DIGITAL TRANSFORMATION AND INNOVATIVE ACTIVITY EFFICIENCY IN GEOLOGICAL ENTERPRISES

Utamurodova Surayyo Shokirjon qizi
PhD Candidate, Tashkent State Technical University

Annotation: *This thesis examines the role of digital transformation in enhancing the efficiency of innovative activities in geological enterprises. In the context of global digitalization and Industry 4.0, geological organizations are increasingly adopting advanced digital technologies such as artificial intelligence, big data analytics, geographic information systems (GIS), remote sensing, and automated management systems. These technologies significantly improve geological exploration accuracy, reduce operational risks, optimize resource utilization, and support evidence-based decision-making. The study analyzes key areas of digital transformation in geological enterprises and evaluates their impact on innovation performance, productivity, and competitiveness. Additionally, major challenges related to the implementation of digital solutions and possible directions for sustainable digital development in the geological sector are identified.*

Keywords: *digital transformation, geological enterprises, innovative activity, efficiency, artificial intelligence, GIS, big data, Industry 4.0.*

Main Part

In recent years, rapid technological development and digitalization processes have fundamentally transformed industrial sectors worldwide. Geological enterprises, traditionally characterized by labor-intensive and data-driven operations, are increasingly influenced by digital transformation trends. The integration of digital technologies into geological exploration, resource evaluation, and management processes has become a critical factor in improving innovative activity efficiency and ensuring long-term sustainability.

Digital transformation in geological enterprises refers to the comprehensive application of modern information and communication technologies to improve operational processes, decision-making mechanisms, and innovation management systems. This transformation enables enterprises to process large volumes of geological data more efficiently, improve forecasting accuracy, and minimize uncertainty in exploration and extraction activities. As a result, innovation cycles are shortened, and the overall efficiency of innovative activities increases.

One of the most significant digital tools in geological enterprises is big data analytics. Geological exploration generates vast amounts of structured and unstructured data obtained from drilling, geophysical surveys, satellite imagery, and laboratory analyses. Traditional data processing methods are often insufficient for handling such complex

datasets. Big data technologies allow enterprises to integrate heterogeneous data sources, identify hidden patterns, and generate reliable predictive models. Consequently, innovation outcomes become more accurate and economically justified.

Artificial intelligence and machine learning technologies also play an essential role in enhancing innovative activity efficiency. These technologies enable automated interpretation of geological data, anomaly detection, and mineral potential mapping. By applying AI-based models, geological enterprises can reduce human error, accelerate exploration processes, and improve the probability of discovering economically viable deposits. Moreover, intelligent systems support continuous learning and adaptation, contributing to sustainable innovation development.

Geographic information systems (GIS) and remote sensing technologies significantly enhance spatial analysis and visualization capabilities. GIS platforms integrate geological, geochemical, and geophysical data into a unified digital environment, supporting comprehensive spatial analysis and modeling. Remote sensing provides real-time information on geological structures and surface changes, improving monitoring accuracy. The combined use of GIS and remote sensing strengthens innovative research approaches and facilitates informed strategic planning.

Digital transformation also improves innovation management and organizational efficiency in geological enterprises. Automated management systems enable real-time monitoring of project performance, cost control, and resource allocation. Digital platforms support collaboration among multidisciplinary teams and enhance knowledge sharing. These factors contribute to increased labor productivity, reduced operational costs, and improved innovation outcomes.

Despite its advantages, digital transformation in geological enterprises faces several challenges. High initial investment costs, insufficient digital infrastructure, and a lack of qualified specialists limit the effective implementation of digital solutions. In addition, resistance to organizational change and data security concerns may hinder digital innovation. Addressing these challenges requires strategic planning, investment in human capital development, and supportive regulatory frameworks.

Conclusion

In conclusion, digital transformation serves as a key driver of innovative activity efficiency in geological enterprises. The adoption of advanced digital technologies such as big data analytics, artificial intelligence, GIS, and automated management systems significantly enhances exploration accuracy, reduces risks, and optimizes operational processes. Digital transformation not only improves innovation performance but also strengthens the competitiveness and sustainability of geological enterprises. To fully realize these benefits, enterprises must invest in digital infrastructure, develop professional competencies, and implement comprehensive digital strategies. Future research should focus on assessing the long-term economic and environmental impacts of digital transformation in the geological sector.

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