SCIENTIFIC AND TECHNOLOGICAL PROGRESS AND ITS IMPACT ON ECONOMIC SECTORS, ECONOMIC GROWTH, AND INNOVATIVE DEVELOPMENT

REVIEW
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Levels of Digital Maturity of Regional Governance

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Abstract. Presidential Decree of the Russian Federation No. 1014 identifies "the digital maturity of public and municipal administration" as a key performance indicator for the highest officials of the Russian regions. A unified assessment of governance digital maturity is particularly important at the regional level. The aim of this study is to develop a framework for the levels of digital maturity of regional authorities. The research employs methods of systemic logical analysis and a structural-functional approach to examine regional management teams and the functions of regional officials. The information base comprises articles indexed in the international database ScienceDirect and the Russian academic electronic library eLIBRARY, retrieved using the search query "levels of digital maturity of regional authorities." As a result, the author has proposed a typology of six levels of digital maturity for regional governance: absence of digital technologies; their existence; application; functional use; substitution of managerial functions by digital technologies; and autonomous regional governance without human participation. The article demonstrates the feasibility of objective analysis through assessing the share of managerial decisions made based on digital technologies. It analyses the evolving role of regional leaders in decision-making as digital technologies are introduced – from making decisions without considering digitalization to the leader becoming an architect of digital processes and technologies. Furthermore, the article shows that these maturity levels can be determined using the method of transactional tomography. The findings contribute to the theory of assessing digitalization processes in territorial governing bodies.

Keywords: digital maturity, regional authorities, transactional tomography, digitalization of governance, maturity levels, managerial decisions, digital technologies

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НАУЧНО-ТЕХНИЧЕСКИЙ ПРОГРЕСС И ЕГО ВЛИЯНИЕ НА ОТРАСЛИ ЭКОНОМИКИ, ЭКОНОМИЧЕСКИЙ РОСТ ИННОВАЦИОННОЕ РАЗВИТИЕ

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Уровни цифровой зрелости региональной власти

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Аннотация. Указ Президента России № 1014 определил одним из важнейших показателей эффективности деятельности высших должностных лиц субъектов Российской Федерации «цифровую зрелость государственного и муниципального управления». Особенно важным унифицированная оценка цифровой зрелости управления представляется на уровне органов региональной власти. Целью исследования является разработка уровней цифровой зрелости региональной власти. В качестве методов исследования были применены метод системного логического анализа и структурно-функциональный подход к анализу региональных команд управления и функций региональных управленцев. Информационную базу исследования составили статьи, проиндексированные в международной базе данных Science Direct и российской научной электронной библиотеке eLIBRARY, найденные с использованием поискового образа «уровни цифровой зрелости региональной власти». В результате проведенного исследования разработана типология шести уровней цифровой зрелости органов региональной власти: отсутствие, существование, применение, использование цифровых технологий, замещение управленческих функций цифровыми технологиями, автономность управления регионом без участия человека. Показана возможность объективного анализа цифровой зрелости по оценке доли принимаемых управленческих решений на основе цифровых технологий. Проанализировано изменение роли руководителей региона в процессе принятия управленческих решений путем внедрения цифровых технологий от принятия решений без учета цифровизации до становления архитектором цифровых процессов и технологий. Показано, что определение уровней цифровой зрелости органов регионального управления может быть проведено методом трансакционной томографии. Результаты исследования развивают теорию оценки процессов цифровизации органов управления территориями.

Ключевые слова: цифровая зрелость, региональная власть, трансакционная томография, цифровизация управления, уровни зрелости, управленческие решения, цифровые технологии

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Introduction

A recent Presidential Decree of the Russian Federation has identified "the digital maturity of public and municipal administration" as a crucial performance indicator for the highest officials of the Russian regions[1]. In the context of active integration of digital technologies into managerial decision-making processes, this approach is highly relevant and in demand both theoretically and practically. A unified assessment of governance digital maturity is especially important at the regional level, given the wide variety of internal and external conditions for development across Russian territories.

Digital maturity is generally understood as the readiness of public authorities to implement advanced technologies in governance activities, and its assessment is usually based on indices measuring the growth of digital interactions. However, this approach does not enable forecasting the development of digitalization processes based on an understanding of the evolutionary stages of regional governance.

Assessing the digital maturity of the managerial process requires differentiating the stages of introducing digital technologies into decision-making. Consequently, a key problem is identifying the distinct levels of digital maturity of regional governance.

An analysis of Russian and international academic literature reveals that the staged nature of digitalization in managerial decision-making remains understudied. At the time of this research, only 253 articles on the topic were indexed in the ScienceDirect international database and 11 in the Russian eLIBRARY database. Moreover, these works do not specify the stages of digitalization within the managerial processes of territorial governing bodies.

The aim of this study is to develop a framework for the levels of digital maturity of regional governance. Achieving this goal involves defining the concept of the "digital maturity of regional governance," formulating

[1] Presidential Decree of the Russian Federation of November 28, 2024, No. 1014 «On Evaluating the Performance of the Highest Officials of the Constituent Entities of the Russian Federation and the Activities of Executive Bodies of the Constituent Entities of the Russian Federation». https://mvd.consultant.ru/documents/1058708 (accessed January 20, 2025).

the research problem, developing a typology of maturity levels, and discussing methods for their analysis.

Current Theoretical Approaches to the Analysis of Regional Governance

Current theoretical approaches to the analysis of regional governance rest on the ecosystem analysis method for territories. The economic ecosystem of a territory is understood as a unified whole that brings together all stakeholdersinterested in the development of that territory. Stakeholders in a territorial economic ecosystem include municipalities, civil society, business, educational institutions, mass media, and other organizations.

Ecosystem analysis has become particularly relevant with the introduction of digital platforms. Data integration and transmission platforms play a decisive role in digitalizing various sectors of regional economies. In complex regional ecosystems involving many stakeholders, such data connectivity and transmission platforms are becoming increasingly convergent. This convergence strengthens digitalization and helps create shared local information between the core of the territorial economic ecosystem (the public authorities) and its stakeholders (Ahokangas et al., 2021).

A distinctive feature of platform architecture consists in its modular and interdependent system of core and complementary components, bound together by design rules and an overarching value proposition. This transforms platform ecosystems into an independent organizational form that possesses neither the hierarchical instruments of a single organization nor the largely uncoordinated decision-making process based on the free choice of participants. Successful platform ecosystems require coordination among multiple participants with possible conflicts of interest (Kretschmer et al., 2020).

The introduction of digital technologies represents a pivotal stage in the development of "smart territory" initiatives, as local authorities increasingly seek to leverage advanced solutions to enhance public services and residents' quality of life. For an economic ecosystem to function successfully, it requires a unified goal, effective internal communication, low entry barriers, seamless information exchange, and broad cooperation among its participants (Sorokina, Yrjonkoski, & Seppanen, 2024). Concurrently, a key task of public administration in Russia is ensuring technological sovereignty. This necessitates planning and implementing policies for technological renewal across economic sectors, grounded in a realistic assessment of current technological development levels (Sukharev, 2024a).

The Impact of Digitalization on the Development of Governance Processes

Digitalization impacts the development of governance processes primarily by enhancing data processing capacity, accelerating information transmission, and fostering environments for collaborative creation (Kochetkov et al., 2019). The integration of massive data volumes and the Internet of Things with other programs and equipment is essential for realizing the "smart territory" concept (Chang, Kadry & Krishnamoorthy, 2020). Concurrently, significant advancements in augmented and virtual reality technologies are revolutionizing the cultural and creative sectors (Restas et al., 2024). Furthermore, digital technologies within the information domain greatly support accurate managerial decision-making during natural disasters and emergency situations (Fischer-Presler, Bonaretti & Bunker, 2024).

Although the level of existing digital services can sometimes hinder their adoption, the current level of digital resource utilization is positively correlated with the intention of innovation intermediaries to provide digital and data transmission services (Sala-Vilar, Li-Ying & Traunecker, 2024).

The transition to a data-driven system of public and municipal administration, underpinned by innovative digital technologies such as data analytics, blockchain, the Internet of Things, and artificial intelligence, will accelerate the development of digital maturity in

Russia. This shift will create a foundation for future technological breakthroughs. Ultimately, digital transformation serves as a key driver for enhancing the efficiency and effectiveness of public administration. It reduces transaction costs and enables in-depth analysis throughout the implementation of technological solutions (Kasianov, 2019, p. 5).

Defining the Notion of Digital Maturity of Regional Governance

The notion of digital maturity is often treated by researchers as synonymous with digital readiness, a concept applied even at the national level (Kuvayeva, 2020, p. 36). However, the digital readiness of regional governance should be understood more specifically as the assessed levels of digital transformation across its functional areas, the adaptability of digital infrastructure to new solutions, the digital competencies of staff, and the maturity of the digital transformation management system – all within the context of an emerging "economics of technology" (Sukharev, 2024b).

In an article applying Industry 4.0 design principles to maturity assessment, researchers from the School of Engineering and Digital Sciences at Nazarbayev University provide a detailed review of prevalent assessment models (Dikhanbayeva et al., 2020, p. 9927). The most significant among these include:

- Digital Readiness Assessment Maturity Model (DREAMY) (Carolis et al., 2017, p. 6),
- Digital Auditing Tool for Ports (DRIP) (Philipp, 2020, p. 52),
- Digitalization Maturity Model for the Manufacturing Industry (Klцtzer & Pflaum, 2017, p. 4216),
- Maturity Model for Data Driven Manufacturing (M2DDM) (Weber et al., 2017, p. 177).

Building on the analysis of these approaches, the digital maturity of regional governance can be defined as the progressive substitution of human intellectual labour, as well as its role in governance, by digital technology components. This substitution aims to overcome temporal and spatial constraints in human interaction and to mitigate the limitations of human nature in organizing activities and processes. This phenomenon can be structured into distinct levels, applicable to an individual action, a process, or an entire region. This understanding of digital maturity provides the necessary conceptual foundation for developing a typology of maturity levels specific to regional governance.

Existing Methodology for Assessing Digital Maturity of Regional Governance

The digital transformation of governance is expected to deliver significant societal benefits in terms of productivity and sustainability. However, its progress has been slower than anticipated. Consequently, authorities are implementing various measures to overcome barriers to technology adoption (Senna, Roca & Barros, 2023). Effective digitalization requires enabling legislation (Langley et al., 2023) and the deployment of advanced tools. For instance, digital twins, created by integrating geographic information systems, data analytics, and artificial intelligence, serve as powerful long-term planning instruments. They enable simulation, comprehensive analysis, and forecasting of the impacts of territorial governance decisions (Villanueva-Merino et al., 2024).

Increased digital maturity of regional governance enhances the efficacy of e-government strengthening public trust in official decisions (Perez-Morote, Pontones-Rosa & Nunez-Chicharro, 2020). Furthermore, systematic digitalization of governance plays a crucial role in monitoring potential policy solutions (Dwivedi et al., 2022) and becomes integral to regional development.

In the Russian Federation, the digitalization of regional governance has spurred the creation of Regional Governance Centres. The implementation of online and network interaction fosters proactive links between citizens and authorities, increasing trust and governance efficacy. Optimization of these Centres requires both enhancing public digital literacy and ensuring the readiness of the regional

governance system to restructure at all levels (Bolshakova & Klimova, 2022).

Russia has adopted a specific methodology for assessing the digital maturity of regional authorities. This method evaluates key sectors, such as education, healthcare, urban services, transport, and public administration, by calculating the share of electronic processes within each sector. For example, one indicator is "the share of physician consultations conducted via videoconference, including through the Unified Portal of State and Municipal Services." A sector's digital maturity index is the arithmetic mean of its indicators, and the overall regional index is the mean across all sectors (Abramov & Andreev, 2022). This approach necessitates that all sectoral indicators share identical units of measurement.

Despite the argument that "to ensure an objective and comprehensive assessment of the level of 'digital maturity' of the public administration system in the regions of the Russian Federation, along with characterizing the basic conditions for implementing digital transformation, which essentially determine the degree of a region's readiness to apply information technologies, it is necessary to take into account the influence of regional factors that hinder or facilitate the development of these processes" (Anufrieva & Krasnodubskaya, 2023, p. 1069), the prevailing assessment of digital maturity relies on an index method measuring incremental growth from a baseline.

Research Problem

Given the considerations outlined above, the core problem addressed in this study consists in the absence of a clear typology for the levels of digital maturity specific to regional governance. Addressing this gap will enable the forecasting of digitalization processes in management by understanding the evolving roles of managers and staff as digital maturity increases. Crucially, it proposes shifting the assessment paradigm from quantitative index calculations to a qualitative evaluation of digital governance practices.

Research Methodology

This study employs a methodological framework that examines the regional digital governance system as its primary object of analysis. The subject of the study is the spectrum of economic relations arising from the digitalization of this system. The research employs a method of systemic logical analysis and a structural-functional approach to analysis of regional management teams and the functions of regional officials.

The information base comprises open-access articles indexed in the international database ScienceDirect. A search using the keywords "levels of digital maturity of regional authorities" yielded a sample of 253 articles. It was supplemented by an analysis of articles from the Russian academic electronic library eLIBRARY, found via the search query "urovni tsifrovoy zrelosti regional'noy vlasti" (the Russian equivalent for "levels of digital maturity of regional authorities"), which added 11 relevant articles.

Furthermore, the study builds upon findings from the author's prior research concerning digital maturity levels in industrial enterprises (Popov, Simonova & Cherepanov, 2021). The working hypothesis is that the maturity levels for an industrial enterprise and for regional management activity may share similarities, as they are shaped by the same foundational digital technologies, albeit with potentially different contextual applications.

The development of the typology also involved elaborating the changing roles of managers and executors within regional digitalization processes and evaluating potential methods for analysing the resulting maturity levels.

Levels of Digital Maturity of Regional Governance

An analysis of academic literature reveals that levels of digital maturity of regional governance can be differentiated along a continuum from simple to complex, from the complete absence of digital technologies to fully autonomous governance without human participation. This progression may also include

intermediate stages characterized by the mere existence, application, and functional use of digital technologies, culminating in the substitution of managerial functions by digital solutions.

These levels of digital maturity for the governance of territorial complexes can be illustrated by real-world examples. In the United Kingdom, digital technologies, such as Building Information Modelling, enable effective solutions to numerous problems in the construction sector, including time and cost overruns, low quality of work, and inefficient use of resources. Despite potential benefits and government support, the introduction of digital innovation in construction remains at a very low level, which results in largely manual management of the construction industry (Shojaei & Burgess, 2022).

The COVID-19 pandemic, in turn, stimulated the mass spread of remote work, online meetings, and e-commerce. A study conducted in Poland showed that this situation led to extensive use of digital technologies in private life but did not change the digital content of managerial functions (Duba & Maria, 2023). This example demonstrates the mere existence of digital technologies, rather than their systematic use in governance.

Digital technologies make it possible for public sector organizations to collect information and knowledge from citizens and other stakeholders (Kochetkov, 2023). E-participation is vital for local authorities because of their proximity to citizens and their role in fostering community engagement in economic and social development. A study conducted in Croatia showed that understanding the factors influencing the adoption of electronic citizen participation in public and municipal administration is critical for designing, planning, and disseminating initiatives that will motivate citizens to use modern digital technologies (Pasalic & Cukusic, 2024).

The introduction and diffusion of digital technologies in governance require appropriate institutional arrangements. A study of state-funded digital innovation intermediaries in France showed that their institutional work focuses on dismantling symbolic systems, creating relational systems, and maintaining managerial routines (Colovic et al., 2025). In this context, one can speak of building governance processes based on digital technologies.

Substituting managerial functions with digital technologies requires attention to five aspects of digitalization: governance strategy, human resources, availability of technologies, development of digitalization processes, and integration of functions. In such a setting, research on the management of seaports in Indonesia has demonstrated the feasibility of achieving a high level of digital transformation maturity (Utama et al., 2024).

Autonomous regional governance without human participation presupposes the development of organizational capabilities throughout the entire digital transformation process. A differentiated approach to the digital transformation process helps to account for evolving capability needs in territorial governance. Just as governing bodies themselves change during this process, different capabilities are required at different points in time to support authorities in their transition to digital technologies (Konopik et al., 2022).

By adapting the levels of digital maturity developed for industrial enterprises (Popov, Simonova & Cherepanov, 2021) to the level of regional governance, it is possible to obtain the positions summarized in *Table 1.* The levels of digital maturity of regional governance presented in *Table 1* demonstrate the sequential development of governance capabilities as advanced digital technologies are integrated. The substantive content of the digital technologies themselves remains beyond the scope of consideration. As a result, the proposed levels of digital maturity are relatively universal in terms of their temporal applicability.

The scientific novelty of this result lies in the development of levels of digital maturity of regional governance, which advances the theory of assessing digitalization processes in territorial governance bodies.

Table 1. Levels of Digital Maturity in Regional Governance
Таблица 1. Уровни цифровой зрелости управления регионом

Level of Digital Maturity	Nature of Digital Technology Application	Examples
Absence	Entirely manual governance	Manual management of the construction sector (Shojaei & Burgess, 2022)
Existence	Use of digital technologies in private life but not in regional governance	Remote work, online meetings, and e-commerce during the COVID-19 pandemic (Duba & Maria, 2023)
Application	Application of digital technologies to solve individual tasks	E-participation services for citizens in decisions by territorial authorities (Pasalic & Cukusic, 2024)
Use	Building governance processes on the basis of digital technologies	Institutionalization of the integration and diffusion of digital technologies in governance (Colovic et al., 2025)
Substitution	Substitution of managerial functions by digital technologies	Digital governance of seaport territories (Utama et al., 2024)
Autonomy	Regional governance without human participation	Development of organizational capabilities based on digital transformation of governance (Konopik et al., 2022)

Source: *compiled by the author*

Possibilities for Analysing Levels of Digital Maturity of Regional Governance

An objective assessment of digital maturity can apparently be conducted along three evident lines: assessing the share of managerial decisions made on the basis of digital technologies, the changing role of regional leaders in the managerial decision-making process, and the reduction of transaction costs for governing actors in territorial development.

The share of managerial decisions made on the basis of digital technologies is directly proportional to the level of digital maturity of regional governance. Increased digital maturity ensures the formation of a regional digital ecosystem, which serves as a "digital macroenvironment for interaction among citizens, business, and public authorities that contributes to sustainable socio-economic development of the region by improving the quality of managerial decisions through the organization of mechanisms for collecting and processing information about regional infrastructure in real time using end-to-end digital technologies" (Abramov & Andreev, 2023, p. 251). However, choosing and implementing the "correct" digital technologies often presents a complex challenge, particularly for regional authorities (Roth et al., 2023). Even so, an increase in the level of digital maturity of regional authorities signifies an expansion of the range of digital technologies employed and, correspondingly, an increase in the share of "digital" managerial decisions made. Purposeful application of digital technologies ensures sustainable development and distributed territorial governance (Sukharev, 2024c).

The changing role of regional leaders in the managerial decision-making process through the integration of digital technologies is determined by the initial conditions and processes for governing the economic ecosystem of the territory (Uzunca, Sharapov & Tee, 2022). Various development strategies may be implemented, the most important of which is the provision of "ecosystem services" (Langen, 2023), since regional governing bodies constitute the core of the territorial economic ecosystem.

Increasing levels of digital maturity alter the roles of managers and executors of decisions in regional authorities *(Table 2)*. The data presented in *Table 2* demonstrate the growing engagement of managers and executors in the digitalization processes of governance as the level of digital maturity of regional governance increases. Accordingly, the question arises of the necessary enhancement of the personal qualifications of managers and executors in the processes of governance digitalization.

The reduction of transaction costs in governing actors of territorial development is

Table 2. Roles of Decision-Makers and Executors in Regional Government Bodies During Digital Transformation

Таблица 2. Роли руководителей и исполнителей решений в органах региональной власти в ходе цифровой трансформации

Level of Digital Maturity	Role of Manager	Role of Executor
Absence	Makes decisions without regard to digitalization	Performs functions without regard to digitalization
Existence	Makes decisions without regard to digitalization but uses digital technologies in private life	Performs functions without regard to digitalization but uses digital technologies in private life
Application	Makes decisions on individual local operations	Applies digital technologies in individual operations
Use	Makes decisions based on digital data	Applies digital technologies in current operations
Substitution	Delegates decisions on individual tasks to digital technologies	Maintains digital technologies that substitute for the executors
Autonomy	Becomes an architect of digital processes and technologies	Performs the role of expert in supporting digital technologies

Source: *compiled by the author*

associated with the transition from manual governance to digital platform-based territorial governance. An economy based on big data creates a fundamental dilemma between "decentralization" on the one hand and "concentration" on the other (Marciano, Nicita & Ramello, 2020). In other words, the integration of digital technologies leads to decentralization of managerial functions and, in some cases, their transfer to autonomous digital solutions, while digitalization simultaneously means the concentration of the architecture of digital transformation in one core of the territorial economic ecosystem.

An important question here concerns the costs of governance for regional authorities when introducing digital technologies. Governance costs are transaction costs. In this case, the interaction of the core of the economic ecosystem with its stakeholders can be described by a transaction function having the following form (Popov, 2008):

$$C = BN^{\lambda} / (F^{\mu} + I^{\nu}),$$

where C represents the transaction costs of the ecosystem core; B is a coefficient of proportionality measured in units of costs that links costs in monetary units and the number of agents in units; N is the number of economically active agents (actors) that have concluded institutional agreements with the ecosystem core; F is the number of formal institutions (contracts); I is the number of informal institutions; and λ, μ and ν are elasticity coefficients for the use of actors, formal institutions, and informal institutions, respectively, in forming the institutional environment. The elasticity coefficients have values in the interval from 0 to 1 and reflect the quantitative change in transaction costs when the number of agents and institutions changes by 1%, respectively.

The formation of economic institutions, in turn, requires substantial transaction costs. In other words, one can speak of an institution production function that presumably exhibits a directly proportional relationship:

$$F + I = f(C),$$

where F is the number of formal institutions (contracts); I is the number of informal institutions; and C represents the transaction costs of the ecosystem core.

It can be assumed that the equilibrium point between the transaction function and the institution production function is the point of optimal size for the economic ecosystem. Transactional configuration thus enables the formation of the most rational interaction

between regional authorities and the stakeholders of the territorial economic ecosystem regarding the introduction of digital technologies, based on optimization of interactions.

It should be emphasized that analyzing the relationship between transaction costs of governance and levels of digital maturity of regional governance is the subject of a separate research study.

The determination of levels of digital maturity of regional governance bodies can be conducted using the method of transactional tomography, which represents a method for analyzing the economic ecosystem of a territory based on layer-by-layer investigation of transactional interactions among its participants (stakeholders), including public authorities, business, universities, municipalities, and society (Popov, Chelak & Kavetsky, 2024). For this purpose, it will be necessary to establish correspondence between levels of digital maturity and the set of advanced digital technologies employed.

Conclusion

In this study, the following theoretical and applied results have been obtained in developing levels of digital maturity for regional governance.

First, based on an analysis of prior research, the research problem – the absence of a typology of levels of digital maturity of regional authorities – has been identified.

Second, a system of six levels of digital maturity of regional authorities has been developed: absence of digital technologies, their existence, application, use, substitution of managerial functions by digital technologies, and autonomous regional governance without human participation.

Third, the possibility of an objective analysis of digital maturity through the assessment of the share of managerial decisions made on the basis of digital technologies has been demonstrated: the share of managerial decisions made on the basis of digital technologies is directly proportional to the level of digital maturity of regional governance.

Fourth, the changing role of regional leaders in the managerial decision-making process through the introduction of digital technologies has been analysed, ranging from decision-making without regard to digitalization to becoming an architect of digital processes and technologies.

Fifth, the findings revealed the fact that the identification of levels of digital maturity of regional governance bodies can be conducted using the method of transactional tomography, i.e. the method of layer-by-layer analysis of transaction costs for integrating advanced digital technologies.

The theoretical significance of these findings lies in the formation of a typology for the levels of digital maturity of regional governance, which advances the methodology for analysing digitalization processes in territorial economic ecosystems. The practical significance consists in developing an applied apparatus for assessing digitalization processes in the governance of actual regions.

Конкурирующие интересы

Автор заявляет об отсутствии конфликта интересов.

Competing Interests

The author declares that there is no conflict of interest.

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