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TECHNOLOGICAL AND ORGANIZATIONAL TRANSFORMATION OPPORTUNITIES IN ENHANCING COMPETITIVENESS

Abstract: *Technological and organizational transformation represents a fundamental prerequisite for achieving competitive advantage in the modern world. In the agri-food sector, this process takes on particular significance, as the transition from traditional methods to modern, efficient systems directly impacts production scales and product quality. This research investigates the current state and development prospects of technological and organizational innovations in Georgia's agri-food sector, with particular focus on the challenges and opportunities faced by small-scale farmers who constitute over 85% of the sector.*

The study employs a mixed-methods research approach, combining quantitative analysis of statistical data from national and international sources with qualitative research through expert interviews and case studies. The research examines export rejection rates across major international markets (EU, US, and China) during 2010-2020, analyzing the primary causes of non-compliance and their relationship to technological and organizational gaps. Special attention is paid to the implementation of precision agriculture, IoT technologies, and modern storage systems, alongside the development of cooperative models and supply chain optimization.

The findings reveal significant improvements in export compliance since 2019, though persistent challenges remain, particularly in meeting EU standards for mycotoxin control. The research identifies key barriers to technological transformation, including limited access to capital, insufficient knowledge transfer mechanisms, and organizational fragmentation. Based on these findings, the study presents a comprehensive framework for sector transformation, incorporating specific recommendations for policy makers, business entities, and international collaboration partners. The proposed approach emphasizes the importance of synchronized technological and organizational development, supported by targeted state programs and international partnerships.

Keywords: *agri-food, technological transformation, organizational innovations, competitiveness, digital technologies, smart farming, supply chain optimization.*

JEL Classification: *Q13, O13, O33, L23, M21, Q16*

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ტექნოლოგიური და ორგანიზაციული ტრანსფორმაციის შესაძლებლობები კონკურენტუნარიანობის ამაღლებაში

აბსტრაქტი: *ტექნოლოგიური და ორგანიზაციული ტრანსფორმაცია წარმოადგენს კონკურენტული უპირატესობის მიღწევის ფუნდამენტურ წინაპირობას თანამედროვე მსოფლიოში. აგროსასურსათო სექტორში ეს პროცესი განსაკუთრებულ მნიშვნელობას იძენს, ვინაიდან ტრადიციული მეთოდებიდან თანამედროვე, ეფექტიან სისტემებზე გადასვლა პირდაპირ აისახება წარმოების მასშტაბებსა და პროდუქციის ხარისხზე.*

წინამდებარე სტატია აანალიზებს ტექნოლოგიური და ორგანიზაციული ინოვაციების როლს საქართველოს აგროსასურსათო სექტორის კონკურენტუნარიანობის ამაღლებაში. ნაშრომი ეფუძნება სამეცნიერო ლიტერატურის მიმოხილვას, სტატისტიკურ ანალიზს და ექსპერტულ ინტერვიუებს. განხილულია ციფრული ტექნოლოგიებისა და თანამედროვე მართვის მოდელების ინტეგრირებული დანერგვის პერსპექტივები და გამოწვევები. სტატიაში განსაკუთრებული ყურადღება ეთმობა მიწოდების ჯაჭვის ოპტიმიზაციას, ხარისხის მართვის სისტემების გაუმჯობესებას და მცირე მეურნეობების კოოპერაციის მოდელების განვითარებას. წარმოდგენილია კონკრეტული რეკომენდაციები პოლიტიკის შემქმნელებისა და დარგის წარმომადგენლებისთვის სექტორის მდგრადი განვითარებისა და საერთაშორისო კონკურენტუნარიანობის ამაღლების მიმართულებით.

საკვანძო სიტყვები: *აგროსასურსათო სექტორი, ტექნოლოგიური ტრანსფორმაცია, ორგანიზაციული ინოვაციები, კონკურენტუნარიანობა, ციფრული ტექნოლოგიები, სმარტ ფერმერობა, მიწოდების ჯაჭვის ოპტიმიზაცია, კოოპერაცია.*

JEL კლასიფიკაცია: *Q13, O13, O33, L23, M21, Q16*

Introduction And Review Of Literature

The academic literature increasingly emphasizes the important role of technological innovation in agricultural transformation. Wolfert et al. (2017) provide a comprehensive

review of big data applications in smart farming, highlighting how digital technologies are revolutionizing agricultural practices. This view is further supported by Herrero et al. (2020), who demonstrate that innovation can accelerate the transition towards sustainable food systems, particularly emphasizing the role of digital technologies in improving productivity and resource efficiency. The organizational aspects of agricultural transformation are also well-documented in recent literature. Bijman and Wijers (2019) explore the inclusiveness of producer cooperatives, providing insights into how collaborative organizational structures can benefit small-scale farmers.

In the Georgian context, Koghuashvili and Archvadze (2023) analyze the current state of food security, emphasizing the need for technological modernization of the agricultural sector. Their research aligns with Kharaishvili et al. (2021), who identify significant challenges in food transportation and policy priorities in Georgia, highlighting the need for improved logistics and supply chain management systems. Recent studies also highlight the importance of integrated approaches to agricultural development. Klerkx et al. (2019) review social science perspectives on digital agriculture and smart farming, emphasizing the need for holistic approaches that consider both technological and social dimensions.

Technological and organizational transformations have emerged as key drivers of economic growth in today's globalized economy. The unprecedented pace of digital innovation, coupled with evolving business models, is reshaping industry competitiveness and charting new development trajectories. This paradigm shift holds particular significance for traditional sectors that must undergo substantial modernization to remain viable.

The global agri-food sector is experiencing a profound transformation. Advanced economies are increasingly adopting smart farming practices, precision agriculture technologies, and integrated production systems as industry standards. This technology-driven approach enables substantial productivity gains while optimizing resource utilization and enhancing product quality. Moreover, the mounting pressures of climate change and intensifying global competition necessitate new approaches to sustainable development and operational efficiency.

At the regional level, these challenges are amplified by the predominance of smallholder farms, technological gaps, and constrained market access. The agri-food sector in Adjara, characterized by limited land holdings and fragmented production, faces particular difficulties in technological modernization and alignment with international standards. Despite the region's considerable potential in subtropical crop cultivation and highland livestock farming, structural impediments continue to hamper the full realization of these opportunities.

Technological and organizational transformation serves as a vital instrument for enhancing sector competitiveness. Contemporary digital technologies—including IoT sensors, drone-based monitoring, advanced analytics, and automated management systems—offer pathways to significantly improve production efficiency. In parallel, innovative organizational frameworks encompassing cooperative associations, cluster-based approaches, and integrated supply chains provide platforms for achieving economies of scale and strengthening market presence.

In developing economies, the agri-food sector's transformation is frequently impeded not only by financial constraints but also by institutional capacity limitations. The successful implementation of technological solutions demands appropriate organizational structures, robust knowledge management systems, and developed human capital. Consequently, it is

essential to develop approaches that facilitate the synchronized evolution of technological and organizational innovations.

Within this context, this research aims to examine the potential for technological and organizational transformation in Adjara's agri-food sector, analyze existing challenges, and formulate strategic recommendations. The study explores the theoretical foundations of technological and organizational transformation, examines international best practices, and evaluates their adaptability within the regional context.

Methodology

The research employs a mixed-methods approach combining quantitative and qualitative research techniques to ensure comprehensive coverage of both technological and organizational aspects of sector transformation. The methodology encompasses several key components:

1. Statistical Analysis:

- Analysis of sector performance indicators using data from the National Statistics Office of Georgia (2023)
- Examination of export rejection rates and causes across international markets (2010-2020)
- Assessment of technological adoption rates and their impact on productivity

2. Literature Review and Document Analysis:

- Systematic review of academic publications on agricultural transformation
- Analysis of policy documents and strategic development plans
- Review of international case studies and best practices in agri-food sector development

3. Comparative Analysis:

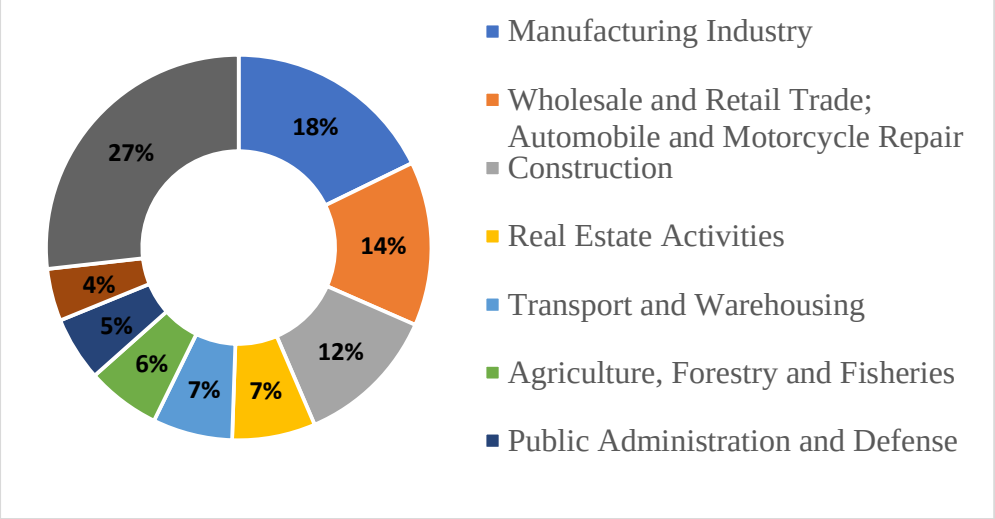
- Benchmarking against successful transformation cases in comparable economies
- Assessment of adaptation potential for international best practices
- Evaluation of technology transfer mechanisms and their effectiveness

The research methodology was specifically designed to ensure practical applicability within the Georgian context while maintaining academic rigor. The combination of quantitative and qualitative methods allows for both broad statistical analysis and deep insights into specific transformation challenges and opportunities.

Current State and Challenges of Georgia's Agri-Food Sector

The sustainable development of the agribusiness sector in today's competitive landscape fundamentally hinges on the effective implementation of technological and organizational transformation. Georgia's agri-food sector (see Diagram N1), which accounts for 6.2% of the country's GDP and 40% of employment (UNIDO, 2023), faces significant competitiveness challenges. Small-scale farming operations constitute over 85% of total production, creating substantial barriers to both the adoption of modern technologies and the achievement of economies of scale.

Diagram N1. Structure of Georgia's Gross Domestic Product by Sector (%), 2023



Source: Compiled by the author based on data from the National Statistics Office of Georgia

Innovative technological approaches represent an important development pathway for the agricultural sector. The implementation of advanced technologies such as vertical farming and smart greenhouses enables maximizing resource efficiency and reducing environmental impact. According to recent research, smart agriculture technologies can increase production efficiency by 30-40%, addressing key challenges in agricultural development (World Bank, 2023).

The transformation of the agri-food sector requires a comprehensive approach that integrates technological innovation with organizational restructuring. Contemporary research emphasizes the importance of multidimensional development, including:

1. Precision Agriculture Technologies: Utilizing GPS, drone monitoring, and advanced data analytics to optimize land use and crop management.
2. Smart Irrigation Systems: Implementing real-time monitoring and resource optimization technologies.
3. Digital Monitoring Systems: Deploying IoT sensors for comprehensive production process control.
4. Supply Chain Optimization: Developing advanced logistics and traceability technologies.

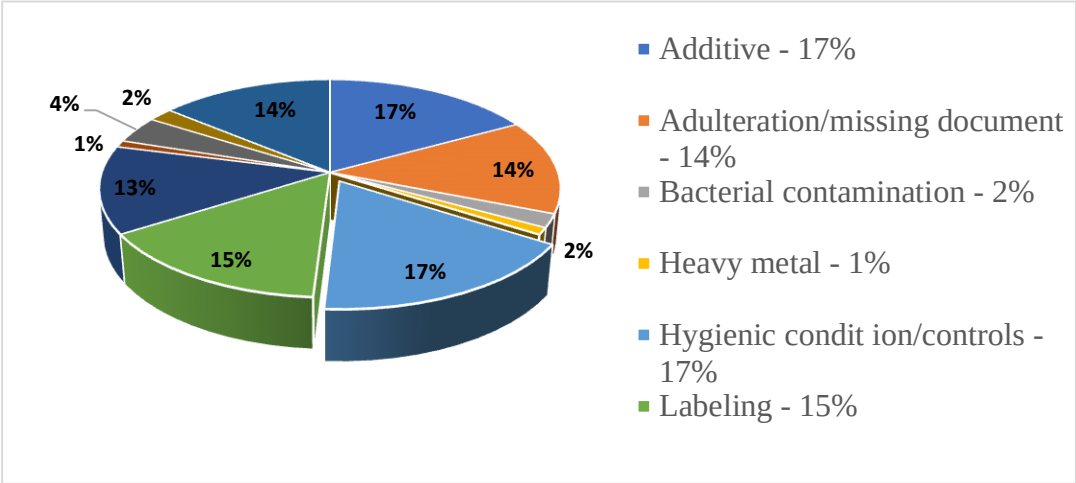
International experience demonstrates various successful approaches to agricultural development. According to the Netherlands Agriculture Export Report (Statistics Netherlands, 2024), the country achieved greenhouse productivity of 488,000 EUR per hectare and agro-exports of 123.8 billion EUR. Similarly, as reported by the Israel Innovation Authority (2023), Israel has achieved remarkable success through innovative approaches, particularly in water resource management, with 70% water savings through drip irrigation and agritech startup investments reaching 1.2 billion USD.

Singapore's experience is particularly noteworthy, as documented in the Singapore Food Agency's Strategic Plan 2023-2030 (2022). Despite limited agricultural land (1% of total

area), the country has established a 260 million USD agrotechnology fund and developed 238 vertical urban farms. This experience is especially relevant for Georgia, where challenges of limited arable land and increasing urbanization necessitate innovative approaches. According to Ministry of Environmental Protection and Agriculture of Georgia (2023), Georgia's comparative advantages in climate diversity and water resources, when combined with appropriate technological solutions, could enable significant production growth in sectors such as viticulture and horticulture.

While these advantages create significant potential, implementing modern agricultural practices in Georgia remains challenging due to various technical and regulatory barriers. According to UNIDO's 2023 research, both technological and organizational challenges significantly impede the realization of Georgia's agri-food export potential. On the European Union market, 72% of rejected products are linked to mycotoxin content, indicating substantial deficiencies in storage and quality control systems. Issues identified in the U.S. market - hygiene conditions/control (30%), labeling (28%), and documentation deficiencies (25%) - demonstrate the necessity for improvements in both technological and management systems. Similar challenges were encountered during exports to the Chinese market. The aggregate rejection rates across all three markets are distributed as shown in Diagram N2

Diagram 2. Distribution of Rejection Reasons (%) for Georgian Food and Feed Exports Across Three Major Markets (China, EU, US), 2010-2020



Source: United Nations Industrial Development Organization, Standards Compliance Analytical Report, 2024

Quality control systems and standardization emerge as critical areas for development. International experience demonstrates that implementing HACCP (Hazard Analysis and Critical Control Points), Global GAP, and GRASP standards significantly enhance product quality and competitiveness in international markets. These standards provide a systematic approach to ensuring food safety, sustainable production methods, and social responsibility throughout the agricultural value chain.

The dynamics of Georgian agri-food export rejections were particularly noteworthy during 2016-2017, when there was a sharp increase in both EU (from 13 to 25 cases) and Chinese markets (from 17 to 25 cases). However, since 2019, a significant positive trend has emerged,

with rejection rates declining substantially in both markets (to an average of 1-4 cases annually). The consistently low rejection rates in the U.S. market (2-3 cases per year) indicate that Georgian companies better understand and meet this market's requirements. Despite these improvements, meeting the EU market's high standards remains a significant challenge, particularly regarding mycotoxin control, necessitating a comprehensive approach and fundamental sector transformation.

Despite these improvements, meeting the EU market's high standards remains a significant challenge, particularly regarding mycotoxin control. This necessitates a comprehensive approach to sector transformation, focusing on:

- Advanced storage technologies
- Improved quality control systems
- Implementation of international food safety standards
- Technological modernization of small-scale farming operations

The integration of innovative technologies such as artificial intelligence, nanotechnology, and precision agriculture presents promising opportunities for addressing these challenges and enhancing the competitiveness of Georgia's agri-food sector.

Technological and Organizational Transformation Components and Implementation

The transformation of the agri-food sector represents a multidimensional process encompassing various aspects, including both technological modernization and organizational restructuring. Contemporary research confirms that sector development is achievable through the effective synthesis of these two components. In their seminal research, Wolfert et al. (2017) emphasize that transitioning to a smart agri-food sector requires not only technological upgrades but also significant transformation of organizational processes and human capital.

Technological transformation, which encompasses the implementation of precision agriculture methods, data analytics, and automated systems, provides the fundamental basis for enhancing productivity and efficiency. The experience of developed countries demonstrates that improving agri-food sector competitiveness is rooted in the widespread adoption of digital technologies. Research conducted by Herrero et al. (2020) in EU countries confirms that the transition to smart farming has increased farm productivity by an average of 40% while reducing resource consumption by 35%.

IoT (Internet of Things) represents a network of interconnected devices equipped with sensors, software, and other technologies for data collection, exchange, and analysis. In the agri-food sector, IoT technologies are extensively deployed across all production stages, from primary production to final product delivery. Throughout the supply chain, IoT systems ensure product traceability and quality control. When integrated with blockchain technologies, IoT systems enable consumers to access comprehensive information about product origin and production processes.

In developing countries, including Georgia, the transformation of the agri-food sector faces additional challenges. These encompass both infrastructural constraints and issues related to technological knowledge and financial resource accessibility. Professors Paata Koghuashvili and Ioseb Archvadze (2023) emphasize that the development of the agri-food sector requires "the implementation of cutting-edge technologies and expansion of processing industry capabilities."

In the modern agri-food sector, technological transformation encompasses several key directions (see Table 1):

Table 1. Components of Technological Transformation in the Agri-Food Sector

Component	Description	Advantages	Application Areas
Precision Agriculture	Land resource management and monitoring using GPS technologies and drones	Productivity increase up to 55%; Pesticide use reduction by 40%; Optimal resource utilization	Crop farming; Viticulture; Grain crops
Smart Irrigation	Intelligent water resource management system based on real-time data and forecasting	Reduced water losses; Irrigation optimization; Increased energy efficiency	Greenhouse operations; Open field farming; Intensive orchards
Digital Monitoring Systems	Use of IoT sensors and data analytics for production process control	Real-time monitoring; Preventive measures implementation; Improved quality control	Livestock farming; Poultry farming; Warehouse management
Supply Chain Optimization	Automation and optimization of product delivery from production to consumer	Reduced logistics costs; Product quality maintenance; Reduced delivery times	Food products; Perishable goods; Export products
Refrigeration-Storage systems and ULO Technologies	Intelligent control systems for temperature, humidity, and atmospheric composition, including ULO (Ultra Low Oxygen) technology that provides controlled atmosphere with low oxygen concentration. Significant extension of product shelf life (up to 6-8 months);	Preservation of product organoleptic properties; Loss minimization; Increased energy efficiency; Reduced seasonal fluctuations	Fruits (especially apples and pears); Berries; Vegetables; Nuts; Fish and seafood; Dairy products; Meat products

Source: Compiled by the author based on research by Rose D.C., Chilvers J (2018), Wolfert et al (2017), and FAO (2019)

The implementation of precision agriculture is particularly crucial for smallholder farmers. Research by Fielke et al. (2020) demonstrates that the utilization of GPS technologies and drones enables small-scale farms to significantly enhance their land resource efficiency.

The deployment of technological transformation components requires substantial initial investments. Research conducted by Turner et al. (2020) indicates that the average return period for technological modernization projects ranges from 2 to 4 years, presenting a significant challenge for small and medium-scale farmers. According to the European Investment Bank report (EIB, 2023), implementing modern agricultural technologies demands considerable capital investment, with precision agriculture systems incorporating GPS technologies, drones, and sensors requiring investments ranging from 50,000 to 150,000 euros on average.

The Emilia-Romagna region's experience (ENRD, 2013) serves as a successful example of overcoming these challenges through a coordinated approach. The Climate changE-R project established a partnership of 11 organizations, encompassing 30% of the region's farms and impacting over 8 million consumers. The project implemented a multi-component support system that included both financial instruments (such as annual subsidies ranging from 60 to 740 euros per hectare for various activities) and knowledge transfer mechanisms.

The success of technological transformation significantly depends on human capital development. EU countries have widely implemented integrated learning programs that combine online education, practical workshops, and mentoring initiatives. The European Innovation Partnership platform (EIP-AGRI) exemplifies this approach's success, where the technology implementation process is closely linked to farmer capacity development.

The FAO report on digital technologies in agriculture emphasizes the importance of an integrated approach, where technology adoption is closely linked to farmer capacity development and strengthening market connections. Based on this experience, the technological transformation process should be founded on cooperation and resource-sharing models, enabling small and medium-scale farmers to overcome the barrier of high initial investments. Simultaneously, it is essential to enhance government support programs and develop innovative models of private sector collaboration.

Results

The research findings reveal several key outcomes regarding technological and organizational transformation in Georgia's agri-food sector:

1. Export Market Performance

Analysis of export rejection data across major markets (2016-2020) demonstrates significant improvements in compliance standards:

- Reduction in EU market rejections from 25 cases in 2017 to 1-4 cases annually since 2019
- Consistently low rejection rates in the U.S. market (2-3 cases annually)
- Notable improvement in Chinese market performance with substantial decrease in rejection rates

2. Technological Implementation Barriers

The study identified primary obstacles to technological adoption:

- High initial investment requirements (50,000-150,000 euros for precision agriculture systems)
- Extended return on investment period (2-4 years average)
- Limited access to capital for small-scale farmers who constitute 85% of the sector

3. Organizational Transformation Impact

Assessment of organizational changes reveals:

- Improved quality control systems leading to reduced mycotoxin-related rejections
- Enhanced traceability through IoT implementation
- Strengthened supply chain management capabilities

4. Human Capital Development

The research highlights critical aspects of human resource development:

- Need for comprehensive training programs
- Importance of knowledge transfer mechanisms
- Role of international partnerships in capacity building

These findings indicate that while significant progress has been made in technological adoption and organizational restructuring, substantial challenges remain, particularly for small-scale agricultural enterprises.

Conclusion

In today's global market, the competitiveness of the agri-food sector is closely tied to technological and organizational innovations. Georgia's agricultural sector faces significant challenges that require a comprehensive approach and coordinated effort from all

stakeholders. Research has demonstrated that successful transformation significantly increases productivity and quality indicators, though this necessitates strengthening state support mechanisms and enhancing their effectiveness.

Improving the competitiveness of Georgia's agri-food sector represents a complex challenge requiring a multifaceted approach. The research has yielded several key conclusions:

The synergy between technological and organizational transformation achieves maximum impact only when implemented simultaneously. As confirmed by Wolfert et al. (2017), isolated technological modernization without corresponding organizational changes fails to deliver sustainable results.

The prevalence of small-scale farms in Georgia's agricultural sector creates additional challenges in attracting investment and achieving economies of scale. The development of cooperative models represents one effective solution to this challenge.

Research conducted by UNDP (2023) emphasizes the critical importance of human capital development. The effective utilization of modern technologies requires specific knowledge and skills, a deficit particularly acute among small-scale farms.

Recommendations:

1. At the State Policy Level:

- Create integrated grant programs that simultaneously cover both technological modernization and human resource development;
- Implement tax incentives for the adoption of innovative technologies in the agri-food sector;
- Strengthen state support for cooperative associations at all stages of the value chain, including both comprehensive support programs and a unified monitoring and evaluation system;
- Establish an international state training program that provides agri-sector specialists with practical qualification enhancement at leading European farms and agro-enterprises, where they can directly experience modern technologies and management methods.

2. At the Business Entity Level:

- Strengthen sectoral and regional cooperation for cost and risk optimization;
- Implement modern management systems based on digital technologies;
- Improve quality control mechanisms to increase export potential.

3. In Terms of International Collaboration:

Strengthen international partnerships in three key areas: technological transfer, investment attraction, and knowledge sharing. For this purpose, it is important to:

- Create an international donor coordination platform that ensures targeted resource allocation according to priority directions;
- Implement long-term international cooperation programs focused on developing strategic directions in the agri-food sector;
- Establish institutional cooperation mechanisms with leading international research centers and agri-food companies for the adaptation of modern technologies and management systems.

The implementation of recommendations should proceed in phases, with initial emphasis on establishing organizational foundations, followed by an accelerated technological modernization process in subsequent stages. Success requires coordinated effort among

governmental, private, and international actors within the framework of a unified strategic vision and action plan.

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