

ABSTRACT

of the dissertation by Aknur B. Yesmurzayeva submitted for the degree of Doctor of Philosophy (PhD) in the specialty “6D051800 – Project Management” on the topic “Development and design the project management system in the field nanotechnology in Republic of Kazakhstan”

Relevance of the research topic. The current stage of global economic development is characterized by rapid progress in innovation, science, digital technologies, and artificial intelligence. Within this context, nanotechnology holds particular significance as a transdisciplinary field that forms the foundation for the creation of new materials, micro- and nanoelectronics, nanomedicine, energy-efficient technologies, and environmentally sustainable production. Research demonstrates that the nanotechnology sector serves as a catalyst for transitioning from a resource-based economic model to a “knowledge economy.” Unlike traditional industries (such as light manufacturing or basic mechanical engineering), nanotechnology is oriented toward the development of new materials, technologies, and markets. This, in turn, provides powerful scientific and technological momentum and opens pathways for enhancing national economic competitiveness. For the Republic of Kazakhstan, the development of nanotechnology is of strategic importance. In the Address of President Kassym-Jomart Tokayev “Kazakhstan in the Era of Artificial Intelligence: Current Challenges and Their Solutions through Radical Digital Transformation” (2025), it is emphasized that the country’s future depends on its ability to create high-tech clusters and strengthen technological sovereignty by integrating cutting-edge scientific achievements into industry and management processes. Furthermore, the national project “Science and Technology for Sustainable Development,” approved by Government Decree No. 965 in 2021, identifies the development of nanotechnologies and new materials as one of the strategic priorities of scientific and technological policy. The 2024 Law of the Republic of Kazakhstan “On Science and Technological Policy” provides for the implementation of effective tools for managing scientific and technical projects, including the standardization and digitalization of research commercialization processes. Nevertheless, several issues related to project management in the field of nanotechnology in Kazakhstan remain unresolved. First, project management in the field of nanotechnology requires the use of specific approaches that differ from those applied in traditional industrial or engineering projects, which complicates the formation and development of systematic methods in this domain. At present, Kazakhstan lacks a unified institutional and methodological framework for managing projects in the nanotechnology sector. Second, although nanotechnology is designated as a priority area at the level of national development strategies and sectoral programs (as confirmed by existing legislative and policy documents), in practice there remains a weak system for evaluating the effectiveness and monitoring the outcomes of ongoing projects. Third, current approaches to managing scientific and innovation projects do not fully consider the specifics of the sector, namely the integration of the research, design, and commercialization stages into a single cycle.

As a result, inconsistencies frequently arise between research institutions, national development organizations, and industrial enterprises. These issues highlight the need to enhance approaches to managing nanotechnology development, improve the efficiency of innovation processes, and integrate all project stages - research, design, and commercialization - into a unified project management system.

In this context, the development and advancement of a project management system in the nanotechnology sector is an important scientific and practical objective. The scientific justification of such a system is essential not only for the academic community but also for the implementation of the country's innovative development strategy. Today, it is necessary to establish effective mechanisms for planning, coordinating, and monitoring nanotechnology projects; to enhance the transparency and efficiency of their implementation; and to ensure the transfer of scientific into the industrial sector. The formation of such a system will strengthen the nation's innovation infrastructure and support Kazakhstan's integration into the global technological landscape.

The aim of the research is to develop institutional, organizational, and methodological mechanisms for improving the project management system in the nanotechnology sector of the Republic of Kazakhstan.

1. To study the theoretical aspects of nanotechnology project management and identify their differences from traditional projects;
2. To scientifically substantiate a model adapted to the specific features of the domestic nanotechnology sector based on the evaluation of the project management system and the analysis of maturity models;
3. To conduct an expert analysis of the standards and approaches used in international practice for managing nanotechnology projects and assess the possibilities of their application to nanotechnology projects;
4. To analyze the current state of the nanotechnology sector in Kazakhstan, as well as the institutional and organizational factors influencing its development;
5. To identify the institutional and organizational limitations of the project management system through assessing the maturity level of organizations implementing domestic nanotechnology projects;
6. To analyze the mechanisms for implementing nanotechnology projects and identify the emerging institutional, economic, and organizational problems;
7. Based on the research findings, to develop institutional, organizational, and methodological recommendations aimed at improving the effectiveness of project management in the domestic nanotechnology sector.

Object of the research – organizations, laboratories, and institutes in the Republic of Kazakhstan engaged in scientific research and innovation activities in the field of nanotechnology.

Subject of the research – the theoretical, methodological, and organizational foundations of establishing and developing a project management system in the nanotechnology sector of the Republic of Kazakhstan, including principles, tools, and models that ensure effective planning, coordination, and implementation of nanotechnology projects.

Theoretical Significance of Research. The research results contribute to the development of the theory of nanotechnology project management. The dissertation introduces an original definition of the term “nanotechnology project,” and scientifically substantiates its distinguishing characteristics among high-technology projects - in terms of scientific uncertainty, interdisciplinary structure, and infrastructural dependence. **The practical significance** is reflected in the applicability of the author’s maturity model, institutional integration framework, and the concept of the automated information system “AIS PM-Nano” in real organizations. The proposed methods can be used in research institutions, innovation-driven organizations, techno parks, and high-tech enterprises to improve project planning, risk management, monitoring, and evaluation processes. Empirical analysis enabled the identification of institutional and organizational constraints in the sector and provided practical recommendations for improving public policy, sectoral programs, and innovation support mechanisms.

The theoretical and methodological foundation of the research is based on scientific approaches grounded in the theory of Sustainable Project Management. Both quantitative and qualitative research methods were used: literature analysis, data collection and comparison, SWOT analysis, content analysis, systematization, modeling, correlation and factor analysis. **The information base** of the research consists of both primary and secondary data. Primary data include survey results and in-depth interviews conducted with 102 leaders and project team members of scientific organizations, centers, laboratories, and institutes implementing nanotechnology projects. Secondary data were obtained from final reports on scientific and scientific-technical projects in nanotechnology, annual reports of organizations, and open official domestic and international documents and statistical sources.

Scientific Novelty of Research. The scientific novelty of the research lies in the author’s development of scientific-methodological foundations for improving the nanotechnology project management system in Kazakhstan. The obtained results allow for an objective assessment of the management maturity of organizations in the nanotechnology sector, identification of institutional weaknesses, and enhancement of management effectiveness.

The following scientific results were achieved:

1. The theoretical and methodological foundations of nanotechnology project management were systematized, and their distinctions from other high-tech projects were clarified in terms of high scientific uncertainty, interdisciplinary nature, infrastructural dependence, and the long commercialization cycle.
2. An author’s definition of the concept of a “nanotechnology project” was proposed, and its innovative nature integrating the stages of research, development, testing, and commercialization was substantiated.
3. A comprehensive scientific and methodological project management model adapted to the specific features of the domestic nanotechnology sector was developed.

4. An original five-level maturity model and a system of evaluation criteria for assessing the project management system of organizations in the field of nanotechnology were developed.

5. An empirical assessment of organizations operating in the nanotechnology sector in Kazakhstan was conducted, identifying institutional, organizational, human resource, and digital limitations of the project management system.

6. The moderating effect of project management methods in strengthening the relationship between management processes and the organization's maturity level was empirically substantiated.

7. An institutional integration model for improving project management in the nanotechnology sector, based on the interaction of "government – science – business," was proposed.

8. A concept for the automated information system "AIS PM-Nano" was developed to digitalize the planning, monitoring, risk management, and budget control of nanotechnology projects.

Main Provisions Submitted for Defense

1. The distinction between nanotechnology projects and other high-tech projects is justified by their high level of scientific uncertainty, interdisciplinary nature, infrastructural dependence, and long commercialization cycle; on this basis, an author's definition of the concept of a "nanotechnology project" was proposed.

2. A comprehensive scientific and methodological project management model adapted to the specific features of the domestic nanotechnology sector was developed.

3. An original five-level maturity model and a system of evaluation criteria for assessing the project management system of organizations in the field of nanotechnology were proposed. This model enables both quantitative and qualitative assessment of the level of project management development in organizations within the nanotechnology sector.

4. As a result of the empirical study, institutional, organizational, human resource, and digital limitations of the project management system in nanotechnology organizations in Kazakhstan were identified.

5. The moderating effect of project management methods in strengthening the relationship between management processes and the organization's maturity level was empirically substantiated.

6. To improve the management system of nanotechnology projects, the "government – science – business" integration model and the concept of the automated information system "AIS PM-Nano" were proposed.

Author's Personal Contribution

The research work was carried out because of the applicant's independent scientific investigations, analytical studies, and model development. All theoretical provisions, comparative analyses, tables, diagrams, and original models presented in the dissertation are the results of the applicant's individual scientific work. The applicant systematized international approaches to project management in the field of nanotechnology and identified the possibilities for their adaptation considering the specific features of the domestic market. During the study, an original project

management maturity model and an organizational–institutional model was developed. These models are adapted to the specifics of the domestic nanotechnology sector and are aimed at improving the efficiency of scientific and innovation projects. As a result of the study, the concept of the automated project management information system “AIS PM-Nano” was developed, and its functional structure and application areas were scientifically substantiated.

Approbation of the main research results. The main findings of the study were discussed at the scientific and methodological seminars of the Higher School of Economics and Business of Al-Farabi Kazakh National University. The main results of the dissertation were presented and discussed at the following international, foreign, and national scientific conferences: the International Conference of Students and Young Scientists “Farabi Alemi-2017” (Kazakhstan), the Conference on International Business and Economics (Vietnam, indexed in the Clarivate Analytics database), the VI Republican Scientific and Practical Conference “Industry 4.0: Dialogue Between Generations and New Guidelines for Young Scientists” (Kazakhstan), and the 5th International Scientific Conference “Reviews of Modern Science” (Switzerland).

Publications Based on Research. The findings and outcomes of the research were published in 11 scientific papers, including: 1 paper published in a journal with a non-zero impact factor and indexed in Scopus; 5 papers published in scientific journals recommended by the Committee for Quality in the Sphere of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan; 5 papers in proceedings of international and national scientific conferences.