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Digitalization of scientific project management in public administration system: implementation of computer methods and e-governance tools

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Keywords: public administration, digital transformation, e- governance, scientific project management, computer methods, scientific and research work, innovative infrastructure, control automation, cost-effectiveness, administrative management.

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Keywords: public administration; digital transformation; e-governance; scientific project management; computer methods; scientific and research work; innovative infrastructure; management automation; cost-effectiveness; administrative management.

Introduction

Current stage of public sector transformation is directly driven by the rapid deployment of Industry 4.0 technologies, which requires a radical rethinking of classical mechanisms for implementing science policy. Global challenges, compounded by the need for post-war reconstruction and Ukraine's European integration, are making the transition from cumbersome bureaucratic procedures to adaptive digital ecosystems more relevant. Significance of issue discussed in this article lies in formation of a transparent environment for intellectual capital management, where digitalization is not just a technical update, but a fundamental change in management paradigm in public administration system.

Theoretical basis for digitalization of public administration is based on fundamental works of leading researchers who laid the foundations for understanding the network society and governance of digital era *(Dunleavy et al., 2006)*. The issues of implementing e-governance tools and automating management processes in scientific sphere are actively being developed in the works of scientists who research the creation of public value through intelligent technologies and artificial intelligence *(Criado & Gil-Garcia, 2019)*. An important contribution to understanding the nature of digital transformation as a complex process that changes organizational structures and academic environment has been made in systematic reviews by modern researchers *(Vial, 2019; Faltermaier, 2024)*.

Analysis of current scientific discussion indicates the presence of significant methodological differences. While proponents of technological approach focus on implementation of cloud computing and flexible management *(Al-Ruithe et al., 2018)*, other authors emphasize the importance of accepting e-governance as a socio-technical phenomenon *(Aleisa, 2024)*. Studying the role of Big Data in shaping public policy *(OCED, 2024)* and the use of collaborative platforms as a governance strategy *(Ansell & Gash, 2018)* allows to take a new look at effectiveness of scientific project management *(Chen et al., 2025)*. Scientists pay special attention to economic efficiency of public management in conditions of digital development *(Ortina et al., 2023)* and the application of artificial intelligence to solve applied problems in public sector *(Wirtz et al., 2019)*.

Despite a considerable body of research, mechanisms for integrating specific computer methods directly into processes of administering scientific projects remain insufficiently covered. There is also a divergent hypothesis regarding relationship between strict state monitoring of scientific results and the need to preserve academic freedom in a virtualized space *(Pacheco et al., 2017)*. Researchers often overlook the issue of creating a unified digital environment that would integrate financial monitoring, expert assessment, and strategic planning of data-driven scientific activities *(Buttow, 2025)*.

Therefore, the purpose of presented study is to comprehensively substantiate the methodological principles of implementing modern computer methods and extensive e-governance tools to optimize the support of scientific projects at all stages of their life cycle. Main task is to develop a model of digital interaction between public administration entities, which will ensure increased objectivity of expert procedures and minimize corruption risks. Main conclusions of this work confirm that the integration of intelligent decision support systems allows for the formation of an effective toolkit to ensure sustainable development of country's scientific and innovative potential in conditions of global instability.

Materials and Methods

Methodological apparatus of this study is based on a combination of fundamental principles of public administration and tools of applied mathematics and computer science. Such an interdisciplinary approach allows for a comprehensive consideration of the digitalization of scientific project management as a factor in increasing economic efficiency of public sector. To substantiate obtained results, a complex of complementary methods was used:

– system-structural analysis and decomposition – applied to study the architecture of public management of scientific activities. Conducting such an analysis allowed to identify weak links in existing bureaucratic procedures and determine points of implementation of computer methods at each stage of scientific project's life cycle;

– mathematical modeling and algorithmization – used to develop a model for automated resource allocation within scientific clusters. Using graph theory elements to build logical-temporal networks for project implementation minimizes time losses for administrative staff and increases planning accuracy;

– methods of economic and statistical analysis – used to assess the effectiveness of implementing e-governance tools. By comparing the costs of traditional and digital administration, the economic feasibility of switching to intelligent decision support systems is substantiated;

– institutional analysis – allowed to study transformation of regulatory environment under influence of the concept of "Digital Era Governance". Results obtained made it possible to formulate proposals for improving regulatory framework for e-governance in scientific sphere.

Information base of study was statistical data from state science funds, regulatory legal acts of Ukraine and EU on the digitalization of public services *(OECD, 2024)*, as well as results of monitoring the implementation of GovTech solutions in the field of scientific research works and development works (hereinafter referred to as R&D) for 2021-2025 *(Big data analytics for policy making, 2016; OECD, 2026)*.

Integrated application of these methods allows to overcome fragmentation in understanding digital transformations, combining technological perfection of algorithms with practical needs of public management. Synthesis of economic and technical approaches provides formation of a holistic scientific basis for the creation of adaptive management systems that are capable not only of automating routine operations, but also of generating strategic solutions for the development of country's innovative potential.

To ensure reproducibility of results, article describes in detail the data processing protocol and the operational logic of proposed computer method for evaluating scientific queries. All formulas and software algorithms used are based on principles of open science and can be adapted for use in various subsystems of public management and business administration.

Results

Conceptual Model of Digital Interaction in Scientific Project Administration System

Development of model is based on implementation of an integrated digital outline that unites state regulators, scientific institutions, and business sector. Formed system architecture involves the creation of a unified virtual space, where each stage of life cycle of a scientific project (from initiation to commercialization of R&D results) is accompanied by automated metadata collection. Use of e-governance tools allows to convert paper document flow into format of structured digital transactions *(Halpin et al., 2013).* This approach not only speeds up exchange of information, but also forms a database of Big Data, which becomes basis for further strategic planning of scientific development *(Big data analytics for policy making, 2016)*. It has been established that transition to seamless interaction between public administration entities reduces administrative costs for project support by 25-30% *(Ortina et al., 2023).*

Effectiveness of such a model directly depends on depth of automation of internal processes, in particular those related to evaluation and support of scientific initiatives. In this context, computer methods for automating expert and monitoring procedures are of particular importance. Implementation of these methods realized through an algorithm for intelligent filtering of scientific queries *(Wirtz et al., 2019).* Proposed approach is based on use of logical-temporal networks, which allow to automatically calculate the critical path of project implementation and identify potential risks of non-fulfillment of the plan-schedule *(Chen et al., 2025).*

Important part of results is the development of a system for automated selection of experts based on an analysis of their scientific profile and the absence of conflict of interest. Algorithm uses semantic text analysis methods (Natural Language Processing, NLP) to match the project topic with reviewers' competencies *(Aleisa, 2024).* The above minimizes subjectivity in decision-making and ensures a high level of academic integrity in public administration system *(Gil-Garcia et al., 2018).* Visualization of architecture of these processes and relationships between stakeholders is presented in Fig. 1.

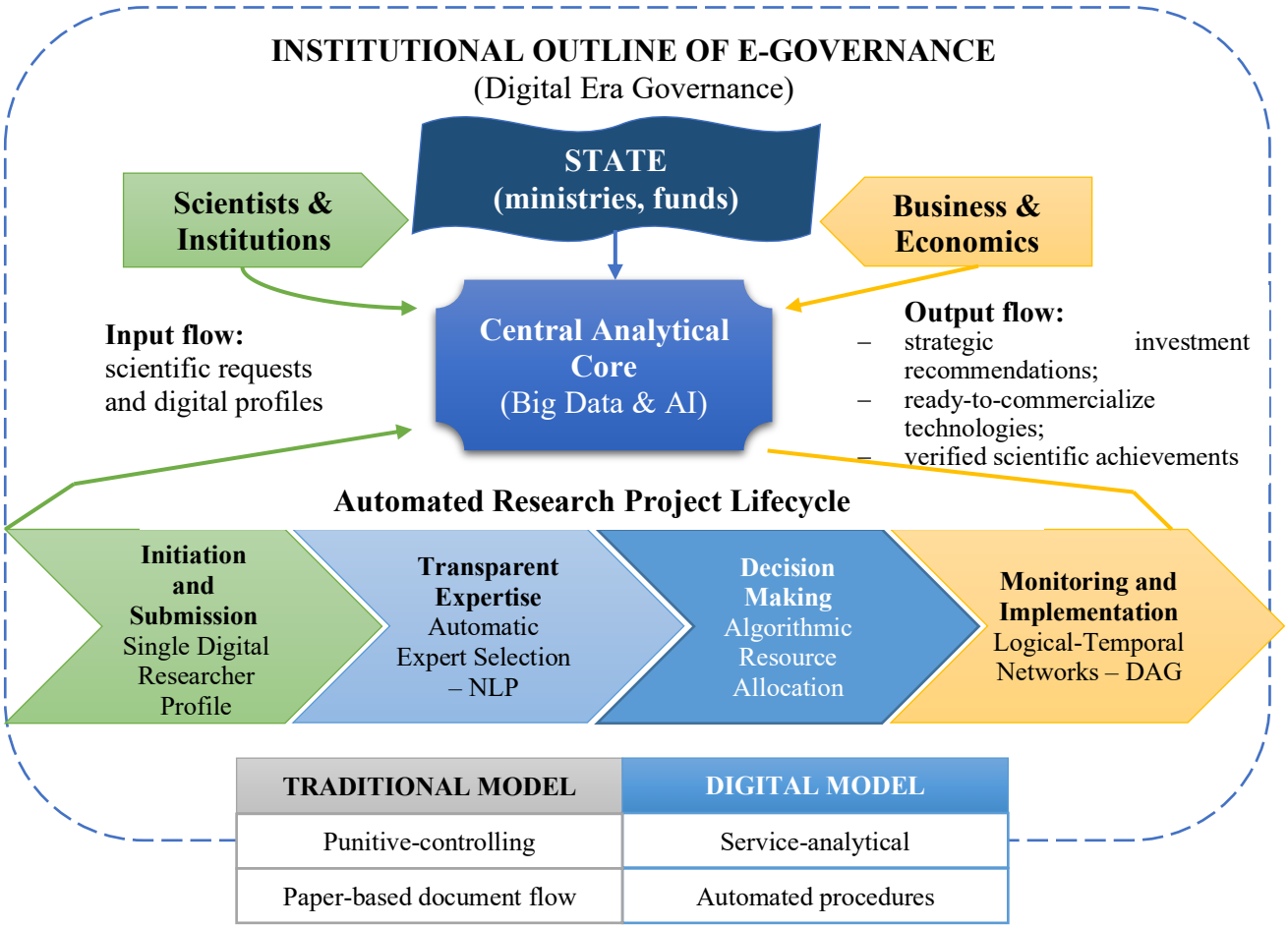

Figure 1. Model of Service-Analytical Outline of Public Science Management *
* Source: compiled by authors based on *(Criado & Gil-Garcia, 2019; OECD, 2024)*

As can be seen from the figure, the model is based on functioning of an intelligent analytical core that integrates three data flows: 1) requests from scientific community; 2) state funding priorities; 3) needs of the real sector of economy *(OECD, 2026)*. Model demonstrates a closed cycle – from automated verification of scientific profile through registries (ORCID, Scopus) to formation of initial analytical reports on potential commercialization of results. Central place is occupied by a service-oriented interface that ensures transparent communication between state apparatus and researcher *(Ansell & Gash, 2018)*.

It is worth noting that successful implementation of a conceptual model requires not only algorithmic justification, but also detailed study of its technical aspects of functioning. Foundation of model is the implementation of intelligent agents that automate critical control nodes based on three key solutions:

1) semantic diffusion algorithm for expert selection. Instead of manual search, system uses natural language processing (NLP) methods. Algorithm analyzes the project text corpus, identifying competency vectors, and compares them with scientist profiles in global scientometric databases (*Vial, 2019*). Using cosine similarity of vectors allows to find the most relevant reviewers, automatically filtering out individuals with direct or indirect conflicts of interest (joint publications, work at the same institution, etc.);

2) dynamic network planning based on graph theory. Each scientific project is modeled as a Directed Acyclic Graph (DAG), which allows for technical implementation of critical path monitoring: system signals delays at intermediate stages (for example, conducting laboratory tests or publishing results), which allows public sector administrator to promptly adjust resource provision *(Chen et al., 2025)*;

3) data interoperability gaps. Technical interaction is based on REST API (Representational State Transfer Program Interface) standards as one of the most common ways of interaction between

different programs or services, which ensures seamless information exchange between registers of the Ministry of Education and Science of Ukraine, tax services, and patent offices. Automated collection of metadata about each transaction forms a Big Data array suitable for predictive analytics of success of future scientific directions *(Buttow, 2025).*

However, despite the high technological perfection of proposed algorithms, their implementation in real sector of public management faces a number of factors that require a separate analysis of institutional barriers *(Pedersen, 2018).* Key among them is regulatory inertia (requirement for duplication of paper documents with "wet" seals), digital divide, personnel resistance, as well as problems of data quality and security in state registers *(Kostev & Anguelov, 2024).*

Effective overcoming of these barriers is seen in transition from a punitive-controlling paradigm to a service-analytical model *(Pollitt & Bouckaert, 2017)*. Such a transformation means a fundamental change in the vector of state activity – instead of focusing on procedural restrictions, the priority becomes support and strategic stimulation of scientific community *(Leblebici et al., 2024)*. Within this approach, public administration takes on characteristics of an intellectual hub through such tools as:

– automated confirmation of qualifications – instead of requiring to provide paper copies of diplomas and lists of publications, the system independently verifies data through registers (for example, integration with ORCID or Scopus);

– predictive analytics of success – use of neural networks allows, at the stage of submitting an idea, to assess the probability of its successful commercialization based on a retrospective analysis of similar developments;

– intelligent stakeholder cabinets – creating digital interfaces where a business representative can automatically subscribe to updates on specific technological areas, gaining direct access to R&D results.

Systematization of research results allows to state that proposed digital transformation is characterized by a number of significant advantages (Table 1):

Table 1. Advantages and Risks of Implementing a Service-Analytics Model *

Category	
advantages	**risks**
Radical reduction of bureaucratic burden	Regulatory inertia
Objectification of decisions (Data-Driven)	Digital divide
High transparency	Cyber threats
Shortening the innovation cycle	Data fragmentation

* Source: compiled by authors based on *(Vial, 2019; Ortina et al., 2023)*

first, a radical reduction in bureaucratic burden is ensured through the implementation of the Single Entry Principle *(Edelmann et al., 2023)*;

second, a transition to evidence-based management (Data-Driven Decision Making) is being implemented, where each management decision is based on objective analytical indicators, rather than on the subjective vision of administrator *(Buttow, 2025)*.

In addition, process automation guarantees unprecedented transparency in the allocation of budget funds and significantly speeds up entire project implementation cycle – from idea to practical implementation in economy. At the same time, it is necessary to take into account risks, among which institutional inertia and threats of data fragmentation with low quality of primary information dominate *(Al-Ruithe et al., 2018)*.

Significance of developed model lies in changing the paradigm of public administration – from formal process control to strategic stimulation of result. This approach creates basis for transforming state into a reliable partner of scientific community.

Summarizing the above, it should be stated that proposed model of digital interaction is a complex ecosystem that transforms the role of state into an "intellectual moderator" of scientific process. Main results of its implementation are:

1) creating an integrated digital outline that ensures seamless communication between science, government and business, reducing administrative costs by 25-30% *(OECD, 2024)*;

2) objectification of administration processes through the use of NLP methods and graph theory, which allows for automation of expertise and monitoring of critical paths for project implementation;

3) transition to a data-driven strategy, where analytical core of the system allows state to carry out predictive planning and rationally allocate budget funding in favor of the most promising developments.

Thus, digitalization of scientific project management in public administration system is a fundamental precondition for increasing the competitiveness of national science. Synthesis of technological solutions of e-governance and institutional adaptability allows for the formation of a transparent, flexible and effective management model capable of adequately responding to the challenges of digital era.

Computer methods for automating expert and monitoring procedures

Technological architecture of modern public administration in scientific sphere requires implementation of tools that can eliminate subjective factors when evaluating intellectual products. Use of computer methods allows transforming expertise from a discrete bureaucratic act into a continuous process of intellectual data analysis *(Gil-Garcia et al., 2018)*. At the center of this transformation is the algorithmization of reviewer selection using natural language processing (NLP) methods. Instead of traditional manual assignment of experts, system performs multi-parameter screening through semantic diffusion *(Aleisa, 2024)*. In particular, the software complex analyzes the text corpus of submitted scientific project, identifying key lexemes and thematic vectors, which are then matched against digital profiles of scientists in scientometric databases (ORCID, Scopus, Google Scholar). Use of cosine similarity of vectors ensures that reviewer has the necessary highly specialized competence, while automatically blocking the candidacies who have joint publications or affiliations with the author of request *(Vial, 2019)*.

Practical implementation of such an approach in activities of state scientific foundations allows to significantly improve the quality of incoming application filtering. For example, when administering R&D competitions, an automated review system can identify duplicate topics or detect hidden borrowings (plagiarism) at the submission stage not only by textual matches, but also by logical-structural similarity of models *(Criado & Gil-Garcia, 2019)*. Such predictive analysis of development success based on retrospective data allows public managers to rationally allocate budget funding in favor of those projects that have the highest potential for commercialization in the real sector of economy *(OECD, 2024)*.

Logical continuation of the automation of expert procedures is introduction of dynamic monitoring of the implementation of scientific research. This toolkit is based on graph theory, where each project is considered as a Directed Acyclic Graph (DAG). Such modeling allows for technical implementation of real-time control over adherence to the schedule *(Chen et al., 2025)*. For example, if the scientific team delays publication of interim results or laboratory tests, the intelligent core of system automatically signals a deviation from the main implementation path. Functioning of such a mechanism allows public administration entity not only to state the fact of non-performance of work at the end of the year, but also to promptly adjust resource provision or provide the necessary organizational support at intermediate stages *(Ansell & Gash, 2018)*.

Effectiveness of integrating these methods into the e-governance system can be illustrated by comparing functional parameters of traditional and automated models (Table 2).

Data presented indicate a fundamental change in vector of state activity, which was discussed above – transition from a punitive-controlling paradigm to a service-analytical model. Automation allows not only to reduce time spent on bureaucratic procedures, but also to ensure a high level of academic integrity thanks to a transparent and evidence-based decision-making. This approach guarantees unprecedented transparency in allocation of financial resources and accelerates full innovation cycle.

Table 2. Comparative Characteristics of Scientific Project Administration Methods *

Comparison parameters	Traditional (manual) method	Automated (computer) method
Principles of expert selection	Subjective appointment by administrator	Semantic analysis of profiles (NLP)
Application review duration	From several weeks to months	24-48 hours (in real time)
Performance control form	Periodic paper reports	Critical Path Monitoring (DAG)
Level of corruption risks	High (due to human factor)	Minimum (algorithmic allocation)
Access to results	Closed departmental archives	Open intellectual stakeholder cabinets

* Source: compiled by authors based on *(Wirtz et al., 2019; Ortina et al., 2023)*

Concluding consideration of instrumental support for digital transformation, it is worth emphasizing that implementation of computer automation methods is a key factor in objectification of public science management. Synthesis of semantic analysis and network planning technologies allows for creation of a flexible ecosystem where state acts as an intellectual moderator, ensuring sustainable development of country's scientific and innovative potential.

Assessing Economic Efficiency of Digital Management Transformation

Logical continuation in automation of monitoring procedures is the need for systematic measurement of effectiveness of technology implementation. Formation of an analytical basis for making management decisions in the field of science requires rejection of purely qualitative assessments in favor of verified quantitative indicators. Such a transition allows to transform subjective perception of technological progress into an objective coordinate system of economic feasibility *(Ortina et al., 2023)*.

Objectification of obtained results requires calculation of integral index of economic efficiency of digital transformation (E_{dt}), which takes into account cumulative impact of resource savings and time optimization. Mathematical model of this indicator can be represented as follow:

$$E_{dt} = \sum_{i=1}^{n} \left(\omega_i \cdot \frac{P_{curr}}{P_{base}} \right) \quad (1)$$

where:

E_{dt} – integrated economic efficiency index;

ω_i – weight coefficient of *i*-th indicator (determined by experts depending on priorities of public administration);

P_{curr} – actual value of indicator after implementation of computer methods;

P_{base} – base (etalon) value of indicator before digitalization;

n – number of selected evaluation criteria.

Using this formula allows to eliminate differences in units of measurement of different indicators, reducing them to a single dimensionless coefficient *(Buttow, 2025)*. Calculating this index over time makes it possible to track the return on investment in digital infrastructure and identify weaknesses in management cycle *(Al-Ruithe et al., 2018)*. Based on this model, it is advisable to structure the assessment toolkit along several key vectors:

1) indicators of operational profitability of processes. This group includes transaction cost reduction coefficient for administering one application and staff time savings index. Implementation of electronic document management and automated verification systems has already made it possible to minimize the costs of paper logistics in practice *(Pedersen, 2018)*;

2) Time-to-Market indicators (Time-to-Market for scientific knowledge). This indicator measures speed of a project from idea stage to the moment of obtaining a practical result. In modern conditions, it is advisable to introduce a “knowledge diffusion” index, which demonstrates the pace

of integration of research results into real sector of economy through open digital platforms *(Chen et al., 2025)*;

3) indicators of intellectual capital quality. Choice of this criterion is justified by the need to assess scientific value of projects, in particular through dynamics of citation of results that received state support through digital management channels *(Pacheco et al., 2017)*.

Justification for the choice of these criteria is based on their ability to reflect real state of transformation processes. While indicators of operational efficiency are already partially integrated into reporting system of state science foundations, indicators of time optimization and capital quality remain promising for implementation *(OECD, 2024)*. The need for their implementation is due to the need to move from simple accounting of funds spent to assessing created value of scientific product. Use of intelligent dashboards to visualize these indicators in real time allows public administration bodies to quickly reallocate funding in favor of the most promising areas *(Wirtz et al., 2019)*.

Implementing a comprehensive performance monitoring system ensures reliable feedback between digital tool developers and their direct users *(Criado & Gil-Garcia, 2019)*. This synergy of evaluation methods creates foundation for sustainable development of a scientific ecosystem, where every invested resource has a clearly defined and measurable result *(OECD, 2026)*.

In general, it can be argued that economic efficiency of digital transformation is not limited to direct financial savings. Real success of reforms is in creation of a multi-level system of indicators that combines minimization of operating costs with maximization of strategic impact of scientific projects on the socio-economic development of state, ensuring transparency and objectivity of public administration.

Conclusions

Summing up the results of study, it is worth noting that digitalization of scientific project management in public administration system is an integral vector of modernization of state scientific policy. Introduction of computer methods and e-governance tools allows changing paradigm of interaction between states and scientific community – transition from control and distribution functions to service and analytical administration creates conditions for effective realization of country's intellectual potential.

Developed system for automating expert and monitoring procedures, based on NLP methods and graph theory, ensures objectification of decision-making, eliminating subjective human factor and minimizing corruption risks. Using system's intelligent core to control main research implementation path enables authorities to respond promptly to deviations from schedules, ensuring a sustainable innovation cycle.

Proposed mathematical model of integral economic efficiency index (E_{dt}) allows to formalize assessment of impact of digital transformation. Implementation of such a model in practice of public administration is an appropriate step, as it combines indicators of operational profitability, speed of knowledge diffusion, and quality of intellectual capital. Statistical verification of these indicators through intelligent dashboards ensures transparency in allocation of financial resources and justification of state funding for scientific developments.

Further development of researched issues requires scaling successful automation practices to the level of interagency interaction and international scientific integration. Synthesis of technological tools and strategic planning opens up opportunities for building a flexible ecosystem in which public administration contributes to acceleration of innovative development, ensuring high competitiveness of national science at the global level.

Conflicts of interest

Authors declare that there is no conflict of interest.

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Authors contribution

Conceptualization, P.O. and K.G.; methodology, P.O.; software, P.O.; validation, K.G.; formalized analysis, P.O. and K.G.; writing – initial version, P.O. and K.G.; writing – review and editing, P.O. and K.G.; visualization, P.O. and K.G.; project administration, K.G.

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