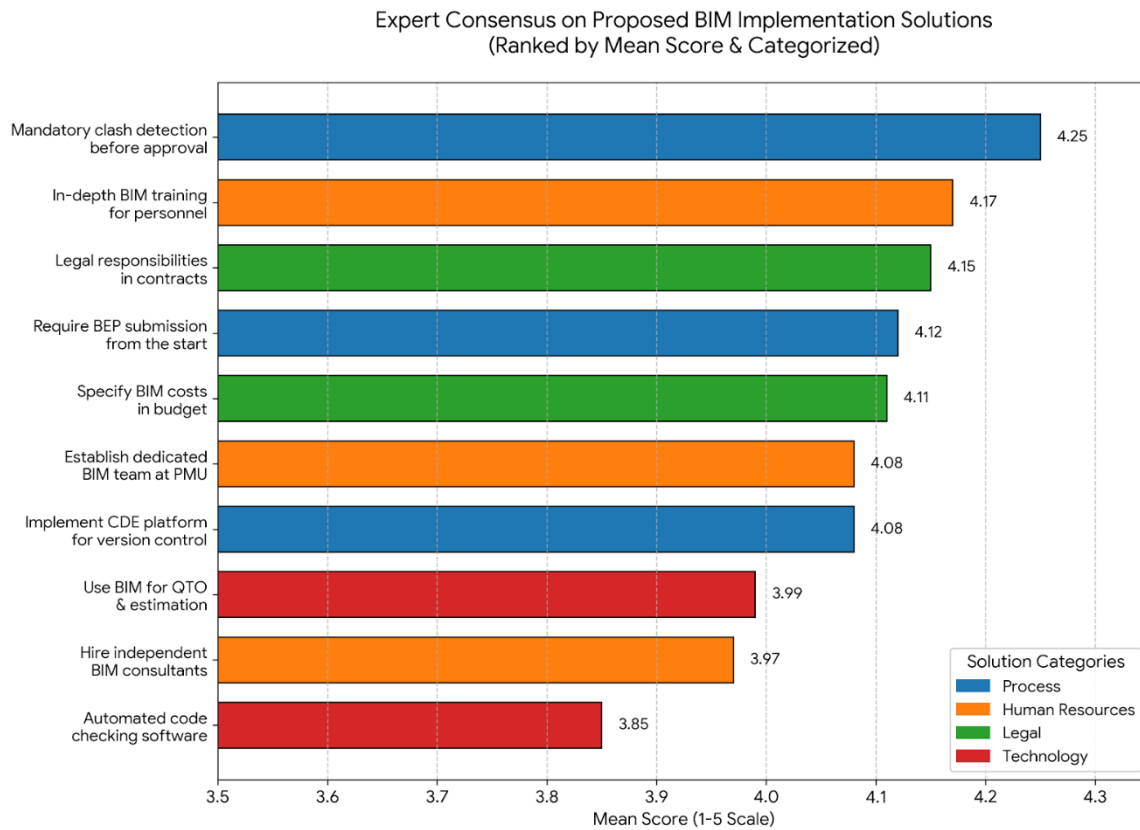


Fig. 4. Assess the necessity of the solutions

The following key observations can be drawn to guide the implementation of BIM in Project Management Units:

- Firstly, there is a very high level of general consensus regarding the entire solution system. The average score of all 10 solutions ranges from 3.85 to 4.25 on a 5-point scale. This confirms that the proposed solution set is on track and closely adheres to practical needs. Most experts are aware of the urgency of changing from traditional management methods to digital data management.

- Secondly, the cause-and-effect logic (Cause - Solution) is clearly demonstrated in the first position. The solution "Mandatory clash detection before approval" received the highest score (4.25). This result directly aligns with the current situation (where the "Position Conflicts Between Disciplines" error was rated as the most serious, with a score of 3.93). This demonstrates that, for current investors and project management units, the core value and immediate effectiveness of BIM is not about visually appealing 3D images, but rather as a tool for physical collision detection, helping them prevent risks of demolition, cost overruns, and delays on construction sites.

- Thirdly, "Human and Legal Factors" are prioritized over "Core Technology," a clear highlight from the results table being that high-tech solutions such as "Using BIM to extract QTO quantities" (scoring 3.99) or "Automated standard review software" (scoring 3.85) are ranked in the lower half of the table. Conversely, the solutions ranked 2nd, 3rd, and 5th in importance belong to the Organization and Mechanism group: In-depth training for staff (scoring 4.17 – 2nd most important), legal liability regulations in contracts (scoring 4.15 – 3rd place), and specifying BIM costs (average score 4.11 – 5th place).

This reflects the very practical thinking of the state management agencies. Even the most powerful software loses its value if staff don't know how to use it, contracts lack legal accountability, and there's no funding to pay BIM contractors. Digital transformation must first be a transformation of awareness and institutions, then tools.

- Fourth, the trend is shifting from spontaneous work to standardized processes. The foundational solutions for standard coordination processes according to ISO 19650, such as the "Requirement to Submit BEP Plan" (average score 4.12) and "Application of Common Data Environment (CDE)" (average score 4.08), were both in the very high-rated group. This indicates that professionals are tired of the decentralized, "everyone for themselves" approach to work, sending files via email. Establishing rules of engagement (BEP) and a common playing field (CDE) from the very beginning of the project is considered the backbone for maintaining document quality.

The survey results have outlined a very clear priority roadmap for the Project Management Units. Therefore, for BIM to be truly effective, the Project Management Board needs to address the "Institutional and Human Resources" issues first (incorporating costs and responsibilities into contracts, training staff), establish "Common Rules of the Game" (BEP, CDE), and only then use "Technology" (Clash Detection) as the final safeguard before design approval.

*3.3.2. Propose key solutions to improve the effectiveness of BIM application in managing the quality of drawing documents.*

Based on the high consensus of the expert group (ratings from 3.85 to 4.25/5 points), the article proposes 5 core priority solutions for Project Management Units:

- Solution 1: "Dual Review" Mechanism and "Clash-Free" Benchmark Requirements (Priority 1 - 4.25/5 points). The mismatch between printed drawings and 3D models needs to be eliminated. The solution involves establishing a Dual Review process requiring: Clash Detection using digital models, in parallel with evaluating compliance with standards on 2D drawings extracted directly from the model. Project Management Units should only approve when digital documents meet the "Clash-Free" standard (completely eliminating rigid collisions between the load-bearing and mechanical/electrical systems), strictly prohibiting contractors from arbitrarily modifying AutoCAD drawings without making corrections on the underlying model.

- Solution 2: Innovate Training and Personnel Structure (Priority 2 - 4.17/5 points) Technology cannot operate without people. Project Management Units need to establish BIM working groups as the core of project coordination. The focus of training should not be on teaching staff to use software for design, but on the capacity for model review and audit, focusing on how to examine the required data fields (metadata) of components based on a checklist.

- Solution 3: Enclose the Legal Significance of BIM in Contracts (Priority 3 - 4.15/5 points) In contracts signed with consulting firms, the BIM model should not only serve as an illustration, but must be stipulated as the official legal basis and the primary data source of the project. Disbursement of payments is not based on the number of drawings, but on the completion level of the LOG/LOI corresponding to the specified LOD level (usually LOD 350-400 for detailed design drawings).

- Solution 4: Standardize EIR and submit BEP from the bidding phase (Priority 4 - 4.12/5 points). Management chaos often stems from the Project Management Unit's lack of direction from the outset. Therefore, the Investor must issue an "EIR" clearly defining the coordinate system, software, and quantity survey objectives (QTO). The consultant responds with a detailed "BIM Implementation Plan" (BEP) as a basis for unified operation throughout the project lifecycle.

- Solution 5: Utilize a Common Data Environment (CDE) to manage data tracking (Priority 5 - 4.08/5 points). Stop exchanging documents via email, which risks data fragmentation. Project Management Units need to establish a CDE environment compliant with ISO 19650, using four data states (WIP, Shared, Published, Archive) for rigorous version control. Coordination and error marking are assigned directly to design coordinates using the BCF format, ensuring that all changes have a traceable history (Audit trail) for accountability and auditing purposes.

#### **4. CONCLUSION**

This study has fulfilled its research objectives, comprehensively addressing issues from theoretical foundations and current situation assessments to proposed solutions. Through the research process and quantitative analysis of 75 expert survey responses, the author draws the following key conclusions:

- Firstly, theoretically: Traditional design document quality management methods based on 2D drawings have revealed systemic limitations. Digital transformation through Building Information Modeling (BIM), with Common Data Environment (CDE) as its core, is not only an inevitable trend but also an optimal data management tool, helping to thoroughly solve problems related to visualization, information synchronization, and risk control.

- Secondly, regarding the current state of document errors and application barriers, based on the analysis of the current situation, combined with expert survey results: Regarding the current state of errors: The practical survey results have shown that "Position conflicts between disciplines" is the most serious and frequent error in traditional 2D design (average score of 3.93/5). This is followed by quantity discrepancies (3.72/5). This shows that the old method no longer meets the requirements of complex projects. Regarding application barriers: The majority of Project Management Units (over 64%) are still only at the stage of learning about or have never applied BIM. Notably, the biggest barrier hindering this process is not in technology or software costs, but in "Limited human resource capacity at Project Management Units" (3.28/5) and the lack of clear mechanisms and standards from state management agencies.

- Thirdly, regarding the proposed solutions: The project successfully developed four synchronized solution groups and received consensus (mean score > 3.85) from the experts participating in the survey. In

particular, the research results indicate three decisive solutions that need to be prioritized for immediate implementation by the Project Management Units: Regarding Process - Technology: Mandatory clash detection before approving documents is considered the most urgent solution (scoring 4.25/5), helping to thoroughly address the problem of real-world spatial collisions. Regarding Organization - Personnel: Providing in-depth training on model reading comprehension and control skills for project managers (scoring 4.17/5) is a prerequisite for mastering the technology. Regarding the Legal Mechanism: It is necessary to clearly define the legal responsibility for the accuracy of the BIM model in the consulting contract (scoring 4.15/5) and specify the BIM cost within the total project investment. The synchronized and decisive application of the above solutions, from preparing "Human Resources - Institutions" to applying "Tools - Processes," will certainly create a turning point in the quality of design documents, save on rework costs, and ensure project progress at Project Management Units in Hanoi.

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