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COMPREHENSIVE METHODOLOGY FOR ASSESSING THE EFFECTIVENESS OF DIGITAL ECONOMY TECHNOLOGY IMPLEMENTATION IN REGIONAL ECONOMIC DEVELOPMENT

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Abstract. *The article examines the impact of digital economy technologies on sustainable regional economic development. Special attention is paid to assessing the multiplicative effects generated by digital infrastructure, e-commerce, digital public services, and artificial intelligence technologies. An integrated assessment methodology based on econometric modeling and composite indicators is proposed. The study identifies the key factors influencing regional digital transformation and evaluates their contribution to economic growth. Recommendations aimed at enhancing the efficiency of digital technologies in regional development are developed.*

Keywords: *Digital economy, regional development, digital transformation, multiplier effect, sustainable growth, digital infrastructure, econometric assessment.*

КОМПЛЕКСНАЯ МЕТОДОЛОГИЯ ОЦЕНКИ ЭФФЕКТИВНОСТИ ВНЕДРЕНИЯ ТЕХНОЛОГИЙ ЦИФРОВОЙ ЭКОНОМИКИ В УСЛОВИЯХ РЕГИОНАЛЬНОГО ЭКОНОМИЧЕСКОГО РАЗВИТИЯ

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Аннотация. *В статье исследуется влияние технологий цифровой экономики на устойчивое развитие региональной экономики. Особое внимание уделено оценке мультипликативного эффекта цифровой инфраструктуры, электронной коммерции, цифровых государственных услуг и технологий искусственного интеллекта. Предложена интегральная методика оценки на основе эконометрического моделирования и системы индикаторов. Выявлены основные факторы цифровой трансформации регионов и их вклад в экономический рост. Разработаны практические рекомендации по повышению эффективности цифровых технологий в развитии регионов.*

Ключевые слова. *Цифровая экономика, региональное развитие, цифровая трансформация, мультипликативный эффект, устойчивый рост, цифровая инфраструктура, эконометрическая оценка.*

MINTAQAVIY IQTISODIY RIVOJLANISHDA RAQAMLI IQTISODIYOT TEKNOLOGIYALARINI JORIY ETISH SAMARADORLIGINI BAHOLASHNING KOMPLEKS METODOLOGIYASI

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Annotatsiya. *Mazkur maqolada mintaqqa iqtisodiyotining barqaror rivojlanishida raqamli*





iqtisodiyot texnologiyalarining ta'siri va multiplikativ samaralari tadqiq etilgan. Raqamli infratuzilma, elektron tijorat, elektron davlat xizmatlari hamda sun'iy intellekt texnologiyalarining iqtisodiy o'sishga ta'siri baholangan. Kompozit indekslar va ekonometrik modellashtirish asosida baholash metodikasi taklif etilgan. Tadqiqot natijasida mintaqalarning raqamli transformatsiyasiga ta'sir etuvchi asosiy omillar aniqlangan. Mintaqa iqtisodiyoti samaradorligini oshirish bo'yicha amaliy tavsiyalar ishlab chiqilgan.

Kalit so'zlar: *Raqamli iqtisodiyot, mintaqaviy rivojlanish, raqamli transformatsiya, multiplikativ ta'sir, barqaror o'sish, raqamli infratuzilma, ekonometrik baholash.*

Introduction

The rapid advancement of digital technologies has fundamentally transformed economic systems worldwide. Digitalization has become one of the primary drivers of productivity growth, innovation, competitiveness, and sustainable development. Regional economies increasingly rely on information and communication technologies (ICT), digital platforms, artificial intelligence, big data analytics, and cloud computing to enhance economic performance.

In recent years, Uzbekistan has implemented a number of reforms aimed at accelerating digital transformation through the Digital Uzbekistan–2030 Strategy. These reforms have expanded access to digital services, increased internet penetration, and stimulated innovation across sectors. However, the multiplicative impact of digital technologies on regional economic sustainability remains insufficiently explored. The multiplier effect of digital technologies refers to their ability to generate secondary economic benefits through increased productivity, employment, investment attraction, and innovation diffusion. Therefore, assessing the contribution of digital technologies to sustainable regional development represents an important scientific and practical challenge.

Literature Review

Theoretical foundations of digital economy development were formed by the works of Don Tapscott, who introduced the concept of the digital economy and explained the transformative role of information technologies in economic systems [1]. Manuel Castells emphasized the importance of information networks and digital infrastructure in shaping modern economic structures and regional competitiveness [2]. Eric Brynjolfsson and Andrew McAfee examined the impact of digital technologies on productivity growth and innovation diffusion across industries [3]. According to Klaus Schwab, digital technologies are key drivers of the Fourth Industrial Revolution and significantly influence sustainable economic development [4].

Among Uzbek scholars, Ravshan Ayupov investigated the institutional foundations of the digital economy and proposed mechanisms for digital transformation in Uzbekistan [5]. Saidahror Gulomov analyzed the role of blockchain technologies and digital platforms in economic modernization [6]. Gulchehra Boltaboyeva studied digital ecosystems and their contribution to regional economic development [7].

Despite numerous studies, the assessment of the multiplier effects generated by digital technologies at the regional level remains insufficiently developed, creating a need for comprehensive methodologies.

Research methodology

To improve the assessment mechanism of digital transformation performance, the Double/Debiased Machine Learning (DML) approach is employed as a modern econometric tool for estimating the causal effects of digitalization factors on economic outcomes. Within this framework, outcome variables may include service output, labor productivity, regional gross product, or economic growth indicators, while treatment variables represent digital investments, ICT infrastructure development, internet penetration, and the share of online services. The DML framework combines machine learning algorithms such as Random Forest, Gradient Boosting,





LASSO regression, and Artificial Neural Networks to capture complex and nonlinear relationships among variables. Furthermore, the application of Neyman-orthogonal estimation and cross-fitting procedures significantly reduces regularization bias and overfitting problems, thereby ensuring robust and unbiased estimates of causal effects.

As a result, the model identifies the net causal impact of digital transformation factors on regional economic performance. The obtained findings provide an evidence-based foundation for developing digital infrastructure, determining investment priorities, allocating resources efficiently, and improving policy decisions at both regional and sectoral levels.

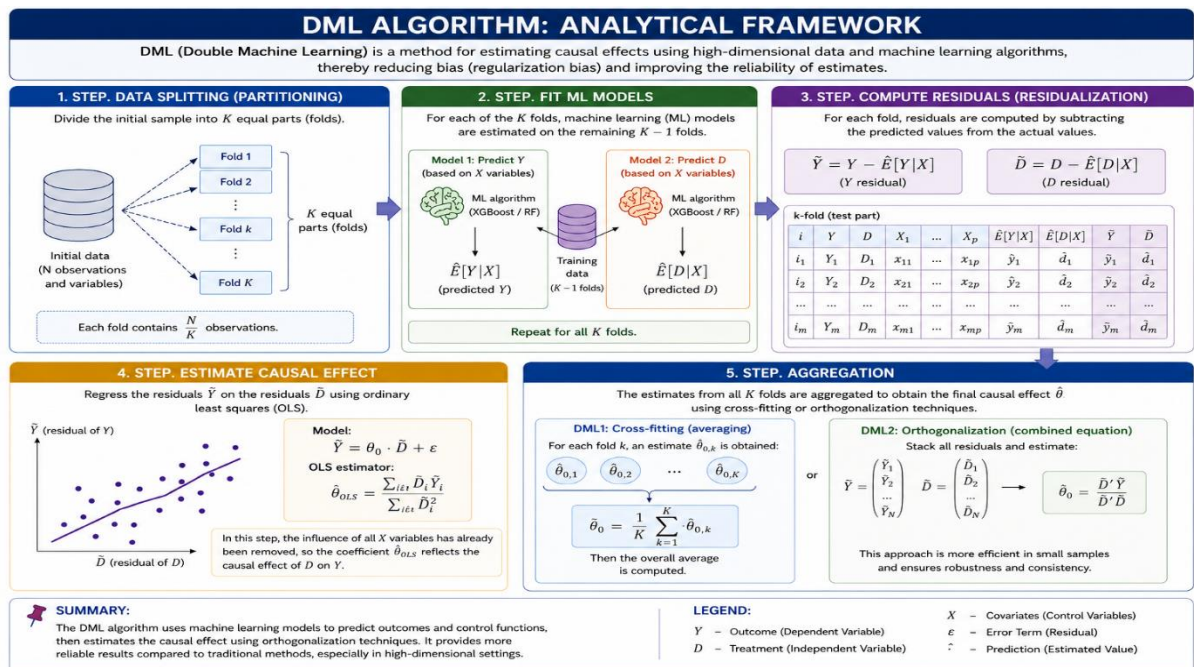
The general specification of the DML model can be expressed as:

$$Y = \theta D + g(X) + \varepsilon$$

where Y denotes the economic outcome variable, D represents the digital transformation factor, X is a vector of control variables, $g(X)$ captures complex nonlinear relationships estimated through machine learning algorithms, θ measures the causal effect of digitalization, and ε is the random error term.

Figure 1.

Double/debiased machine learning (DML) algorithm for estimating the causal effects of digital economy technologies on sustainable regional economic development*



* Author development

Within the framework of the study, an integrated model for assessing the multiplicative effects of digital economy technologies was developed as follows:

$$ME = f(DI, ICT, EG, EC, AI)$$

Table 1.

Research Variables Used in the DML Model*

Variable	Description
ME	Multiplicative Effect
DI	Digital Infrastructure
ICT	ICT Utilization
EG	E-Government Development
EC	E-Commerce Development
AI	Artificial Intelligence Adoption

* Author development





The proposed framework provides a comprehensive methodology for evaluating the contribution of digital technologies to sustainable regional economic development and identifying the most influential digital transformation factors.

Analysis and results

The theoretical and empirical analyses reveal that sustainable regional economic development is strongly associated with the level of digital transformation. The findings indicate that digital economy technologies generate substantial multiplier effects through productivity growth, innovation enhancement, increased investment attractiveness, and improvements in public service delivery.

The empirical results demonstrate that regions characterized by higher levels of digital infrastructure and digital technology adoption achieve better economic performance compared to less digitalized regions. Digital transformation facilitates business activities, reduces transaction costs, improves access to information, and stimulates entrepreneurial development. Consequently, digital technologies contribute not only to direct economic growth but also to secondary multiplier effects throughout regional economic systems.

Table 2.

Estimated causal effects of digital transformation factors*

Factor	Coefficient
Digital Investments	0.342
ICT Infrastructure	0.287
Artificial Intelligence	0.311
E-Government Services	0.241
E-Commerce Development	0.198

* Author development

The results indicate that digital investments exert the strongest influence on regional economic development. A one-unit increase in digital investment is associated with a significant improvement in productivity, innovation performance, and regional competitiveness. Similarly, the development of ICT infrastructure enhances connectivity, improves information accessibility, and supports business modernization. Artificial intelligence technologies demonstrate a substantial positive impact on economic performance by increasing operational efficiency, improving decision-making processes, and accelerating innovation activities. Likewise, e-government services contribute to administrative efficiency and transparency, while e-commerce development expands market opportunities and strengthens entrepreneurial activity.

Figure 2.

Multiplicative effects of digital economy technologies on regional economic development*



* Author development





Figure 2 illustrates the multiplicative effects of digital economy technologies on sustainable regional economic development. The analysis demonstrates that digital transformation influences regional economies through several interconnected channels, including economic growth, employment creation, investment attraction, innovation development, improvement of public services, and sustainability enhancement. The findings indicate that artificial intelligence technologies generate the strongest multiplier effect, with an estimated impact coefficient of 0.311. The adoption of artificial intelligence contributes to process automation, innovation diffusion, and data-driven decision-making, resulting in higher productivity and greater economic efficiency. Consequently, regions actively implementing AI technologies achieve stronger competitiveness and accelerated economic growth.

Digital infrastructure development represents the second most influential factor, with a coefficient of 0.287. The expansion of broadband connectivity, communication networks, and digital platforms improves access to information, reduces transaction costs, and creates favorable conditions for business development. As a result, digital infrastructure serves as the foundation for regional digital transformation and sustainable economic progress.

ICT utilization and digital investments also demonstrate a significant positive effect on regional development, with an estimated coefficient of 0.276. Increased investments in digital technologies facilitate technological modernization, stimulate entrepreneurial activity, and enhance the innovation capacity of regional economies. Moreover, digital investments contribute to attracting both domestic and foreign capital, thereby strengthening regional economic resilience.

The impact of e-government services is estimated at 0.241, indicating their important role in improving administrative efficiency and service quality. Digital public services reduce bureaucratic barriers, increase transparency, and provide faster access to government services for citizens and businesses. These improvements contribute to a more favorable institutional environment and support sustainable economic development.

E-commerce development exhibits a positive multiplier coefficient of 0.198. Although its impact is relatively lower than other digital factors, the expansion of e-commerce platforms increases market accessibility, supports small and medium-sized enterprises, and stimulates trade activities. The growth of online business ecosystems creates additional employment opportunities and enhances regional economic integration.

The analysis further reveals that digital economy technologies generate broader socio-economic benefits beyond direct economic growth. Digital transformation contributes to job creation through the development of new digital professions and skills, improves the quality and accessibility of public services, strengthens innovation ecosystems, and increases investment attractiveness. In addition, digital technologies support sustainable resource utilization and improve regional resilience to economic shocks.

Overall, the results confirm that digital economy technologies create substantial multiplier effects across economic, social, and institutional dimensions. Among the analyzed factors, artificial intelligence, digital infrastructure, and ICT investments have the greatest influence on regional economic performance. Therefore, policymakers should prioritize the expansion of digital infrastructure, increase investments in advanced technologies, promote artificial intelligence adoption, and strengthen digital public services to maximize the long-term benefits of digital transformation and achieve sustainable regional economic development.

Conclusion

The study demonstrates that digital economy technologies play a vital role in sustainable regional economic development. The findings confirm that digital transformation generates positive multiplier effects by improving productivity, innovation, investment attractiveness, and service efficiency.

The results indicate that artificial intelligence, digital infrastructure, and ICT investments have the strongest impact on regional economic growth. Therefore, accelerating digitalization





processes is essential for enhancing regional competitiveness and achieving long-term economic sustainability. To maximize the benefits of digital transformation, it is recommended to expand digital infrastructure, increase investments in advanced technologies, strengthen e-government services, support digital entrepreneurship, and improve digital skills among the workforce.

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