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Evaluation of high-tech project success in the Republic of Kazakhstan based on international standards of project management

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NORMATIVE REFERENCES

The next standards were used in this dissertation work:

Address of the President of the Republic of Kazakhstan Kassym-Jomart Tokayev to the Nation. Astana, April 9, 2019.

Address from the Former President of the Republic of Kazakhstan - Leader of the nation N. A. Nazarbayev to the people of Kazakhstan "The Kazakhstan Way - 2050: common Goal, Common Interests, Common Future". Astana, January 17, 2014.

The Law of the Republic of Kazakhstan “On state support for industrial and innovative activities” from July 4, 2013.

Decree of the President of the Republic of Kazakhstan dated June 4, 2013 No. 579 “On approval of the Concept of innovative development of the Republic of Kazakhstan until 2020”.

“About the approval of the Concept of Industrial-Innovative Development of Kazakhstan for 2015-2019 years”. Resolution of the Government of the Republic of Kazakhstan dated December 31, 2013. №1497.

The State Program "Digital Kazakhstan" approved by the Decree of the Government of the Republic of Kazakhstan dated December 12, 2017 No. 827.

National classifier of the Republic of Kazakhstan «General classifier of types of economic activity NK RK 03-2019» Approved by the Committee for Technical Regulation and Metrology of the Ministry of Industry and Infrastructure Development of the Republic of Kazakhstan dated February 22, 2019 No. 68-od.

NOTATIONS AND ABBREVIATIONS

APF	-	Adaptive project framework
AIPM	-	Australian Project Management Institute
ANSI	-	American National Standards Institute
APM	-	Association for Project Management
APMBOK	-	Association of Project Management Body of Knowledge
BS	-	Balanced scorecard
CAPM	-	Certified Associate in Project Management
CPMC	-	Construction Project Management Committee
CS	-	Customer satisfaction
CSP	-	Critical success process
CSF	-	Critical success factor
DIN	-	Deutsches Institut für Normung
ENAA	-	Engineering Advancement Association
EKSTU	-	East Kazakhstan State Technical University
EU	-	European Union
FITSU	-	Federal IT Steering Unit
GDP	-	Gross Domestic Product
HR	-	Human resources
IBM	-	International Business Machines
ISO	-	International Organization for Standardization
ICT	-	Information Communication Technologies
IIL	-	International Institute for Learning
JSC	-	Joint-stock company
KBTU	-	Kazakh Britsh Technical University
KEGOC	-	Kazakhstan Electricity Grid Operating Company
LMI	-	Lead Market Initiative
LLP	-	Limited Liability Partnership
MES RK	-	Ministry of Economics and Science of the Republic of Kazakhstan
MDDIAI RK	-	Ministry of Digital Development, Innovation and Aerospace Industry of the Republic of Kazakhstan
MNE RK	-	Ministry of National Economy of the Republic of Kazakhstan
MEGNR RK	-	Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan
ME RK	-	Ministry of Energy of the Republic of Kazakhstan
NASA	-	National Aeronautics and Space Administration
NATD	-	National Agency of Technological Development
NIF	-	National Innovation Fund
NC	-	National Company
NNLOT	-	National Nanotechnological Laboratory of Open Type
OECD	-	Organisation for Economic Co-operation and Development

OPMM	-	Organizational project management maturity
OGC	-	The Office of Government Commerce
PMAJ	-	Project Management Association of Japan
PRINCE2	-	Projects in controlled environments, version 2
PMPQ	-	Project management planning quality
PQ	-	Process quality
PM	-	Project manager
PMBOK	-	Project management body of knowledge
PMP	-	Project management professional
PRINCE2	-	Projects IN Controlled Environment, version 2
PMRC	-	Project Management Research Committee
QIM	-	Quality Inspection Management
RBS	-	Resource breakdown structure
ROI	-	Return on investment
RD	-	Research and development
R&D	-	Research and Development
RK	-	Republic of Kazakhstan
SEC	-	Social Entrepreneurship Corporation
SITC	-	Standard International Trade Classification
STEM	-	Science, technology, engineering and mathematics
SME	-	Small and medium size enterprises
TQM	-	Total Quality Management
TNC	-	Transnational Corporation
UN	-	United Union
USA	-	United States of America
UK	-	United Kingdom
VCR	-	Video Cassette Recording
WBS	-	Work breakdown structure
WKATU	-	West Kazakhstan Agrarian Technical University

INTRODUCTION

General description of work. The thesis is devoted to the evaluation of the high-tech project success level in the Republic of Kazakhstan by using the PMBOK standard.

Relevance of the topic. In his Address to the Nation, the President of the Republic of Kazakhstan Kassym-Zhomart Tokayev noted that in order to support national business in international markets, it is necessary to develop new technological phenomena. Kazakhstan should become a platform for the development of the latest digital technologies and a brand as an open jurisdiction for technological partnerships [1]. Moreover, according to the second reform of the Development Strategy of the Republic of Kazakhstan until 2050, entitled “Technological update and digitalization”, Kazakhstan seeks to be in the ranks of technologically competitive countries. For this, it is necessary to create an innovative infrastructure in the economic sphere based on knowledge, modernization of basic industries and the emergence of new markets [2]. In addition, one of the key tasks of the State program of industrial and innovative development of the Republic of Kazakhstan for 2015-2019 is the creation of prerequisites for the emergence of a critical mass of innovative and active business. In turn, the implementation of high-tech projects can be an effective tool in solving the above problems, since the concept of creating high-tech projects is one of the main stages of the transition to an innovative economy.

Today, one of the important directions of state policy in the field of economic security is to increase competitiveness in the geopolitical space. The orientation of the economic system to the innovative component is one of the driving forces of socio-economic development, which forms the competitiveness of the national economy [3].

The domestic economy sectors that implement high-tech projects are key sectors for the sustainable growth of the economic system, which is carried out through the widespread introduction of leading technologies and the creation of products with high intellectual labor costs [3]. In addition, high-tech projects are carried out on the basis of a number of tasks of the State Digital Kazakhstan programs adopted for 2018-2022. Successful implementation of high-tech projects will help to solve important problems in achieving one of the goals of the programs. The goal called the “Digital Existing Economy” is based on the use of a pragmatic start consisting of specific high-tech projects in the field of digital and technological restructuring.

According to literary sources, in the development environment of high-tech products, the percentage of unsuccessful startup projects ranges from 90% to 99%. Such projects do not fit into well-structured and internationally accepted project management methods due to the fact that they are distinguished by their complexity, increased risk, the unpredictability of results and high technology. In addition, studies have not yet been conducted on the topic of managing the success of high-tech projects in the Republic of Kazakhstan. Therefore, research in this area will remain relevant and highly significant.

Degree of elaboration of the research topic. The topics of the innovative and technological development of the national economy, the innovation system and its infrastructure, innovation policy, problems of sustainable innovation, some aspects of modern trends in the development of the international high-tech market, the introduction of innovative technologies in the domestic market are contained in studies of foreign scientists, such as Beckman S., Bernardy A., Clarke M., Cortright J., Demin S., Hall S., Huarng K.H., Kalenskaya N., Karatayev M., Ramey K., Rodriguez J., Salikhova E., Sharma A., Sinha K., Seelman V., Shpolyanskaya A., Schumpeter S., Toffler E., et al.

Among domestic scientists it is worth noting the works of Alzhanova F.G., Alimova, N., Chulanova C., Dnishev F.M., Dzhunusov A., Karenov R.S., Kupeshova S.T., Mukhamediev B.M., Sabden O., Sagieva R.K., Sansyzbayeva G.N., Skakova D. A., Tazhibayev E., Turginbayeva A.N., Tsareva N.A., Zhatkanbayev E.B., Ziyadin S.T., Zhidebekkyzy A., et al.

At the same time, the features of the development of the high-tech market infrastructure and the factors affecting the implementation of high-tech projects have not been fully investigated.

A significant contribution to understanding the fundamentals and problems of project management, including high-tech and innovative projects, critical processes for their success, and evaluating their effectiveness, was made by studies of foreign scientists, such as Archibald R., Baker B., Collyer S., Denisov T., Dvir D., Jugdev K., Law C., Levy O., Meredith J., Milosevich D., Murphy D.C., Muller R., Munns A., Pinto J., Samset K., Shenhar A., Serrador P., Statsenko L., Turner R., Yaroshenko F., Zolin R. J., Zwikael O., et al.

Among domestic scientists should be noted works such as Abdygapparova S.B., Adilova A.M., Akhmetova Z., Bolatzhanuly, T., Dzholdasbaev O., Duysembekova G., Karmazina L., Mukhtarova K.S., Narbaev T.S., Nekrasova A., Sailaubekov N.T., Tsekhovoy A.Ph., et al.

These works didn`t consider the conceptual bases of high-tech projects in detail, methodological aspects of high-tech project success management, specific success criteria for high-tech projects. The vast amount of studies aimed to investigate separate types of high-tech projects like software projects, nanotechnology projects. Especially, there is a lack of studies dedicated to analyzing high-tech projects implemented in Kazakhstan. Therefore, these facts explain the necessity and relevance of dissertation work.

Purpose and object of the study. The aim of the study is to evaluate the success of high-tech projects in the Republic of Kazakhstan based on project management standards.

In accordance with the goal, the following tasks were solved:

1) to systematize the theoretical and methodological aspects of managing high-tech project success;

2) to compare existing international standards for project management and their applicability in the management of high-tech projects;

3) to determine global trends and features of managing high-tech project success in foreign countries and consider ways of applying their practice in the Republic of Kazakhstan;

4) to analyze the infrastructure elements of the innovation system of the Republic of Kazakhstan, affecting the implementation of high-tech projects;

5) to evaluate the level of success of high-tech projects in the Republic of Kazakhstan and show in this the role of project management processes based on the developed economic and mathematical model;

6) to suggest ways for improving the high-tech project success management in the Republic of Kazakhstan.

The object of the research is organizations that implement high-tech projects in the Republic of Kazakhstan.

The subject of the research is the interconnection of project management processes and the success dimensions of high-tech projects in the Republic of Kazakhstan.

Theoretical and methodological base of the research. The dissertation is based on research by foreign and domestic scientists and experts. The work uses regulatory acts of the Republic of Kazakhstan related to the formation and development of innovative infrastructure, as well as program documents and methodological developments of international experts and organizations. The dissertation research was carried out on the basis of system-structural and functional approaches.

In the course of the work, the following quantitative and qualitative methods were used: generalization, systematization, comparison, induction, deduction, abstraction, formalization, concretization, classification, statistical analysis, qualitative and quantitative research, survey, economic and mathematical modeling, regression, dispersive and factor analysis.

The information base of the research. The information base was the data of the Statistics Committee of the Ministry of National Economy of the Republic of Kazakhstan; analytical reports of the National Agency for Technological Development, the Ministry of Investment and Development of the Republic of Kazakhstan, the World Bank, OECD, UN; materials of ISPC and foreign databases such as ScienceDirect, Springer, Ebscohost, Australian Library, Exeter Library, Elsevier, Taylor&Francis.

Scientific novelty. The scientific novelty of the dissertation research lies in the development of methodological approaches and practical recommendations for the management of high-tech projects in the Republic of Kazakhstan, ensuring their success. The following **scientific results** were obtained during the research:

1. The author’s definition of high-tech projects has been developed and justified, in which industry features and the level of knowledge intensiveness are highlighted as specific features.

2. The author has developed and generalized an approach for high-tech project classification based on typology of high-tech industries suggested by international organizations, including industry and knowledge intensiveness characteristics as the main features.

3. The economic-mathematical model has been built for assessing the relationship between the success dimensions of high-tech projects and project management processes according to the PMBOK standard.

4. A quantitative assessment of high-tech project success was conducted, where the main variables are project management processes, the schedule and cost overruns, as well as the level of customer satisfaction.

5. New approaches and ways to improve the infrastructure in the framework of the implementation of high-tech projects in the Republic of Kazakhstan were proposed.

6. An algorithm of processes for managing the success of high-tech projects in the Republic of Kazakhstan has been developed.

The main provisions to be defended:

1. The author’s definition of the term “high-tech project”, which differs from the well-known interpretations by highlighting such attributes as the level of knowledge intensiveness and uncertainty, scope, time and other resources.

2. The author's classification of high-tech projects, based on typing by industry, containing 9 groups, and the level of knowledge intensiveness.

3. A quantitative assessment of the success of high-tech projects in the Republic of Kazakhstan based on the developed economic-mathematical model.

4. Regression analysis of the relationship between the success of high-tech projects in the Republic of Kazakhstan and project management processes in accordance with the PMBOK standard.

5. Recommendations for improving the management of high-tech project success in the Republic of Kazakhstan.

Theoretical and practical significance. The theoretical conclusions obtained during the study will contribute to the development of a holistic concept for managing high-tech projects in the Republic of Kazakhstan to create a knowledge-based economy. Also, the research findings will be able to make a significant contribution to enriching the science of project management.

Conclusions and suggestions of this study may be useful for stakeholders of the innovation system of the Republic of Kazakhstan. Systematic information on key elements of the high-tech industry infrastructure can be used by domestic market participants, in particular, business representatives.

Research results, scientific and practical recommendations can be taken into account when implementing, developing and improving strategies, programs, concepts and development plans of the Ministry of National Economy of the Republic of Kazakhstan and Ministry of Digital Development, Innovation and Aerospace Industry of the Republic of Kazakhstan. The materials contained in the research work can also be used in the following disciplines: “Project Management”, “Management of Innovative Projects”, “Innovation Management”.

Approbation of the main results of the work. The main results of the thesis were presented in proceedings of foreign and local international conferences, such as the XIV International Scientific Conference of Young Scientists “Lomonosov-2018” (Kazakhstan); International Conference on Business and Economics (Vietnam, indexed by Web of Science); 58th International Conference for Young Scientists "Youth, Science and Practice" (Russia), etc.

The results of the dissertation work were used in other scientific researches:

– “Development of virtual electronic laboratories with elements of augmented and virtual reality technologies for studying physics in secondary educational institutions”;

– "Obtaining nanomaterials by pulsed plasma spraying and their application in production", IRN № AP05130108;

– № 0298-17-GK, “Organization of small-scale production of energy-saving gas-discharge lamps with increased glow intensity based on new technologies”.

The reference to the use of scientific conclusions and proposals in the project implementation processes is attached (Appendix A, Appendix B, Appendix C).

Publication of research results. The main provisions to be defended are reflected in 13 scientific works: 2 - in journals indexed in the Scopus database, 1 - in journal indexed in the Web of Science, 4 - in scientific journals recommended by CCSES MES RK, 6 - in proceedings of foreign and local international conferences.

The structure of the dissertation. The work consists of content, notation, abbreviations, introduction, three chapters, conclusion, references and appendixes.

1 THEORETICAL AND METHODOLOGICAL APPROACHES TO THE HIGH-TECH PROJECT SUCCESS MANAGEMENT

1.1 Theoretical bases of high-tech project management

In connection with the continuous growth of global competition and increasing technological changes, the theory and practice of managing high-tech projects are becoming increasingly important.

It is worth noting that high-tech projects involve the use of breakthrough technologies and innovations, which, in turn, need effective management. The successful implementation of such projects will contribute not only to the development of the competitiveness of domestic enterprises, but also to the economy as a whole. Since breakthrough projects, in particular, their results can bring multimillion-dollar profits, improve conditions and living standards of the population, create and develop various advanced industries.

The study didn`t find any official definitions of high-tech projects in existing literature, despite the relevance and significance of such projects. Therefore, further discussion will be devoted to identifying what is high-tech project and how to manage it.

What is known about high-tech projects is that they belong to the category of those projects, the development of which uses the latest achievements and results of research and development in priority sectors and sectors of the economy. The main component of such projects is the latest high-end technology.

For understanding the essence of high-tech projects, the study investigates what is technology, high technology, high-tech industry and classification of high-tech projects. Also, it`s important to underline the link between high-tech projects and innovative projects. Thus, it will help to understand the essence of high-tech projects and develop a definition.

The phrase “technology” was first used in 1958 in The New York Times story advocating "atomic energy" for Europe [7]. Toffler [8] presented the technology very figuratively, by describing it as the reason for economic changes. Because as he says, technology changes the intellectual environment and worldview of people, In addition, technology brings changes to society by solving personal and global problems**.** Ramey [9] supports this statement and explains technology as a body of knowledge that creates tools and extracts materials for implementing particular tasks in order to simplify our daily lives.

Another interesting point of view suggested by Alzhanova [10]. She distinguishes innovation from technology and states that technology may support the creation of innovation. On the other hand, Schumpeter [11] explains technology as a supply-driven component that directly affects innovation.

High technology, often abbreviated to high-tech. According to Cortright [12], high-tech is technology that is at the cutting edge: the most advanced technology available. The opposite of high tech is low technology, referring to simple, often traditional or mechanical technology. It should be noted that high-tech requires high professional human resources. Since according to a study funded by the Workforce Information Council, the high-tech sector differs from others by a high concentration of workers in what is referred to as STEM (science, technology, engineering, and mathematics) [13]. On the other hand, it is well-known that the low involvement of human capital assumes a high level of technology.

According to Merriam Webster dictionary, *high technology is* scientific technology involving the production or use of advanced or sophisticated devices especially in the fields of electronics and computers [14]. This interpretation limits the scope of implementation of high-tech projects that may take place in other different sectors.

Hecker [15] states that high technologies are technologies that systematically use scientific and technical experience. “High Technology” is generally applied to economic and industrial sectors wherein technological innovation is emphasized. High-tech industries play an important role in the modern economy, and often experience significantly higher pay than other industries. Projects implemented in these industries called high-tech projects [16].

Literature review helps to find out two approaches to high-tech project classification. The first based on the technological uncertainty level, the second based on industry type. According to the first approach of high-tech project`s classification, they differ from each other by the newness and complexity of involved technology. Shenhar [17] classified an entire spectrum of projects into four types: low-tech, medium-tech, high-tech, super high-tech. He identified the proper management styles for various kinds of projects. Low-tech projects called projects of type A, medium-tech - type B, high-tech - type C, super high-tech - type D (table 1).

Table 1 – Classification of high-tech projects by technological uncertainty level

Project type	Level of technology	Typical projects &Examples	Development work Design freeze Risk involvement	Managerial style, Strategy and attitude Communication Pattern required
Type A Low-tech	No new technology utilized	Construction, installation, rebuilding a product (bridges, telephones).	No development needed. Specifications set before installation. Limited risks due to weak planning , human errors or “act of God”	Firm style. Build to “print.” Formal communication at predetermined periods.
Type B Medium-tech	Some new technology is utilized	Additional commercial model. Improvement of a product (autos, TV).	Some development and testing needed. Early design freeze. Additional risks due to the utilization of some new technology.	Moderately firm style. Build to specs. Accept some changes. Additional communication needed; some informational interaction.

Continuation of table 1

1	2	3	4	5
Type C High-tech	Integration of new, but existing technologies	New military system. New commercial family. First VCR, Macintosh	Considerable development, integration and testing. Late design freeze. Additional risks of integrating new technologies for the first time and due to wrong tradeoff decisions.	Moderately flexible style. Build to state-of-the art. Expect many changes. High levels of communication needed - multiple channels; extensive informal interaction.
Type D Super high-tech	Key technologies do not exist at project`s initiation	New system concept. Sidewinder, Eagle computer.	Enormous development work needed. Very late design freeze. Extensive risks in unknown technologies and integration.	Flexible style. Build to advanced need. Live with continuous change and "look for trouble." Enormous levels of communication are essential - must enhance number of channels and facilitate informal interaction.
Note - Compiled by author based on [17]				

As depicted in table 1, projects from types C and D are considered as high-tech projects. As we go from lower- to higher-tech projects, risks are continuously added because of the increased uncertainty in technology. It`s difficult to identify the type of project according to this approache. Because there are no exact indicators that help to identify the real type of high-tech project. It`s difficult to measure is it high-tech projects or no.

For example, Shenhar described projects from type C as projects that include several new key technologies that existed before. Projects of this type may include the development of a new family of products or a completely new product based on advanced technologies that are incorporated into a product for the first time. Examples of this kind of project are video cassette recorders, the first personal Computer of IBM and the building of the Macintosh.

Furthermore, projects from D type explained as projects that integrate several key technologies that do not fully exist at the starting point of the project. They are risky and require some research work during the lifecycle in order to develop and prove the new not yet existed technologies. Examples of this type of project are NASA`s Apollo moon landing project Eagle minicomputer and "Blackbird" Aircraft. They called super high-tech projects because of using non-existing technologies that never used before.

These descriptions presented by Shenhar do not allow to exactly classify high-tech projects by type due to lack of clear information and precise measuring indicators that help to measure the level of technology, uncertainty or risk level needed for differing the type of high-tech project. It is difficult to classify existed high-tech projects by this classification. Therefore, the study considers the classification of high-tech projects by industry type.

By the way, Archibald [16, p. 66] deeply investigated high-tech project management and mentioned the lack of knowledge about high-tech project types and classification, and prepared a group of projects that may be classified as high-tech projects according to industry type. Among the ten recommended categories of projects listed in his book, he highlights the following five group of high-tech projects:

1. Aerospace / Defense Projects.
2. Projects of communication systems.
3. Projects of information systems.
4. Projects of product and service development:
   – industrial products;
   – consumer products;
   – pharmaceutical products;
   – services.
5. R&D projects:
   – related to the environment;
   – industrial;
   – related to economic development;
   – medical;
   – scientific.

Thus, examples of Aerospace projects are satellite development, space station modification, new weapons system, etc. These projects are in most cases at the forefront of high technology. Their life cycles are unique, determined by policies and standards for fulfilling government orders, and in most cases are financed from the state budget [16, p. 67].

Projects of Communication systems include projects from Network communication systems and Switching Communication areas like communication networks using microwaves.

R&D projects are one of the most promising and risky groups of high-tech projects that may solve the next kind of global problems: ways to reduce emissions; determining the crop most suitable for cultivation in the Sahara desert; determining the probability of life on Mars.

Projects of product and service development cover projects implemented in listed above spheres that aimed to produce absolutely new products or services. IT projects directed at developing a new information system for managing projects like Microsoft project and others.

According to Archibald, the next group of high-tech projects is capital construction projects. Many capital construction projects include elements of high technology. International development projects also often include high-tech projects like capital construction projects, but they have significant differences in their life cycles and management processes [16, p.68].

Classifications suggested by Archibald limited by a short list of industries. This fact requires the analysis of the classifications of high-tech projects under industry type. Before this, we should define the types of high-tech industries. There are common three approaches to classifying the high-tech industry.

In total, three classifications are known and used in practice to classify types of industries to a particular level of technological development:

1. Classification of the Organization for Economic Cooperation and Development (OECD);
2. USA National Science Foundation classification;
3. UN classification (within the framework of the Standard International Trade Classification - SITC).

After analysis of the differences in international classifications of precisely high-tech types of industries, we can present the generally recognized classification of high-tech industries.

The list of the OECD and the UN is not exhaustive, it is a representative sample of high-tech industries, sufficient to identify their features, their role in the economies of developed countries and the situation on the world market of high-tech products (table 2).

Table 2 – Generally recognized classifications of high-tech industries

№	According to the classification of the US National Science Foundation	According to the classification of the OECD (Organization for Economic Co-operation and Development)	According to the UN classification (within the framework of the Standard International Trade Classification)
1	2	3	4
1	Aviation and space-rocket industry	Pharmaceutical Production	Air and spacecraft
2	Computers and telecommunications	Production of office equipment and computers	Computer and office equipment
3	Electronics	Production of equipment for radio, television and communication	Electronics, equipment for radio, television and communication
4	Nuclear technology	Manufacture of medical equipment, measuring instruments, optical instruments and equipment, watches	Radioactive materials and other chemical products
5	Production of weapons and military equipment	Production of aircraft, including space	Armament
6	Biotechnology		Pharmaceutical preparations;
7	Optoelectronics		Devices (medical, optical, measuring)
8	New material development		Non-electric machines (nuclear reactors, gas turbines, etc.)

Continuation of table 2

1	2	3	4
9	Production related to computerization		Electric cars.
10	Life sciences		
	Note – Compiled by author based on [18]		

According to table 2, general sectors are nuclear and space technology, biotechnology, engineering, communication. They are mentioned in the list of all three organizations. Of course, the list of high-tech industries and high technologies cannot be stable – it must change accordingly with the advent and development of new achievements of science and technology.

Another classification of industries as high-tech, medium-tech, high-level, low-level or low-tech was proposed by the OECD [18]. In addition, Germany classifies its high-tech industries according to this approach. Since industries with R&D expenditures of less than 2.5% are considered low-tech in Germany, while according to the OECD classification, these industries are classified as high-tech. The OECD classification has been revised, the criteria for assigning industries to a particular group have been changed in 2009.

The next table (table 3) compares the classification of high-tech industries by OECD and Germany.

Table 3 – Classification of high-tech industries by Germany and OECD according to R&D expenditure [18]

Classification of industries	Germany	OECD (criteria after 2009)
High-tech	>7 %	>7 %
High Level medium tech	2.5–7 %	2–7 %
Low level medium tech	Less than 2.5 %	0.5–2 %
Low-tech	-	Less than 0.5 %

As table 3 shows, industries with R&D costs more than 7% are high-tech. But, the study claims that it isn`t enough to rely only on this criterion for the classification of high-tech industries. High R&D expenses don`t guarantee to launch a new product or technology on the market. Moreover, an additional approach may be used for measuring the knowledge-intensiveness of companies that are similar to R&D maturity. For example, Bazhanov [19] states that the share of the costs of science in the overall structure of the costs of production shows the level of knowledge-intensiveness of the company. This formula (1) is presented below.

$$S=C_{science}/C \quad (1)$$

where $C_{science}$ – costs of science, C – overall costs of production.

This formula helps to calculate the knowledge-intensiveness of the company. The most common thesis is that a company can be considered high-tech if the share of costs for the science/knowledge intensiveness is more than 4.5% [19]. Nevertheless, as discussed above, the company may spend more on R&D, but doesn't produce high-tech products. Thus, most authors see the share of R&D expenditures as the main criterion for high technology, but some of them add the importance of personnel directly involved in R&D [20-21]. They state that the important resource for creating the high-tech product is research staff, precisely, STEM specialties.

Human capital plays a vital role in the high-tech industry, a carrier of knowledge, without which investments in research and development will be useless [21]. However, there are no tools for measuring the quality of staff engaged in the entire industry according to the STEM approach.

Further, Abrashkin [22] argues that the knowledge-intensiveness of company may be identified by the quality of personnel engaged in R&D on the base of the next formula (2).

$$P_{k-i}=N_{R\&D}/N_{total} \quad (2)$$

where $N_{R\&D}$ – number of personnel involved in R&D, N_{total} – total number of personal.

According to this approach, personnel involved in R&D consists of staff with an academic degree and engineers. A high number of them show a high level of knowledge-intensiveness in the company.

To sum up, it is difficult to use these approaches for identifying that is company/industry high-tech or no. Because there is no complicated data about the R&D expenditure of domestic companies and industries.

The study found a little number of companies that share this kind of information about their staff quality. Moreover, the study assumes that it`s not enough to measure the technological development of a company or industry relying only on staff quality.

The next interesting finding from the literature analysis is an additional approach to identifying high-tech companies. It is known that the Tobin coefficient is used among the experimental factors suitable for evaluating a business. This ratio was developed in 1969 by the American economist James Tobin. The coefficient is defined as the ratio of the company's market price to the replacement price of its tangible assets [23].

The gap between these indicators is explained by the presence of intangible assets that increase its market value and capitalization. For such enterprises of the "traditional", "material" sectors of the industry as mechanical engineering, oil production and oil refining, metallurgy, etc., the Tobin coefficient, as a rule, does not exceed unity ($q<1$) [23, p. 149]. For high-tech companies, where the focus is on the production of innovative products, the value of this coefficient can significantly exceed unity (q>1).

This coefficient may be used for measuring and classifying high-tech companies. It`s explained by the increasing market value of the company. The formula for evaluating Tobin`s coefficient (q) is presented below in formula (3).

$$q = P / C \quad (3)$$

where P is the market value of the assets of the company (capitalization), C is the replacement cost of the company's assets, equal to the sum of expenses necessary to acquire all the company's assets at current prices, precisely, book value.

If the Tobin Ratio q>1, then the market value exceeds the book value of the company's assets. This means that market value reflects some of the company's immeasurable or non-recordable assets. On the other hand, if q<1, then the market value of the company's assets is less than their book value. This means that the organization is a high-tech company.

Hence, we can formulate a new approach to the concept of "high-tech company". High-tech companies are determined on the basis of a quantitative assessment of the ratio of the market price of the company to the replacement price of its intangible assets, where the emphasis is on the production of innovative products (know-how, patents, inventions and the like), due to which the value of the Tobin coefficient significantly exceeds unity.

For example, calculations of Tobin coefficients for domestic companies are depicted in table 4.

Table 4 – Calculation of Tobin's q for high-tech companies of the Republic of Kazakhstan for 2019

№	Company	Area	Market value (capitalization)	Book value (actives)	Tobin coefficient (q)
1	Kazakhtelecom	IT and communications	2 855 423 800	1 061 918 453,00	2,68
2	KEGOC	Energy	413 933390	773 572 573	0,54
3	Logycom	IT	42 775 337	34 994 994,00	1,2
4	Kazatomprom	Nuclear production	1 391 909,86	1 683 412,00	0,83
Note – Compiled by author based on own calculation and [24]					

As table 4 shows, the market value of Kazakhtelecom for 2019 more than 2 billion, book value is about 1 billion tenge and Tobin's q is 2,68. Thus, it means that this company is high-tech oriented due to Tobin's coefficient more than 1. But this coefficient less than 1 for KEGOG and Kazatomprom, despite their orientation on energy and nuclear industries, that well-known as high technological. Moreover, there is difficulty related to the absence of available data regarding variables of Tobin`s q.

To sum up, the study had faced difficulties when choosing the approach to identifying the research sample. Considered approaches for measuring and evaluating high-tech companies and industries help to reveal available and suitable one for choosing high-tech projects. It bases on the classifications of high-tech industries, according to the US National Science Foundation, OECD, and UN approach. Because a national classifier of industries of the Republic of Kazakhstan doesn`t include high-tech industry at all [25].

Therefore, after analysis of different approaches, the study suggests the next new classification of high-tech projects (table 5).

Table 5 – Suggested classification of high-tech projects

№	Project type	Description / Definition
1	Biotechnology projects	Projects in the field of science that studies living organisms (and their metabolic products), which can be used in conjunction with the latest technological developments for the benefit of society.
2	Nanotechnology projects	Known by using methods for the production and use of products with a given atomic structure by the controlled manipulation of individual atoms and molecules.
3	Chemical technology projects	Implemented by using the most economical and environmentally sound methods for the chemical processing of raw natural materials into consumer goods and means of production.
4	Engineering projects	Project implemented in the field of human intellectual activity, the task of which is to apply the achievements of science, technology, use the laws of physics and natural resources to solve specific problems, goals and tasks of mankind.
5	Software projects	Aimed to develop effective software systems for different industries.
6	Green energy projects	The main direction of these projects is the search and use of alternative (non-traditional) energy sources. They are implemented in the sphere of producing alternative energy by using sun, wind and other natural sources of energy.
7	Nuclear projects	Projects aimed at the production of electric and thermal energy by converting nuclear energy.
8	Communications projects	Projects that implemented in sphere of communication technology and aimed to upgrade this sphere.
9	R&D projects	Research and development (R&D) projects aimed to increase the base of knowledge and new applications of existed knowledge.
Note – Compiled by author on the base of [26-32].		

As depicted in table 5, high-tech projects were divided into 9 groups according to the implemented area. All listed projects have general features. They are science-intensive, high risky, aimed to improve living standards, require using cutting-edge technologies and high financial investment. Moreover, such projects often implemented by narrowly specialized professionals with deep knowledge due to difficulty in managing.

Conducted above comprehensive analysis helps to develop own definition. The study has mentioned the absence of an accepted definition for high-tech projects. The literature reveals a single definition of high-tech projects given by Denisov [33]. He assumes that a high-tech project is a project related to high technology and aimed at achieving a specific goal (including the development of a high-tech product). This definition has a quite narrow meaning which mostly concentrated on the product approach. Moreover, it doesn`t show the entire essence of the high-tech project concept.

For understanding what a high-tech project is, we first should understand what a project is. It`s well-known that the project explained in PMBOK Guide as a temporary enterprise designed to create unique products, services or results [34]. Thus, listed above discussion let to highlight the next characteristic features of high-tech projects novelty;

– strong scientific and technical basis;
– creation of advanced, revolutionary products;
– replacement of old technologies;
– quite long and expensive processes;
– creating or revolutionizing demand;
– high requirements for human resources;
– knowledge intensiveness;
– high level of risks and uncertainty.

These characteristics are enough to develop a definition of high-tech project. In addition, table 5 presents the definitions of different types of high-tech projects. The study compares them and extracts the general features of these projects. High-tech projects are often referred to as leading-edge projects. Both are the same. Thus, listed above analysis of high-technology, high-tech industry and classification of high-tech projects helps to develop own **definition of the high-tech project** that states: "a high-tech project - is a high knowledge-intensive and high risky project aimed to create advanced product, service or result, constrained by time and cost, and implemented at both traditional and high-tech industry by using cutting-edge technologies". This definition implies the implementation of high-tech projects in any industry, regardless of its technological development. For example, a new technological software project may be implemented in service industry or during the educational process.

Moreover, the definition was developed based on the most listed general features of high-tech projects like high risk and uncertainty level, knowledge intensiveness, the existence of cutting-edge technologies. By the way, the uncertainty of the market for high-tech sectors of the economy distinguishes it from the markets of other industries with the launch of innovative products on the market when the reaction of potential users is still unknown. However, the closer the development of new innovative technology, a new product to the real needs of the market, the corresponding risk becomes less [3, p. 252].

The next challenge of this paragraph is defining how to manage high-tech projects. Project management is known as one of the critical factors for project success. According to the International Project Management Association (IPMA), the use of modern methodology and project management tools can usually save about 20-30% of the time and about 15-20% of the money spent on projects and programs [34, p. 57].

According to Beckman and Sinha [35], high-tech companies often face challenges when managing high-tech projects due to their complexity.

Many quite promising projects show significant results, but then in conditions of increasingly uncertain prospects, they close. Even the most successful high-tech projects may fail at any time of their life cycle. There is a risk of the appearance of competitors with more advanced technologies.

Managing high-tech projects is a difficult professional task of management. The content of managing high-tech projects are significantly different at different stages of its creation and implementation [3, p. 248].

Literature reveals several methodologies for managing projects. There is inconsistent information in the literature. Some methodologies are positioned like standards or methods and contrariwise. The next table shows the basic PM methodologies (table 6).

Table 6 – Basic PM methodologies

№	Methodology	Description
1	PMI Methodology	It is based on the concept of project management through a group of standard processes .
2	TenStep Project Management	This methodology provides a flexible approach that allows to rationally implement the best project management practices outlined in the PMBOK Guide. Its ideology of rationality implies the use of only those practices that will bring additional benefits to the project. "Small project has a small and simple methodology, large project has a large and complex methodology."
3	Waterfall methodology	Each stage corresponding to the stage of the project life cycle continues the previous one. In order to move to a new stage, we must complete the current one.
4	Agile	Agile is a flexible approach to development, including various methodologies (Scrum, Kanban, XP, Lean and others). It combines several approaches designed to minimize all sorts of risks with a set of principles.
5	Six Sigma	It is the best way for improving quality / reducing waste by helping organizations produce products and services better, faster, and cheaper.
Note – Compiled by author based on [34, 36-39]		

As depicted in table 6, there are basic methodologies that help to properly manage projects. All methodologies have their advantages and disadvantages if compared to different project characteristics. There is no silver bullet for using the project management approach and project management methodology for specific project. Approach selection should be handled with care, considering both project characteristics and characteristics of the organizational environment [40].

The traditional approach (classic PM) is more appropriate for projects with a very low level of uncertainty not for high-tech projects. The most used one is the PMI Methodology accepted by the Project management institute. Many scholars state that it is one of the suitable methodologies for managing high-tech projects for its detailed structure, that cover risk, and quality management. On the other hand, the agile methodology is devoted to research projects or new innovative product development projects [41]. Other methodologies are not often mentioned in connection with high-tech projects. Thus, the study extracts two methodologies as suitable for managing high-tech projects that rely on literature analysis: PMI and Agile. It is worth noting that PMI methodology bases on PMBOK Guide.

To sum up, the absence of an accepted definition of high-tech project and fragmentation of classifications make it difficult to choose a sample of projects for the research in this area. Literature analysis helps to develop a complicated definition for a high-tech project and to suggest another view of high-tech project classification. An additional approach based on the calculation of Tobin`s coefficient helps to reveal the method for measuring the level of technological development of companies. Moreover, measurement of the knowledge-intensiveness of the company was considered as a possible indicator for identifying high-tech companies.

Finally, revealed classification allows us to split projects according to industry. Thus, the study suggests 9 kinds of high-tech projects. Moreover, the comparison of existed methodologies of PM helps to derive the appropriate tools for managing high-tech project success. PM standards are often mentioned as the most appropriate guides for high-tech project management.

1.2 Methodological approaches for evaluating high-tech project success

The age of information technology is pushing society toward ever-increasing competition and the speed of launching products on the market to stay ahead of the competition. Thus, market “players” try to come up with different success formulas.

Every project manager aims to achieve success when executing a project. Project success is probably the most frequently discussed topic in the field of project management.

Project success might seem like an obvious determination to make; however, success remains the focus of significant debate [42].

At present, there is no single universally accepted point of view regarding the determination of factors and criteria, on the basis of which the measure of success of a project is determined.

This paragraph discusses the vast approaches of measuring project success and factors that contribute to high-tech project success, and developers appropriate one for measuring high-tech project success.

Measuring project success is not straightforward [43].

According to the most common approach, project success is determined by components that form the “iron” triangle of project management. This “Iron” triangle is shown in figure 1.

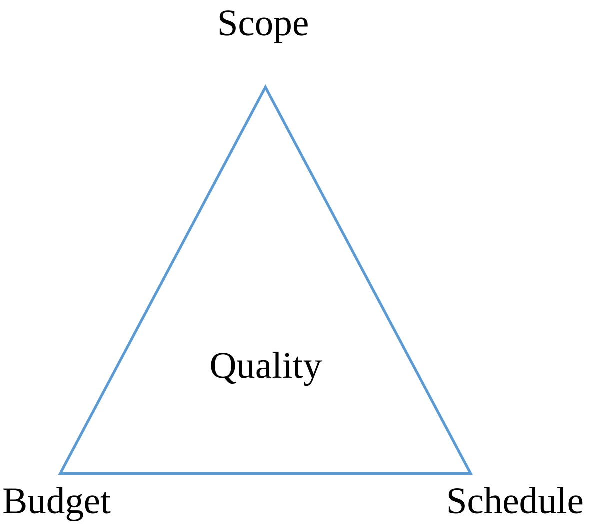

Figure 1 - “Iron” triangle of PM

Note - Compiled by author based on [44]

As depicted in figure 1, three constraints in triangle corners like scope, schedule, and budget determine the quality of the project.

Rosenau [45] goes so far as to identify these three criteria as the triple constraint. Because a change in the value of one parameter will certainly lead to an imbalance in the triangle. But the most interesting fact that this triangle doesn`t always work. Because as literature reveals, some projects may exceed budget and schedule but can be considered successful, and vice versa, a project may satisfy all requirements of the “iron” triangle and fail despite good results [46].

Moreover, as suggested by many authors, project success should be considered wider than the traditional “iron triangle” of the project. For example, Shenhar and Dvir [47] measure success by taking into account the benefit of the organization, not just meeting the “iron triangle”. They state that “there are many cases where projects are executed as planned, on time, on budget and achieve the planned performance goals, but turn out to be complete failures because they failed to produce actual benefits to the customer or adequate revenue and profit for the performing organization” [48].

The authors also found that “all four success-measures (meeting planning goals, end-user benefits, contractor benefits, and overall project success) are highly inter-correlated, implying that projects perceived to be successful are successful for all their stakeholders”.

Fifth Edition of a Guide to the Project Management Body of Knowledge (PMBOK Guide) expands the triple constraint and adds the components like scope, quality, schedule, cost, stakeholder interests, risks and resources that may impact project success [49].

The literature reveals that project success is measured differently in different methodologies. The next table (table 7) shows the existed interpretations of project success.

Table 7 – Project success determination by different methodologies and standards

№	Methodology	Viewpoint
1	PMBOK	The project is successful if it is completed according to the approved criteria: volume, time, quality, and with the satisfaction of a customer.
2	Scrum	The project is successful if the customer is satisfied.
3	Program management	Focused on long-term interaction with the Customer and not on a single project / contract.
4	PRINCE2	The project is successful with a balance in at least three categories - business, user orientation and technological maturity.
Note – Compiled by author based on [34, p. 60; 50]		

As depicted in table 7, project success can be evaluated in various ways. If we consider the interpretation of each methodology in detail, PMBOK, focused on a contract with the strict fixing of requirements and minimizing changes during the project, believes that "the project is successful if it is completed according to the approved criteria: volume, time, quality".

Thus, the project is successful if the contract between the Customer and the Contractor is completed and closed. Moreover, the success assessment is the same for both the customer and the contractor.

Furthermore, a flexible Scrum methodology focused on customer satisfaction with flexible requirements management believes that a satisfied customer is key to the success of a project.

Program management focuses on long-term interaction with the customer, on the continued cooperation of the contractor with the customer in subsequent projects and other interactions.

According to PRINCE2: the emphasis is placed on the financial success of the project, user satisfaction and technology development. Success ratings can vary from the point of view of the business, user, and contractor. Such assessment techniques are more often used for internal projects when the customer and the contractor are in the same organization.

Another interesting finding of literature analysis related to the importance of project type in measuring project success. Müller and Jugdev [51] found that projects vary according to their definition and measurement of success. They supported the idea that there is no single universal and unique theory that can explain every project's success. The success depends on the organization, its management, and the nationalities and culture involved in it. In addition, Meredith and Zwikael [52] claim that it is difficult to apply project success measures to all project types, and project success may change over time.

Shenhar and Dvir [47, p. 16] develop a success model that includes five components. It`s one of the well-known approaches determined by scientists as “the most important line of research” in determining project success. They established success on five criteria, mainly project efficiency, impact on the team, impact on the customer, business and direct success, and preparation for the future. Their model is depicted on the next table presented below (table 8).

Table 8 – The five dimensions of project success by Shenhar and Dvir

Success dimensions	Measures
Project efficiency	Meeting schedule goal Meeting budget goal
Team satisfaction	Team morale Skill development Team member growth Team member retention
Impact on the customer	Meeting functional performance Meeting technical specifications Fulfilling customer’s needs Solving a customer’s problem The customer is using the product Customer satisfaction
Business success	Commercial success Creating a large market share
Preparing for the future	Creating a new market Creating a new product line Developing a new service Developing a new technology
Note - Compiled on the base of [49, p. 32]	

According to table 8, project success measures are integrated into five groups. Project efficiency is the most measurable dimension because it has precise criteria like schedule and budget. Both of them are expressed by qualitative indicators. Also, team satisfaction and business success may be measured more precisely by using specific technics. This is a moot point that team satisfaction directly affects project success. This statement one of the least mentioned ones in the literature. Finally, preparing for the future may be prospected [53]. Moreover, this approach of identifying success is complex and it requires measurement of so many factors. The recent project managers modify this approach and delete the team satisfaction dimension. They assume that team satisfaction doesn`t affect project success due to nonsignificant influence. According to new model, these dimensions are hierarchical and will be addressed differently for different projects and different time frames as depicted in figure (figure 2) below.

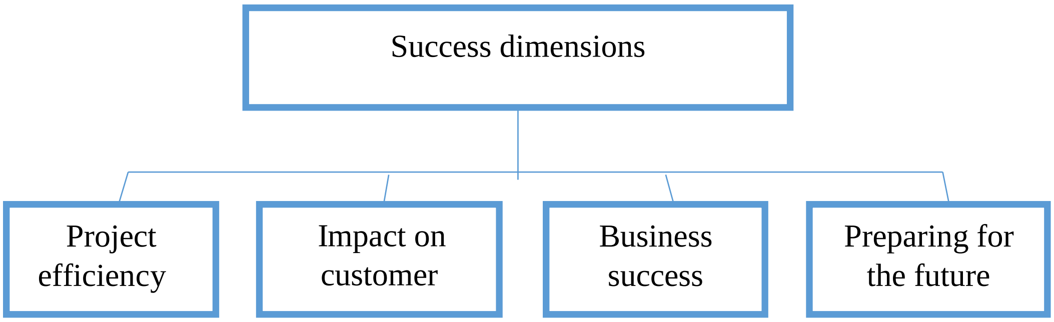

Figure 2 – The Four Dimensions of Project Success by Samset

Note - Compiled by author based on [54]

According to figure 2, there are 4 success dimensions. Their meanings may be explained as the next:

1. Project efficiency measured by time and budget. Success isn`t considered as the contributor to the long-term benefit of the organization. Some organizations may use additional measures. For example, the efficiency of safety measures, purchase orders, reliability, etc. can be considered as additional measures. However, do not necessarily mean total success, they relate only to the successful implementation of project execution.

2. Impact on the Customer. This dimension focuses on the customer or end-user. This dimension addresses the importance organizations should place on customer requirements and real wants and needs.

3. Business Success. This dimension concentrates on the benefit of the organization. The main components in this regard are sales, income, profit, market share.

4. Preparing for the Future. This component aims to build organizational and technological infrastructure for the future. This dimension explores the readiness of the company for new opportunities and innovations in the future. In addition, Samset determined the main criteria for a project’s success. He ascertained that success is contingent on the realization of five important outcomes depicted in figure 3.

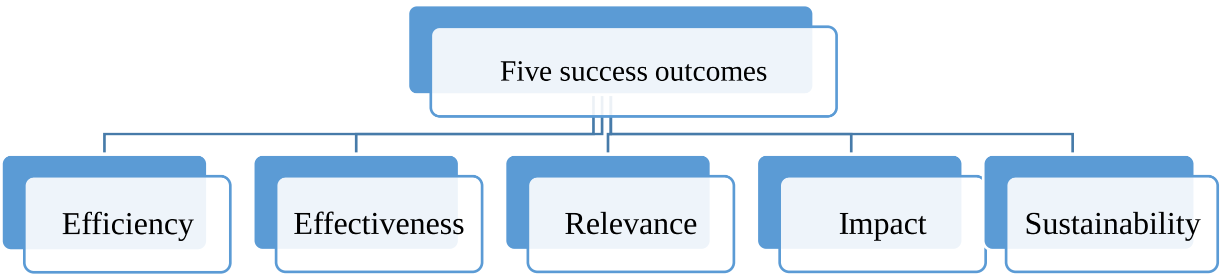

Figure 3 – Project success components by Samset

Note - Compiled by author based on [54, p. 44]

According to Samset, project success contains efficiency; effectiveness; relevance; impact; and sustainability. These findings have inspired organizations to look for better ways to produce a project's outputs, manage projects, fit the project to the organization and its environment, and ensure long-term success. But there is no clear explanation of ways of measuring these dimensions.

One of the interesting points of view regarding project success suggested by Munns and Bjeirmi [55]. They note that a project can be successful despite poor project management performance. According to them, using PM tools is not always necessary for achieving project success.

Thus, as it becomes clear from the previous discussion, projects are often considered as successful if they complete according to budget and schedule, and technical goals. These internal measures of efficiency (staying on budget, on schedule, and meeting technical goals) are partial and sometimes misleading. They disregard incidents where a project was run efficiently but eventually did not meet customer or organizational expectations.

These reasons motivated several researchers to add a new element to the notion of project success: the satisfaction and welfare of the customer [56]. A study performed by Baker [57] confirmed the previous findings and identified customer satisfaction as a dimension of project success.

Zwikael and Globerson [58] state that project success should be measured by project efficiency and project effectiveness. The efficiency was measured by time and cost overruns, and project effectiveness was identified as the second component of project success and included project performance and customer satisfaction.

Most of the scholars link project efficiency with project success. The two concepts of efficiency and effectiveness are applied within PM literature but they are rarely defined and they are usually applied in an unclear manner. Literature reveals that project efficiency is measured in a variety of ways.

The study choses the methodology of evaluating project success based on the method of Zwikael and Globerson [59]. According to them, project efficiency ads schedule and cost management, project effectiveness includes two dimensions as customer satisfaction and meeting project goals (figure 4).

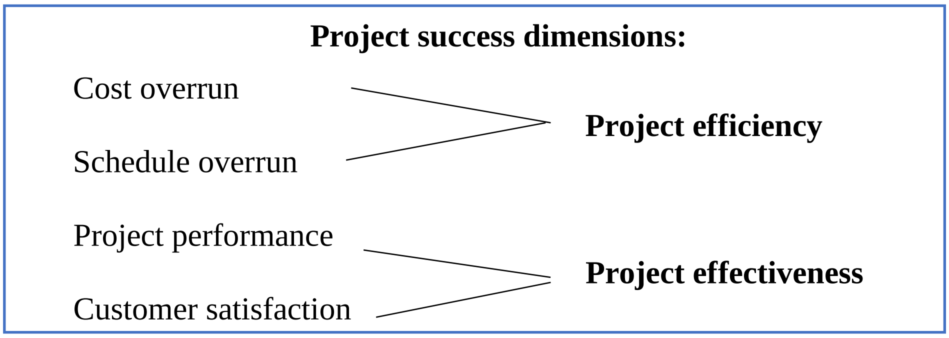

Figure 4 – Project success dimensions by Zwikael and Globerson

Note - Compiled by author based on [59, p. 670]

According to figure 4, project efficiency and project effectiveness contribute to project success in different areas. There are many researchers who conducted different researches in order to find out various critical success factors for project success. For example, Shenhar et al. [42, p. 7] distinguish three traditional dimensions of project efficiency – time, budget, and scope. They assume that scope is the most important factor due to its impact on the satisfaction of the customer. Thus, the literature analysis identifies that the success of the project itself is often measured by project efficiency. The study assumes that one of the required components of project success is project efficiency measured by time and cost.

Another interesting finding from recent studies dedicated to exploring project success on the viewpoints of several parts. Meredith and Zwikael [52, p. 3] suggest a comprehensive approach. They identify the different (often even contradictory) perspectives of success from various project stakeholders and state that evaluation models should be more comprehensive to represent differences in objectives. They develop a model of distinct but related success dimensions that distinguishes between the achievement of the goals of the project's leaders and the realization of net value for the funder who approved the project. Suggested by them triple-test of project success evaluation dimensions is depicted in table 9.

Table 9 – Triple-test project evaluation dimensions

Project evaluation dimensions	Who/What is evaluated	Who is evaluating	Key performance criterion
Project management success	The project manager	The project owner	Achieving the project plan
Project ownership success (POS)	The project owner	The project funder	Realizing the project plan
Project investment success (PIS)	The project`s overall success	The project funder	The project was a worthwhile investment for its funder
Note – Compiled by author based on [52, p. 3]			

Thus, project management success achieved when project has completed on time, within budget and within the agreed scope. Project ownership success achieved when the project has realized all target benefits, without undesirable benefits. The project investment success achieved when the project was an investment success.

Further Zwikael and Globerson faced with the absence of specific planning assessment tools. They created a measurement tool for analyzing planning processes called Project Management Planning Quality (PMPQ) model after conducting deep research [61]. PMPQ model helps to evaluate projects in different industries. The model is valid and reliable for measuring the impact of planning and organizational support on project success. The model was checked by several statistical tests as Cronbach`s alpha (0.91 and 0.93) and t-test. Furthermore, this model used by other scholars [62-63].

The original model is shown in figure 5.

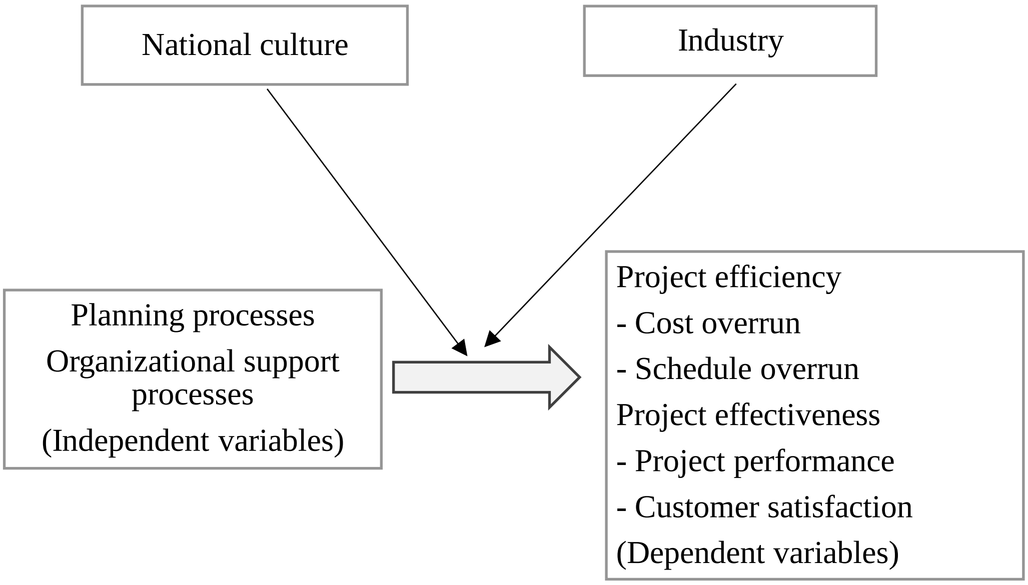

Figure 5 – Model for project success measurement by Zwikael

Note - Compiled by author based on [58, p. 1548]

As can be seen in figure 5, independent variables of the model are 16 planning processes and 17 organizational support processes influence on dependent variables that include 4 dimensions such as cost overrun, schedule overrun, project performance and customer satisfaction. In addition, there are two moderating variables as country and industry. PMPQ index shows the average extent of the use of 16 planning processes for each project.

Research model. The study uses the next model for the research, depicted in figure 6.

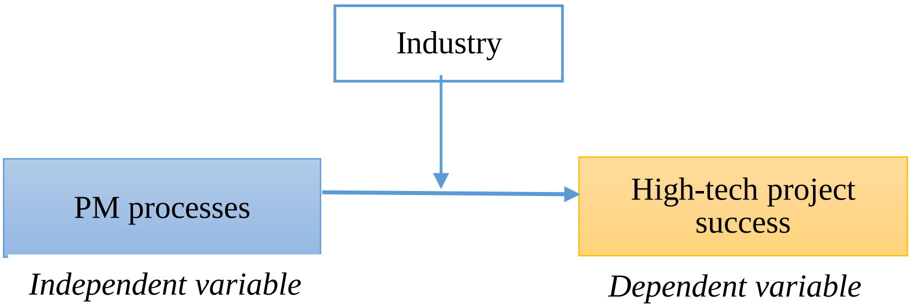

Figure 6 – Research model

Note – Compiled by author based on own research

As can be seen in figure 6, simply, the research model includes independent variables in the form of 16 planning processes from 10 knowledge areas and dependent variables in the form of time, cost overrun and customer satisfaction.

The study measures this impact through the use of intensity of PM planning processes that exist in each PM knowledge area. For example, project integration management is carried out by performing particular planning processes. This connection is depicted in figure 7.

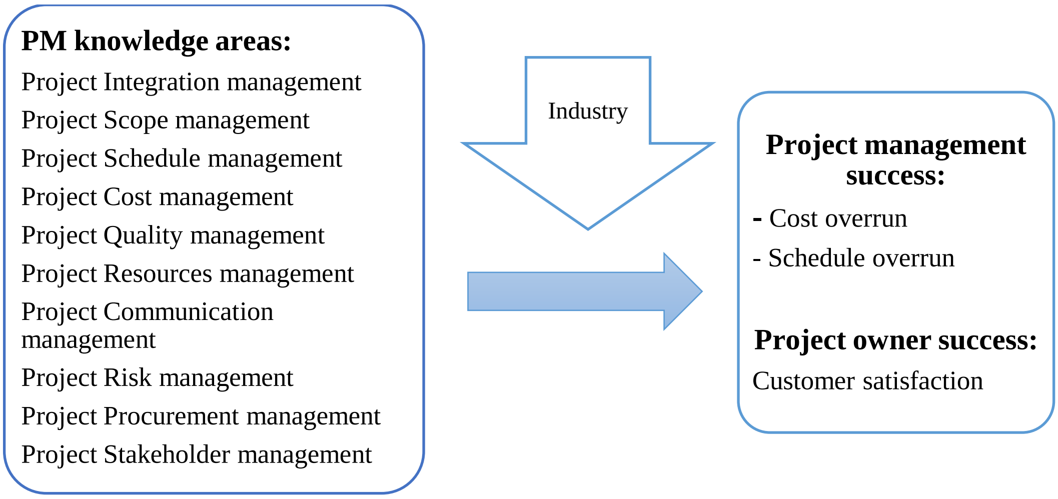

Figure 7 – Research design

Note – Compiled by author based on own research

The model is designed for the investigation of the relation between PM knowledge areas and high-tech project success. There are two variables where PM knowledge areas in the form of planning processes are independent variables and project success is the dependent variable. Thus, the model measures which PM knowledge areas have a higher impact on high-tech project efficiency. According to this research design, the study identifies PMPQ index of each planning process which expressed by its average use intensity and evaluates the impact of these processes on success dimensions. Planning processes had an average correlation with a cost overrun and schedule overrun (r>0.6) and a very high correlation with customer satisfaction and project performance (r>0.8). National culture and industry act as moderators between independent and dependent variables, because they may affect both variables.

An average use intensity of planning processes presented by PMPQ index. The authors found that PMPQ index highly correlates with project management success dimensions that are measured by cost and schedule overrun. Table 10 presents the planning processes that constitute knowledge areas.

Table 10 – The linkage between PM knowledge areas and planning processes

№	PM Knowledge areas	Planning processes
1	2	3
1	Project Integration management	Develop project management plan
2	Project Scope management	Scope planning Collect requirements Define scope Create work breakdown structure (WBS)

Continuation of table 10

1	2	3
3	Project Schedule management	Plan schedule management Define activities Sequence activities Estimate activity resources Estimate activity durations Develop schedule
4	Project Cost management	Plan cost management Estimate costs Determine budget
5	Project Quality management	Plan quality management
6	Project Human Resources management	Plan human resource management
7	Project Communication management	Communications management planning
8	Project Risk management	Risk management planning Identify risks Perform qualitative risk analysis Perform quantitative risk analysis Plan risk responses
9	Project Procurement management	Procurement management planning
10	Project Stakeholder management	Plan stakeholder management
	Note - Source [34, p. 124]	

The study covers 16 of these planning processes depicted in table 10. Questions about their use intensity were added to the research questionnaire attached in Appendix D.

The next design of dependent variables is chosen for measuring project success (figure 8).

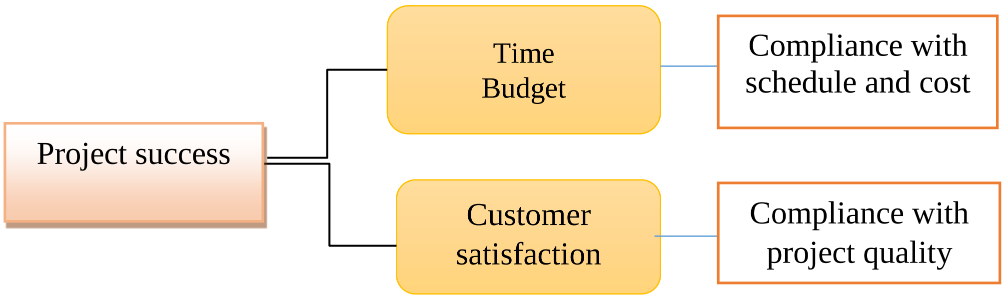

Figure 8 – Project success dimensions

Note – Compiled by author based on own research

As depicted in figure 8, the study takes into account project management success and project owner success. Because they understand and accept project success differently. Generally, the success dimensions that contribute to project success are time, cost and customer satisfaction.

The reliability of the model was checked by using the Cronbach alpha test. The Cronbach alpha coefficient is a number that ranges from 0 to 1; a value of 1 indicates that the measure has perfect reliability, whereas a value of 0 indicates that the measure is not reliable and variations are due to random error [64]. In general, an alpha value of 0.9 is required for practical decision-making situations, whereas a value of 0.7 is considered to be sufficient for research purposes [65].

The formula (2) for calculating Cronbach`s alpha is depicted below.

$$\alpha = \frac{N * \overline{r}}{1 + (N - \overline{r}) * \overline{r}} \tag{4}$$

Where, N – number of questions, $\overline{r}$ – correlation score of investigated variables.

According to calculations made in Excel, N - 16, $\overline{r} - 0{,}4$ for project manager`s success dimensions like time and scope. Thus, $\alpha = 0{,}9$. Both measures showed a high Cronbach alpha score (0,9), which means that they are correlated. The results of the Cronbach's alpha testing let us assume that the items chosen for measuring project success were valid and reliable for this study (table 11).

Table 11 – Validity test for the data

№	Efficiency measure	R	p-value	Meaning
1	Cost overrun	0.51	<0.001	Average correlation, high significance
2	Schedule overrun	0.57	<0.001	Average correlation, high significance
3	Customer satisfaction	0.89	0.001=	High correlation, high significance
	Note – Compiled by author based on own calculation			

As depicted in table 11, correlation between variables are high and results are significant. This fact proves the assumption that all variables are interrelated [66]. Moreover, the study found that all results are significant with *p*-values under 0,001. The datasheet calculated in Excel attached in Appendix F.

Furthermore, literature analysis helps to reveal the next factors influencing project success:

- Quality of planning (the more qualified and deliberated project planning is applied, the easier it is to forecast risks and choose proper risk management strategy) [67];
- Quality of operational management (how effectively the resources are managed when they are immediately in utilization or operation);
- Technologies used in the working processes (the better the technology used, the more economical their rate of success is);

– External factors that are hard to forecast (disasters, emergent leaves of key staff members, the bankruptcy of stakeholders).

To sum up, the analysis helps to choose the most appropriate methodological approach for evaluating high-tech project success. The term “Project success” one of the discussed and relevant topics in PM nowadays. The basic PM practice measures it by the “Iron triangle” that includes time, budget and scope. The analysis conducted in this paragraph proposes the research model that expands the meaning of the project success. According to the suggested new approach, project success may be perceived by the viewpoint of the project manager and the project owner. The project manager accepts success by evaluating project efficiency dimensions like time and cost overrun. The project owner focuses on customer satisfaction levels. Independent variables of the research model are PM processes and dependent variables are project success dimensions like cost overrun, schedule overrun ad customer satisfaction. Thus, the success indicators of project management should correspond to the following parameters: Co <15%; So <15%. In turn, the level of customer satisfaction reflects the success of the customer of the project and is evaluated on a Likert scale from 1 to 10, where the highest result shows a high level of success of a high-tech project.

1.3 Overview of international project management standards: global trends

The world market with full confidence can be called dynamically developing and focused on the use of high technologies. The struggle between market players increasingly occurs as a struggle for their projects. Producers from different industries launch high-tech projects and manage them in a different manner for achieving success. There is a lack of practical and methodological recommendations about how to manage high-tech projects [68]. But its well known that they are managed by using international standards of PM.

This paragraph presents the global trends in the high-tech industry and project management; discusses existed standards of PM; compares the practice of using PMBOK standard in technological leading countries.

The study reveals the next global trends in high-tech project management:

1. The rapid development of new technologies. The vast amount of innovative technologies that are created every day increases the amount of high-tech projects all over the world.

2. Consolidation of high-tech projects. One of the pronounced modern trends in the management of the competitiveness of high-tech projects is the implementation of large projects that provide a wide selection of various goods and services. This phenomenon may be linked with existed growth of multicultural projects.

3. The trend of today's effective project management is the ability to work in changing conditions and accumulate the results of these changes. At the same time, this circumstance opens up a new problem - it is very difficult to find those people who have the experience of quality work in changing conditions. Knowledge and trends are becoming more flexible. Trends are changing rapidly. Therefore, project managers have to accumulate new experience in the process of working on projects. A high level

of adaptability is becoming an integral part of the professional portrait of the project manager.

4. In modern companies, the structure and model of relationships in teams are changing. In addition, the company-client relationship is no longer what it used to be. Now customers are turning into full partners. One of the tasks of project management at present is the detailed development of those ways of encouraging an active loyal audience that will create positive reviews about the brand. This will encourage customers to share reviews and opinions. In fact, you will get an audience that will partly take on the role of your PR manager.

5. Increase of qualitative human resources qualified in PM. There are 932,720 active PMP certified individuals worldwide for August 2019 [69].

6. Increase in quantity of different tools and technics of managing projects due to the development of national and international standards in this area.

7. Project virtualization that expressed by the development of virtual technology and the value of the virtual component of the project. People engaged in project implementation may connect with each other through using tools of the Internet and multimedia technologies. For example, they can interact with online platforms or devices.

Project managers have to take into account these trends when running high-tech projects for achieving success.

The literature reveals the next global trends in the high-tech industry:

The high-tech sector is characterized by constant movement, the pace of which is growing as the development of scientific and technological progress accelerates. Statistics don`t keep pace with the rapid development of high-tech industries. New products, new classifications, and international standards are developed at a breakneck pace. This makes it difficult to conduct an objective and relevant analysis of the high-tech products market. However, the Science and engineering report (2018) states that the Global value-added of high-technology manufacturing was $1.8 trillion in 2018, making up 16% of total manufacturing output. The high-technology manufacturing industries account for a 5% share of world GDP [70].

2. The global trends in the market of high-tech goods and services include an increase in the share of ICT services and software. It supports a strong growth in the international market which is demonstrated by sales of communications and consumer electronics. The three ICT manufacturing industries like semiconductors, computers, and communications highly globalized. They involve complex value chains in the production process.

ICT industries made up a collective $0.8 trillion in global value [70, p. 354]. It is worth noting the rapid development of communication channels, the Internet, communication technologies and devices, which causes accelerated obsolescence of equipment and the need to constantly update it. In addition, nanotechnologies, biotechnologies, information, and communication technologies, which provide an estimated annual economic growth of up to 35% become popular nowadays [71].

The study adds the industry of alternative energy to this list due to its relevance and growing pace all over the world. For example, the share of alternative energy sources in Britain's total electricity production reached record highs of 33.4%, 40% in German, more than 40% in Portugal.

1. Developed countries of the world increase their expenses to alternative energy technologies. The application of green energy will generate up to 50% of all energy in 2050. It increases the amount and relevance of green energy projects [72].

2. The distinctive feature of the global market for high-tech goods and services is the transfer of production to countries with lower labor costs and the widespread use of outsourcing. The countries of Southeast Asia have particularly proved themselves in this, for example, the undisputed leaders in the outsourcing market - India, Bangladesh, Vietnam, and China. High-technology product exports accounted for 21% of the $13.3 trillion in total manufactured goods exports [73].

3. The main producers and exporters of high-tech products and services are industrialized countries, with the United States, EU countries and Japan taking the lead. The share of these countries is more than 60% of all high-tech products. They are also the main importers of technology and high-tech products.

The countries importers of high technology can also include the countries of Southeast Asia, in particular, South Korea and Singapore, as well as some states of Latin America, in particular Brazil. These trends identify the future activities of project owners and managers. Because it is very important to adopt for the side of new changes that occur in the current market [74].

By the way, these trends are linked with PM standards that show how to manage projects on the conditions of rapid technological growth properly. The next table (table 12) shows the basic PM standards used worldwide.

Table 12 – Basic standards of PM

№	Standard	Description
1	2	3
1	PMBOK (Project Management Body Of Knowledge)	American national project management standard. It contains the amount of professional knowledge that allows to successfully achieve goals when implementing projects in various fields of activity.
2	ISO 10006:2003 (International Standards Organization)	Guidelines for quality management in projects. The standard is a guide to quality management in projects. The Standard provides basic principles and practices of PM.
3	ISO 21500:2012 (International Standards Organization)	Guidance on project management. The standard contains general guidance on concepts and processes of project management.
4	BS 6079-1:2010	It helps professionals and organizations to ensure effective and efficient implementation of projects, as well as to establish training on projects and the process of continuous improvement of project management in the organization.
5	APMBOK (Association of Project Management Body of Knowledge)	Key component of the system «Five dimensions of professionalism». Here are the areas you need to know for successful project management. The standard provides a basis for certification, accreditation and research.

Continuation of table 12

1	2	3
6	P2M (Project and Program Management for Enterprise Innovation)	Knowledge system, presented in the form of “Guidelines for the management of innovative projects and programs of enterprises”. The main advantage of P2M over other project management schools is that there is an emphasis on developing innovation as an approach to program management and managing stakeholder expectations
7	PRINCE2 (Projects IN Controlled Environment)	A structured project management method approved by the UK government as a project management standard. The PRINCE2 methodology includes approaches to management, control and organization of projects.
8	ST KR ISO 21500-2014	Guidance on project management. The national standard includes general guidance on processes of managing different types of projects.
Note – Compiled by author on the base of [34, p. 12; 50, p. 37; 75, 76]		

As depicted in table 12, projects are run by taking into account some standards that provide their management in a proper and legal manner.

The literature highlights the next standards as the most suitable for managing high-tech projects due to their specific features: PMBOK Guide [77, 78], and P2M [79-81].

The next table (table 13) shows the national standards applied in different countries.

Table 13 - National PM standards in different countries

№	Country	PM Standard	PM orgnization	Used approach	The features
1	2	3	4	5	6
1	USA	PMBOK, NASA Project Management, APF	PMI	Process	Introduction to the body of knowledge on project management from different industries and with varying degrees of complexity
2	China	C-PMBOK,	Project Management Research Committee (PMRC), Construction Project Management Committee (CPMC)	Process	Based on PMBOK principles.

Continuation of table 13

1	2	3	4	5	6
3	Japan	P2M	Project Management Association of Japan (PMAJ), Engineering Advancement Association (ENAA)	Systemic	Considers the project in terms of creating a new value that it will bring to the customer. A project in P2M is a manager's commitment to create value as a product in accordance with the strategic goals of the company.
4	Germany	V-Modell	Deutsches Institut für Normung (DIN)	Systemic	It is rather a set of standards in the field of projects related to the development of new products.
5	UK	PRINCE2, APMBOK	The Office of Government Commerce (OGC), Association for Project Management (APM)	Process	Universal project management method; designed as a guide for practitioners, consultants, top managers in design organizations, etc.
6	Switzerland	Hermes	Federal IT Steering Unit FITSU	Systemic	Mainly applicable for project management in the field of information technology.
7	Russia	SOVNET	Project Management Association «SOVNET»	Process	National standart that focused on operational management of projects
8	Kazakhstan	ISO 21500-2014	Kazakhstan Institute of Standardization and Certification	Process	General guidelines on project management concepts and processes that are important and have a significant impact on the successful achievement of project results
	Note - Compiled by author on the base of [34, p. 14; 50, p. 25; 76]				

According to table 13, each country in this list has own national standard which consists of the set of methods and tools for managing projects. Moreover, one country may use many standards or mix them when running projects. The most popular of them is PMBOK which is used in a vast amount of countries as a guide for project management. Kazakhstan accepted its own national standard ISO 21500-2014 in 2016. This standard is based on PMBOK and has lots of similarities with it.

At this point, the study should note a large contribution to the development and widespread use of PM standards that were made by professional organizations uniting PM specialists in different countries. By 1970, professionals from developed countries of different continents had formed the next national and then international associations and organizations: International Project Management Association (INTERNET) in Europe; Project Management Institute (PMI) in North America; Australian Project Management Institute (AIPM) in Australia; Japan Engineering Development Association (ENAA) in Asia. These organizations have established close mutual contacts for the exchange of information, ideas, mutual participation in national and international forums on public relations [82].

Further discussion is dedicated to the explanation of high-tech project management by using the PMBOK Guide and P2M. Because these standards are the most cited as an appropriate tool for managing complex technological projects.

Table 14 presents the groups of processes and areas of knowledge, as well as their relationship with each other.

Table 14 – 10 Knowledge areas and 5 process groups according to PMBOK Guide

№	Knowledge areas	Process groups				
		Initiation	Planning	Executing	Monitoring and control	Closing
1	2	3	4	5	6	7
1	Integration management	Develop project charter	Develop project management plan	Direct and manage work	Monitoring and controlling project work	Close project or phase
2	Scope management		Scope planning Collect requirements Define scope Create work breakdown structure (WBS)		Control scope	
3	Schedule management		Plan schedule management Define activities Sequence activities Estimate activity resources Estimate activity durations Develop schedule		Control schedule	

Continuation of table 14

1	2	3	4	5	6	7
4	Cost management		Plan cost management Estimate costs Determine budget		Control cost	
5	Quality management		Plan quality management	Perform quality assurance	Perform quality control	
6	HR management		Plan human resource management	Acquire project team Develop project team Manage project team	Control risks	
7	Communication management		Communications management planning	Manage communications	Control procurement	
8	Risk management		Risk management planning Identify risks Perform qualitative risk analysis Perform quantitative risk analysis Plan risk responses		Control risks	
9	Procurement management		Procurement management planning	Conduct procurements	Control procurement	
10	Stakeholder management	Identify stakeholders	Plan stakeholder management	Manage stakeholder engagement	Control stakeholder engagement	Close procurement
	Note - Compiled by author based on [34, p. 43]					

As depicted in table 14, each knowledge area has own processes that should be performed by project managers for achieving project success. The use of the PMBOK Guide in the United States as a national standard was approved by the American National Standards Institute (ANSI).

The PMBOK Guide identifies and describes in detail the 47 project management processes that make up the five "process groups" and 10 "knowledge areas" for project management.

The PM knowledge areas show us how to manage projects, especially high-tech projects too. Successful high-tech project management requires a precise set of skills, knowledge, flexibility, and creative problem-solving.

Each knowledge area has specific tools and technics those will be helpful for high-tech project management.

The five PMBOK process groups outline the necessary competencies that must be achieved in order to secure the most effective use of project resources. These five essential areas or process groups are depicted in figure 9.

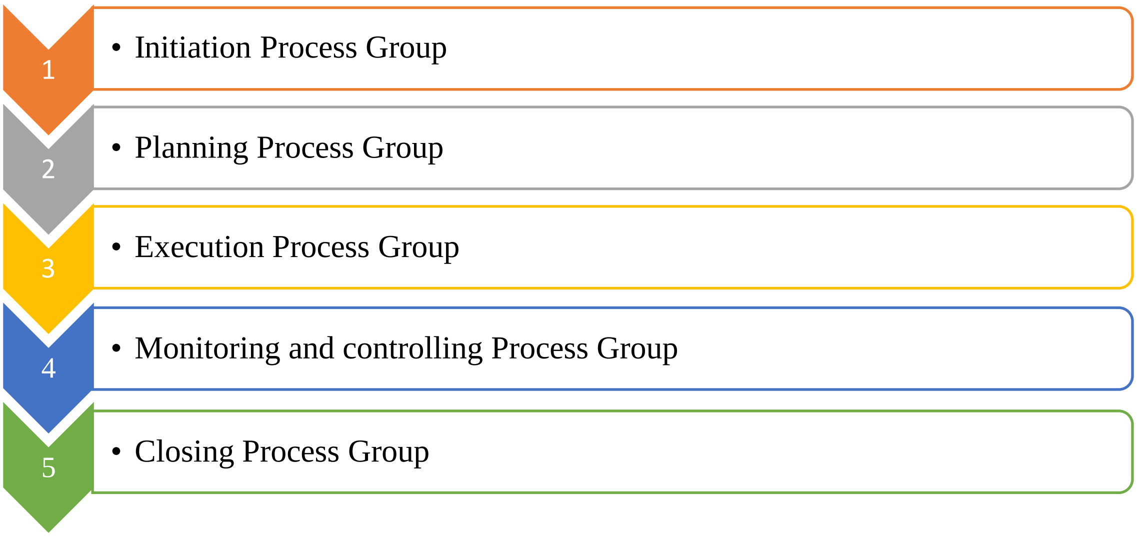

Figure 9 – 5 process groups of PMBOK

Note – Compiled by author based on [34, p. 42]

These groups of processes consist of specific processes corresponding to each knowledge area. Mentioned processes show step-by-step instructions for managing a project.

Thus, these facts let to state that Guide to the Project Management Body of Knowledge provides a best-practice approach to tackling project management challenges across the industry at all professional levels.

Further discussion dedicates to P2M standard because it is directed to innovative projects that imply high-tech projects due to novelty, high level of uncertainty and risk, technological difficulty, etc. On the other hand, high-tech projects are unique and specific by their nature and couldn`t be managed according to general methods. They require using the specific methods, accordingly, standards too.

The P2M is defined as one of the most suitable instruments for them. This standard is based on PMBOK. P2M is a Japanese approach to managing complex projects implementing innovative technologies at the enterprise level in an unstable environment. The P2M framework methodology is built on the basis of the “trilemma” - three fundamental concepts: complexity, value, and resistance, which make up the so-called “iron” triangle of contextual constraints within which innovation is carried out. The more complex the business problem, the more value its potential solution contains and the fewer people are able to understand this in order to resist the corresponding innovative idea [83].

P2M is known as a knowledge system presented in the form of “Guidelines for managing innovative projects and programs of enterprises”. The structure of the P2M methodology is shown in figure 10.

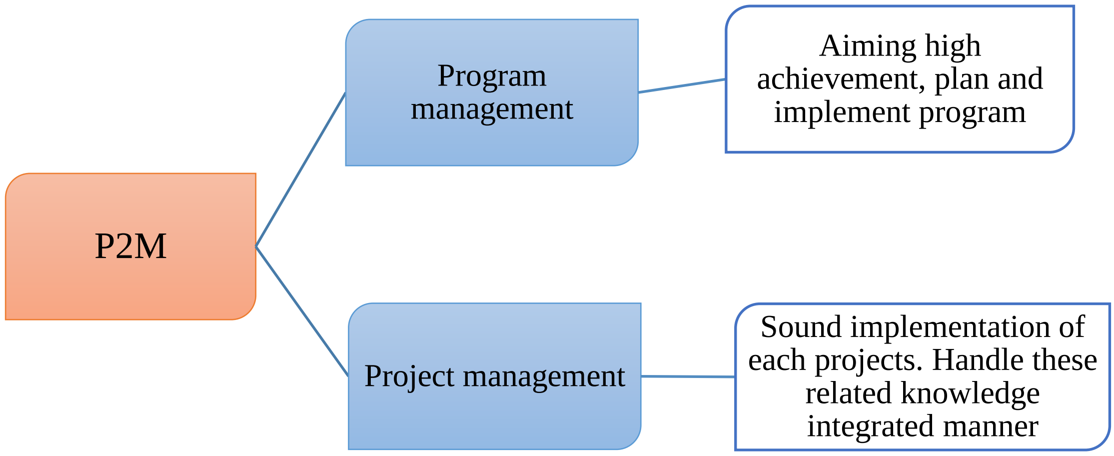

Figure 10 – The structure of P2M standard

Note – Compiled by author on the base of [84]

As figure 10 shows, the P2M standard directed to project and program management. Each part have own specifics. Further, table 15 compares the PMBOK and P2M in detail.

Table 15 – Comparing PMBOK and P2M

№	Indicator	PMBOK	P2M
1	Orientation	Objective and process oriented	Mission oriented
2	Purpose	It focuses on the process to achieve clearly expected outcome at initiation.	Improve a business value by regarding the external environment changes and opening the way for solutions to complex challenges, and improve the business value.
3	Applicable for	All types of projects	All types of projects
4	Utilization	Relatively simple	Difficult
5	Project definition	A project can be defined as a temporary endeavor undertaken to create a unique product or service	A project refers to a value creation undertaking based on a specific mission, which is completed in a given or agreed timeframe and under constraints, including resources and external circumstances
6	Constraints	Resources, time, budget, quality, schedule)	Resources and external circumstances
7	Project outcome	Unique product or service	Innovation, modification, new product or service
	Note – Compiled by author on the base of own research		

T able 15 shows the basic differences between compared standards. As it becomes clear, P2M is oriented to innovative products and achieving a mission of the company. The innovative product is often a result of high-tech projects. It increases the attractiveness of P2M for application in high-tech project management.

P2M includes the next knowledge areas: Project Strategy Management, Project Financing Management, Project Systems Management, Organizational Project Management, Project Goal Management, Project Resource Management, Project risk management, Project Information Technology Management, Project Relationship Management, Project Cost Management, Project Communications Management [80]. The main features of this methodology from PMBOK are the absence of stakeholder management and quality management areas. The both areas are very important for high-tech projects due to their complexity and high level of uncertainty. In addition, the P2M standard described as difficult to understand and apply. Therefore, the study chooses the PMBOK standard as a base for further analysis.

The existence of these standards shows that PM practices are becoming increasingly important in modern business. They are significantly diverse between countries, and project managers often lead similar projects in a completely different way [85]. Over the past 40 years, a big amount of research has shown that managers in different countries make different strategic decisions and prefer different types of organizational structures [86]. They do this under the influence of national cultural differences, which affects managers` behavior. It is important to explore these differences when projects often comprise of people and organizations from different national cultures such as multicultural teams, foreign managers, and international partners [62, p. 214]. Because literature indicates that national culture affects project success and failure [87-90].

Trompenaars [91] argued that culture was based on languages, economy, religion, policies, social institutions, class, values, status, attitudes, manners, customs, material items, aesthetics, and education, which subsequently influenced managerial values. Thus, it is no surprise that people who are different by such a long list of positions run projects in a different manners. Comparison of different cultures, especially their PM styles and project success levels helps to extract the appropriate one for our market and increase the success of local high-tech projects.

The world`s countries present different cultures, different PM styles, and project success levels accordingly. The study considers the countries with the most advanced technologies for comparing how leading countries use PM standards (table 16).

Table 16 – The share of countries in the global high-tech production for 2014-2018, in% ratio, %

№	Country	2014	2015	2016	2017	2018
1	2	3	4	5	6	7
1	USA	37,1	39.8	31.4	29.0	28.7
2	China	3.4	9.8	18.2	23.4	27.3
3	Japan	19.1	13.9	9.1	8.0	5.1
4	Germany	5.2	6,2	4,6	4,8	4,9

Continuation of table 16

1	2	3	4	5	6	7
5	Taiwan	2,7	3,9	3,8	3,9	3,8
6	UK	4,9	4,1	3,4	3,2	3,1
7	South Korea	2,9	4,2	4,4	3,4	3,1
8	Switzerland	1,5	2,0	2,4	2,4	2,4
9	Singapore	1,1	1,5	2,0	2,0	1,8
10	France	3,4	3,2	2,1	1,8	1,8
The share of 10 leading countries		81,3	81,6	81,3	81,9	82,1
51	Kazakhstan	0.0	0.1	0.1	0.1	0.1
Note - Compiled by author based on [92]						

As can be seen from table 16, the leader in the production of high-tech products is still the United States, which accounts for more than a quarter of the value-added produced by high-tech industries in the world. This data helps to choose the countries for further discussion.

Among other development trends in this segment, one should note a sharp increase in the share of China, which is rapidly catching up with the world leader and, most likely, will overtake him in the near future. More than 80% of Chinese high-tech exports account for assembly products or processing of foreign technologies made from imported components [93].

Japan takes place in the third-place (5,1%). The level of high-tech products in this country decreases constantly. It may be due to the high competition in the high-tech markets and the occurrence of new “players”. Since World War II, Japanese electronics firms have made great progress by acquiring, developing, and transferring technologies. It's pushing the technological development of Japan.

The government provides legislation that promotes the development and use of technology. And these activities encourage businesses and people to use technology. In the mid-1990s, departments of professional technical service firms of large IT companies in Japan, who were used to managing the project before in their own way, began to realize that the development of modern high-tech project management among their rivals in the United States began already in the early 1990s, and its influence was constantly growing. The Japanese government started to fund structures and organizations involved in PM. Thus, Japan exceeds other countries in high-tech project management.

It should be noted that the highest level of R&D expenses in the share of GDP in the world is achieved by Israel (4,25% in 2017) despite its absence on showed above table (table 16). Tel Aviv competes with Silicon Valley and well-known as a country that spends more on technological development [94]. It means that this country has a huge experience in high-tech project implementation.

Further, the study discusses the features of using PMBOK standard in Israel, Japan and the Republic of Kazakhstan. The study presents the cultural comparison of project performance in detail. The literature reveals the next distinctions in performing PM knowledge areas according to PMBOK standard (table 17).

Table 17 - Performing PM knowledge areas by Japan, Israel and Kazakhstan

№	Project knowledge area	Low importance	High importance	Literature source
1	Integration	Japan	Israel	[95]
2	Scope	Japan	Israel	[95], [97]
3	Time	-	Japan, Israel, Kazakhstan	[96], [97], [98]
4	Cost	Israel	Japan, Kazakhstan	[97], [95], [98]
5	Quality	Kazakhstan	Japan	[99], [99]
6	HR	-	Japan	[97]
7	Communications	-	Japan	[100]
8	Risks	Japan, Israel	No findings	[96]
9	Procurement	No specific findings	No specific findings	-
10	Stakeholders	No findings	Japan	[100]
Note - Compiled by author based on mentioned sources				

As depicted in table 17, Japan is described by literature as leading in quality and communication. Especially, Japan is well-known for its high-quality management standards and control.

Japanese managers make more use of cost estimation and communication planning processes. Further Israeli project managers were identified as good performers of integration, scope and time planning [85, P. 459].

No specific finding in the literature about Kazakh project managers except that they spend more effort on time and cost [101]. It may be due to a lack of practice in using PM.

Further literature analysis helps to identify typical PM processes for all chosen countries (table 18).

Table 18 - Maximum and minimum extent of use planning processes by Japan, Israel and Republic of Kazakhstan

№	Country	Most used planning processes	Least used planning processes
1	2	3	4
1	Japan	Cost estimating, schedule development, activity duration estimating, scope planning.	Risk management planning, communication planning, procurement planning, quality planning.
2	Israel	Activity duration estimating, activity definition, scope planning, schedule development.	Communication planning, risk management planning, quality planning.

Continuation of table 18

1	2	3	4
3	Kazakhstan	Project plan development, activity definition, scope planning, schedule development.	Communication planning, risk management planning, quality planning.
Note - Compiled by author based on source [102]			

Table 18 shows that the most used knowledge areas are time, cost and schedule management in all chosen countries, and least used areas are communication, risk and quality management. We may explain these findings through the effect of the "Golden Triangle". Precisely, the components of the "Golden triangle" like time and cost are often used and well-known by project managers all over the world. Therefore, project managers often use common processes than necessary and difficult processes like risk management and quality management during the project running. Moreover, the study reveals the positive relation between planning and project success. Although the extent of the use of planning processes does not much differ between the three countries but has a different level in use intensity of specific processes.

The next figure presents the success level of projects in Japan and Israel, investigated by Zwikael et al [85, p. 459], and compares it with Kazakhstani results (figure 11).

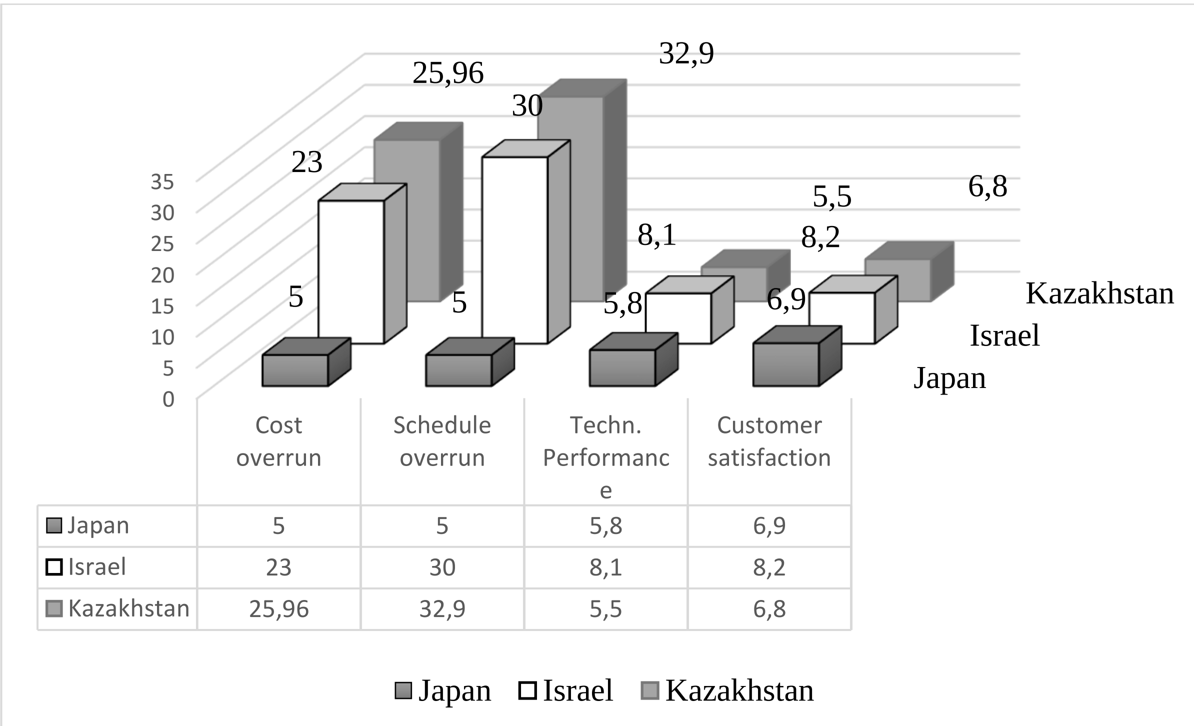

Figure 11 - Project success rate in Japan, Israel and Kazakhstan

Note - Compiled by author based on own research

Figure 11 shows that cost overrun and schedule overrun well performed by Japanese managers, but the level of technical performance and customer satisfaction are not as high as in Israel. We assume that this is features of Japanese culture – to pay significant attention to scheduling. Also, it may be result of spending more effort on cost and time planning, because the use intensity of planning processes strongly correlates with projects' success dimensions. These results also show that Kazakh projects have the worst level of the cost overrun (25, 96%).

Interesting findings are opposite results of technical performance and customer satisfaction between these three countries. As depicted in figure 11, the highest level of technical performance and customer satisfaction revealed in Israel. Country managers pay more attention to the better technical performance of projects through spending more money what reflects in cost overrun and focus on customers` needs. This may be due to the high technological development of Israel supported by the state. Because the Government of Israel treated with awe and attention to the needs of people who created the main value of technological developments: ideas that could change the world. This simple but effective solution allowed scientists, researchers, and entrepreneurs to concentrate on solving project related problems. The main economic strategy of Israel is the export of high-tech technologies that solve global demand problems. Disadvantage of Kazakh start-ups is that they don`t focus on solving global problems. Many of them are aimed at solving small problems at the local level and not interested in foreign markets.

The practice of Israel repeats with Kazakh managers' behavior in achieving technical performance, because they have a bit lower results from Japan in customer satisfaction. Kazakhstani projects complete with the worst success outcome. Moreover, it`s important to mention that Kazakhstan has the lowest level of technical performance. This finding can be interpreted as Kazakh customers require high technical performance and managers try to do this through spending-over budget and time. They could not achieve this because of several reasons as a lack of experience and qualified project managers or spending fewer efforts on performing planning processes and low levels of organizational support.

The research results show that projects of developed countries like Japan and Israel are more successful than projects of developing countries like Kazakhstan. It may be explained by long list of factors like experience, innovative development, competitiveness level, etc. But this study focuses on PM tools and practices.

Literature reveals lack of researches about using PM standards in the Republic of Kazakhstan. The need for the application of the best PM practices has increased there since its independence in the 1990s and the local research in this field gained an interest in the early 2000s [103]. Kazakhstan is less experienced in PM, rare use PM tools and has problems with qualified project managers [104]. There is a lack of qualified PM specialists and human resources qualified in the management of innovations in the Republic of Kazakhstan [105]. Furthermore, public-private projects often implemented insufficiently due to the weakness of the project implementation controlling system.

Thus, it became clear that in many developed countries (Japan and Israel) project management is seen as an advanced tool for bringing effectively innovations to the market. Vast amount of foreign countries apply project management methods and develop own standards for managing their projects. Kazakhstan lags behind world leaders in the maturity of project management despite of acceptance of own national PM standard. Comparative analysis of the experience of managing projects according to PMBOK standard in leading countries` and Republic of Kazakhstan, shows that the level of project performance is quite low in Kazakhstan. This paragraph helps to compare PM styles of leading countries; to reveal PMBOK as the most suitable standard for managing high-tech projects; to extract the best PM practice of leading countries.

2 ANALISYS AND EVALUATION OF HIGH-TECH PROJECT SUCCESS IN THE REPUBLIC OF KAZAKHSTAN

1.1 Analysis of the current state of infrastructure for the implementation of high-tech projects

The high-tech industry is one of the most perspective and promising areas. High-tech is a core component of marketing, innovation, entrepreneurship, and diffusion. High-tech can boost innovation in tourism, services, branding, and products. By the way, entrepreneurship highly relates to innovation [106]. Thus, how to provide successful and advanced high-tech products, services, and systems is a focal issue nowadays.

An analysis of the trends in scientific and technological development in the world indicates that Kazakhstan is significantly behind the foreign countries in the field of high technologies. In recent years, the scientific and technical sphere has undergone several reforms, which led to the destruction of effective structures, the loss of personnel [107]. It must be recognized that our economy is developing mainly extensively, and domestic enterprises are characterized by a high level of energy consumption and a low level of labor productivity [108]. It slows down economic growth. In addition, it is well known that the main source and driving force for economic growth in Kazakhstan is the income of industries engaged in the extraction and export of oil and other mineral resources.

Progressive technologies are present mainly in the fuel and raw materials industries, while weak capitalization of non-extractive industries creates weak incentives for borrowing advanced technologies, conserves technological backwardness and, taking into account the degree of wear and tear of this industry, production of products that meet international standards is not out of the question [109]. In this regard, the country is faced with the task of developing new, competitive industries whose products will be in demand in foreign markets. And this cannot be achieved without new technologies, without the introduction of modern management models that are oriented to work in the conditions of global competitive markets. According to experts, Kazakhstan has entered the industrial phase of economic development. However, we should think about the next stage, the so-called post-industrial society - the period of development of innovation and technology [108].

The Republic of Kazakhstan is a newly industrialized country with an emerging economy that can`t compete with leading countries. It`s a developing country that leads to Central Asia and focuses on technological development [110]. In addition, the country starts to concentrate on building a mature innovative system [110], a knowledge-based economy [111] and improving the commercialization system [113-116]. For getting the full picture of the country`s high-tech industry development the study considers the wide rank of factors. Thus, it analyses the high-tech market in a complex way by evaluating an environment of the high-tech industry. Because the development of the high-tech industry is not real without the supportive infrastructure in the form of an innovative system. The model of the high-tech industry`s environment is depicted in the next figure (figure 12).

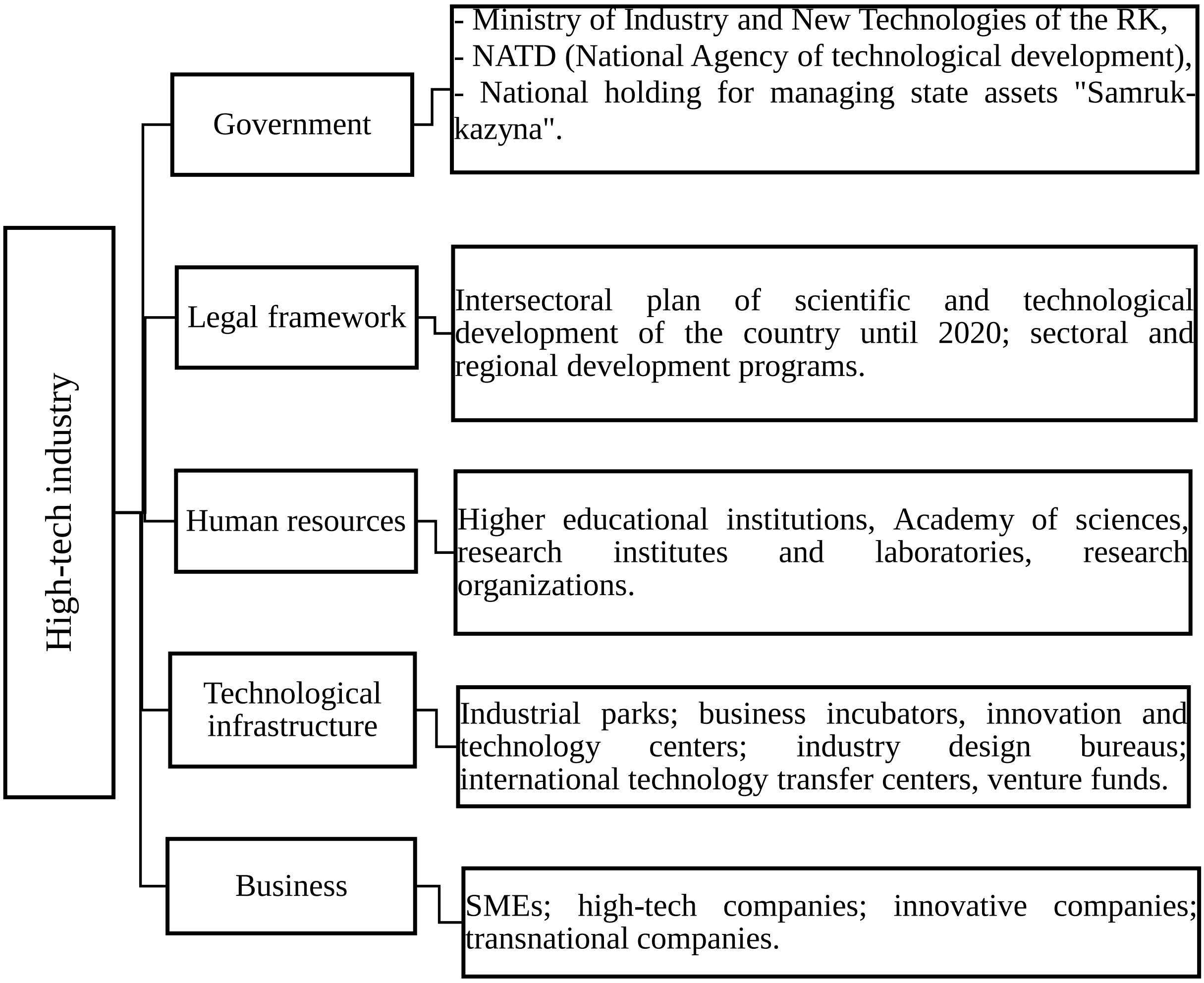

Figure 12 - Infrastructure system for the implementation of high-tech projects in the Republic of Kazakhstan

Note - Compiled by author based on own research

As depicted in figure 12, national infrastructure for implementation of high-tech projects includes 5 basic groups: government, legal framework, human resources, technological infrastructure, and business. These groups consist of numerous components. Further research focuses on the main indicators of these components. In addition, one of the important indicators for assessing scientific and technological development in the world is relative indicator of internal costs evaluated by the share of R&D expenditure in GDP and R&D expenses per capita. National expenditure on R&D considered one of the key indicators of the country's scientific and technological development [3, p. 249].

The experience of government stimulation of breakthrough research by OECD member states shows that a 1% increase in government spending on R&D by 0.85% increases the likelihood of successful innovations and increases the share of new products in turnover by 0.7% [18].

The next table shows the costs of R&D in the world`s leading countries (table 19).

Table 19 – R&D expenditure (% of gross domestic product) for 2016-2017

№	Country	Expenses (%)
1	Israel	4.25
2	S. Korea	4.23
3	Japan	3,14
4	Austria	3,09
5	Germany	2,94
6	United States	2,74
7	France	2,25
8	Australia	2,20
9	China	2,11
10	Russian Federation	1,10
	Kazakhstan	0,13
Note - Compiled by author based on [92]		

As can be seen in the table 19, the highest level of R&D expenses is in Israel. Kazakhstan takes place in low position (0,13 % of GDP for 2017 and 0,12 in 2018). As world practice shows, it`s slows down the development of high-tech industry due to lack of funding and state support [117].

The dynamics of R&D expenditure in Kazakhstan is shown in the figure 13.

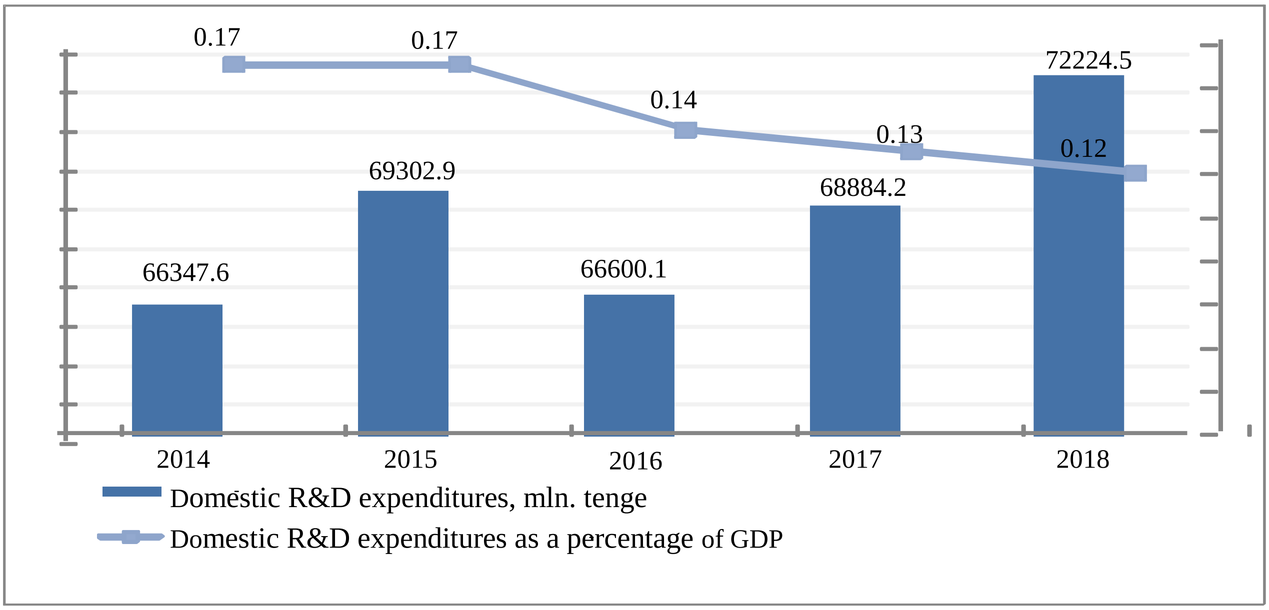

Figure 13 - Domestic R&D expenditure for 2014-2018 in Kazakhstan

Note - Compiled by author based on [117]

As figure 13 shows, domestic R&D costs increase until 72224.5 mln. tg. in 2018, but R&D costs share in GDP shows negative dynamics from 2014 and achieve 0.12 percent. This certainly affects the quality and development of the high-tech industry and may be explained in the further discussion dedicated to the high-tech industry`s infrastructure analysis.

“Government”. This component plays a very important role in the development of the high-tech industry. The government acts as a customer and sponsor. Moreover, it may support technological development in the face of different funds, national agencies, etc. For example, the Ministry of education and science of the Republic of Kazakhstan and the Ministry of industry and infrastructure development are the higher institutions that fund and regulate the development of the studied industry.

The other components of the group “Government” are shown in figure 14.

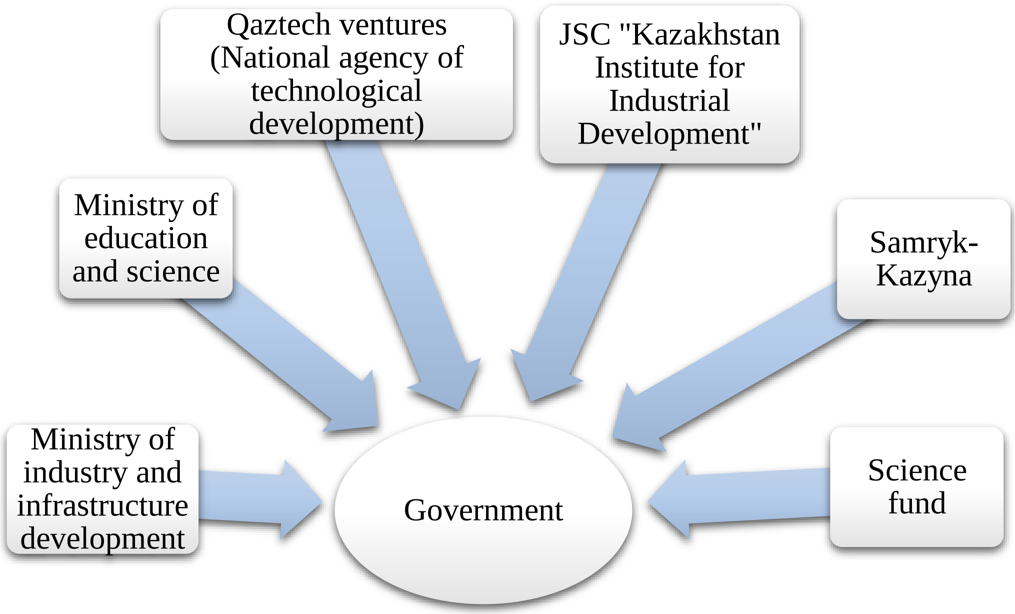

Figure 14 – Components of the group “Government”

Note - Compiled by author based on own research

Figure 14 shows the basic “players” of the “Government”. They usually focus on financial and informational support and, sometimes, on the coordination of the project implementation process. For example, QaztechVenture invested 340 innovative projects for a total of 14,230.2 million tenge. The largest number of innovative grants was received by entrepreneurs and developers from Almaty, Astana and the Karaganda region. For the first half of 2018, the agency concluded three contracts for a total of 347.9 million tenge from 2011 to 2018 [118].

JSC «Kazakhstan Institute of Industry Development» is responsible for the development of territorial clusters from different sectors of the economy.

“Samryk-Kazyna” an investment holding company that provides high financial performance, investment income, and a developing portfolio. The priority sectors for new projects of the fund include the chemical and mining industries, energy and high technology. Therefore, this fund plays a vital role in the high-tech industry.

The next organization is the Joint-Stock Company “Science fund”. The main subject of the Science fund is to promote the development of priority, proactive, risky research and experimental projects, ensuring the practical implementation of scientific research in the country. The role and the result of the functioning of these organizations for 2018 are listed below:

- 18 innovative grants worth 4.67 billion tenge were issued;
- The total volume of products produced by innovative grants projects amounted to 35.6 billion tenge;
- As part of the development of a technology transfer system, 19 technological proposals assigned with international partners, 8 memorandums were signed with foreign partner organizations;
- 13 supported projects by a grant for technological development of enterprises;
- 3 supported technology commercialization projects;
- Support for 3 technology incubators and etc.

These results show the positive influence of government on high-tech industry development, but the level of funding is still quite low. Therefore, the number of supported projects, commercialized technologies and organizations is very low. In addition, project results are not evaluated after completion. Mentioned above organizations don`t pay attention to the long term effect of supported projects.

Legal framework. The legal framework includes national strategies, concepts, programs, and laws that support the technological development of the country, also help to regulate and control innovation system functioning. The next figure illustrates the basic general legal framework (table 20).

Table 20 – Main strategies, concepts and laws supporting high-tech projects implementation

№	Programs	Accepted period	Aim
1	State program of industrial and innovative development of the Republic of Kazakhstan	2015-2019	To stimulate diversification and increase the competitiveness of the manufacturing industry.
2	State program "Digital Kazakhstan"	2017	Accelerating the pace of development of the economy of the republic and improving the quality of life of the population through the use of digital technologies in the medium term, as well as the creation of a digital economy of the future in the long term.
3	The concept of innovative development of the Republic of Kazakhstan	2015-2019	Directed to ensuring and supporting innovative development of the economy
4	Intersectoral plan of scientific and technological development of the country until 2020	2010-2020	Achievement of technological leadership in sectors of the economy, key in terms of long-term development prospects of Kazakhstan
5	Law of the Republic of Kazakhstan on state support for innovation	July 5, 2011	Development of innovative potential of the Republic of Kazakhstan; an increase in the share of high-tech products in the structure of gross domestic product;
Note – Compiled by author based on [119]			

As is shown in table 20, the general aim of these documents is to increase the competitiveness of the national economy by supporting technological development. In addition, there are vast amounts of legislation devoted to supporting different areas of high-tech industries like green energy, biotechnology, nanotechnology, IT-industry, etc. Negative point of these legislations – there is no specific legislation which straightly directed to the development of technologies and the technological sector. The program of technological development of the Republic of Kazakhstan was not extended until 2015. In addition, there is a lack of tools for measuring the effectiveness of such programs and concepts that may show their real benefit for the industry. The built innovative infrastructure cannot function successfully in the absence of developed market institutions. The institutional environment of innovation is today an obstacle to innovation. Moreover, the State program of industrial and innovative development of the Republic of Kazakhstan for 2015 - 2019 considers the issues of innovative and technological development of the national economy but doesn`t explain or describe methodological approaches of developing and introduction of high-tech in the domestic market. The national standard of a PM that coordinates and regulates the management of domestic projects were accepted recently (in 2016). Proper application of PM should be supported by relevant legislative norms. There is no special law, which regulates PM activity in Kazakhstan.

Human resources. This component plays a vital role in technological development and, as discussed above, includes the contingent of human resources with the highest scientific qualifications, scientific research institutes, scientific organizations, higher education institutes (table 21).

Table 21 - Amount of organizations by types engaged in R&D [117]

№	Organization	2014	2015	2016	2017	2018
1	HEI	89	90	93	89	89
2	SRI	245	237	225	230	197
3	Other organizations	58	63	65	67	100
4	Total	392	390	383	386	286

As depicted in table 21, there are stable development excluding the reduction in the number of universities by 4 units.

The next table (table 22) shows the structure of employee engaged in scientific R&D.

Table 22 – Employees involved in R&D in Kazakhstan for 2013-2018 [117]

	2013	2014	2015	2016	2017	2018
1	2	3	4	5	6	7
Number of employees involved in R&D, people (total in Kazakhstan)	23712	25793	24735	22985	22081	22378

Continuation of table 22

1	2	3	4	5	6	7
of them:						
Research specialists	17195	18930	18454	17421	17205	17454
of them:						
Doctors of science	1688	2006	1821	1828	1818	1740
Doctors by profile	605	596	549	493	354	-
PhD	218	330	431	456	589	856
Candidates of science	4915	5254	5119	4726	4541	4360

Table 22 shows the quantity reduction of research specialists from 2014. The largest number of employees were registered in 2014 (25793 people) over the five-year period. Accordingly, the number of employees has decreased by 3.7 thousand people in 2018. This may be the result of a reduction in project funding by the government or due to the fact that this area is not attractive for long-term career growth. In addition, the level of salary and motivation of staff in this area is quite low. The positive fact is the increased amount of PhD that may contribute to the quality of R&D.

Unavailability of the domestic education system to the challenges of accelerated industrialization and the fulfillment of tasks for the development of high-tech sectors of the economy. The project leaders should have sufficient experience and knowledge of the high-tech project management specifics.

Research continues to rely on the old staffing potential, as there is a shortage of personnel in the field of project management and innovation management in the country. These specialties are relatively new, and there is a lack of scientific staff who may train specialists. Considering the fact that doctoral studies in the field of project management were started only in 2009, there are still few domestic researches in the field of project management. The first doctoral dissertation in this specialty was defended in 2013 [120]. Therefore, it cannot be said that research is carried out on a regular basis, and we definitely cannot talk about the formation of a national scientific school.

According to the Union of Project Managers of the Republic of Kazakhstan, 55 Kazakhstanis have a PMP status until 2018. However, this indicator is less than 1% of the total amount of certified specialists. IPMA certification was obtained by an even larger number of Kazakhstanis - 523. However, this is also only 0.3% of the total certified number in the world. There is no national assessment of project management professionals in Kazakhstan.

Technological infrastructure. The important components of the technological infrastructure are business incubators, technoparks, industry design bureaus and etc. In Kazakhstan, definitions of such terms as business incubators and technology parks have been introduced since 2006 [121].

There are more than 20 business incubators in Kazakhstan. The most active and productive of them are shown in figure 15.

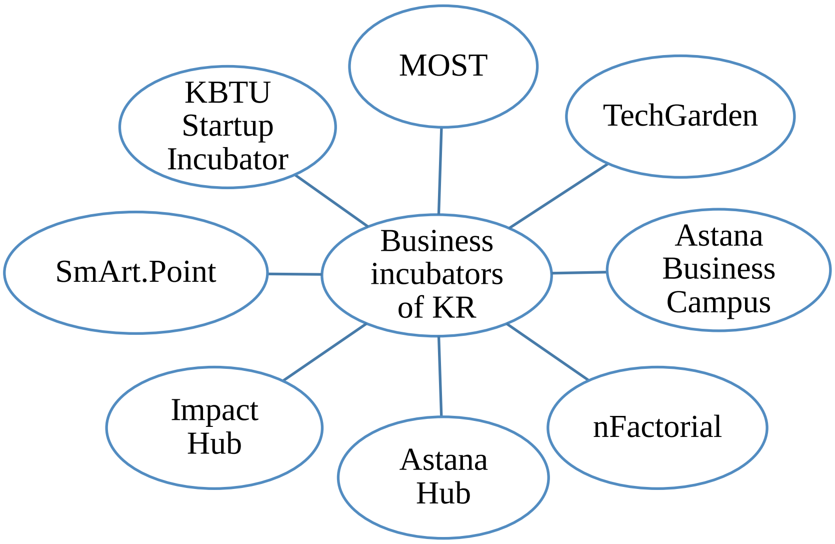

Figure 15 – Business incubators of the Republic of Kazakhstan

Note - Compiled by author based on [122]

Most of these incubators are located in Nur-Sultan and Almaty. The largest and most famous start-up sites are Almaty Tech Garden and the capital's Astana Hub, which are supported by the state. There are also private business incubators, for example, MOST or nFactorial. In the latter, mobile app developers are trained. Over three years, 300 people from 14 countries have become their graduates, having created more than 200 mobile applications [122]. The worth noting fact is the lack of a monitoring system, quantitative and qualitative data on the results of business incubators. Moreover, there is a lack of a platform for interaction and exchange of information between incubators at both regional and national levels. Business incubator programs in Kazakhstan are little known domestically and abroad.

Technoparks. A two-level system of technology parks is being formed in the republic - national technology parks and regional ones. Technology parks act on a regime of the Special Economic Zone with preferential taxation. The regional technoparks are depicted in table 23.

Table 23 – The regional technological parks in Kazakhstan [123]

Name of organization	State share %	Year of establishment	Founders	City
1	2	3	4	5
Technopark LLP Alatau	100	2012	JSC NATD	Almaty
LLP “Almaty Regional Technopark”	100	2005	JSC NATD	Almaty
LLP “Regional technopark of Astana”	100	2007	JSC NATD	Astana
LLP “Regional Technopark of the South Kazakhstan Region”	91,9	2008	JSC NATD, RIC “Maximum” LLP	Shymkent

Continuation of table 23

1	2	3	4	5
Saryarka LLP	84,3	2004	JSC CITT, JSC “National Company” SEC “Saryarka”	Karagandy
LLP “Technopark KazNTU them. K.I.Satpayev”	53,7	2004	JSC “KazNITU them. K.I. Satpayev”, JSC NATD	Almaty
LLP “East Kazakhstan regional technical park” Alatau	50,3	2004	EKSTU named D.Serikbayev, LLP “CB GMO”, JSC CITT	Oskemen
Technopark Algoritm LLP	35,6	2004	JSC “RIC” Gradient, JSC CITT, “RGKP” WKATU named “Zhangir Khan”, JSC Reasearch Institute “Gidropribor”	Uralsk

These technology parks concentrate on support and development of new industries, using the existing scientific and technical potential, financial and labor resources. The main share technopark`s clients in the Republic of Kazakhstan is made up of companies engaged in production (food, sewing clothes, furniture manufacturing) and working in the service sector (training, consulting, construction). Only 2% are engaged in high-tech production.

The next important component of technological infrastructure is Industry design bureaus. It`s a legal entity owning a material and technical complex, created by the national development institute in the field of technological development to assist the subjects of industrial and innovative activity in organizing the production of new or improved goods [124]. The list of domestic bureaus is depicted in figure 16.

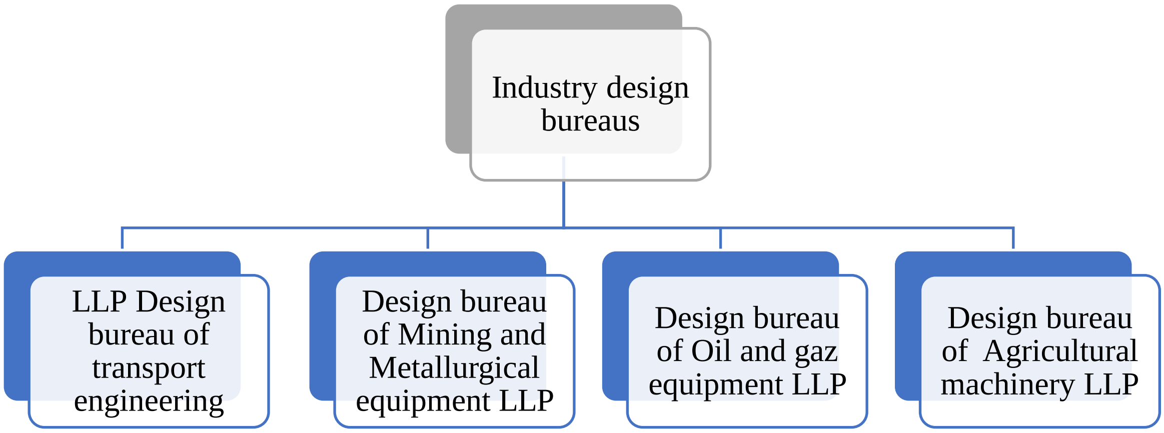

Figure 16 – Industry design bureaus in Kazakhstan

Note - Compiled by author based on [124]

The functions of these bureaus are development of technological equipment; comprehensive testing of prototypes of products; development of enterprise standards, instructions and specifications; development of technological processes for the organization of serial, large-scale and mass production of equipment, development of technological memorandums those connect different large companies with SMEs and etc. As the result of their work, 16 technological memorandums have been concluded between MIID RK and the largest industrial enterprises, JSC “NC “Kazakhstan Temir Zholy”, JSC “NC “KazMunayGas”, LLP “Kazakhmys Corporation”, LLP “Kazcinc” and others [125].

The created system of development institutions didn`t become a reliable mechanism for promoting high-tech projects and the necessary coordination between them was not achieved. The work of the components of the innovation system is not interconnected. They work separately without any communication. In addition, innovation policy is isolated from regional development. In addition, the activities of the institutes are not aimed at non-financial support of innovative projects - information, consulting, and export.

The results of scientific and technical activities remain unintroduced into the real sector of the economy, do not generate revenue for developers and do not provide budget revenues.

The most serious disadvantage of the system of development institutions in its current form is the failure to fulfill its main purpose - to support truly innovative high-risk projects. Institutions designed to support the development of small innovative enterprises actually invest in mature companies.

Business. The number of enterprises that use innovations and technologies may represent the innovative and technological development of the entire country. Some statistics related to the innovative activity of domestic companies are depicted in table 24.

Table 24 - Indicators of innovative activity of enterprises by type of economic activity in Kazakhstan for 2014-2018 [117]

№	Category	2014	2015	2016	2017	2018
1	Number of enterprises, units	24068	31784	31077	30854	30 501
2	of them having innovations	1940	2585	2879	2974	3 230
3	The level of activity in the field of innovation, in%	8,1	8,1	9,3	9,6	10,6
4	The share of innovative products (goods, services) to GDP, as a percentage	1,46	0,92	0,95	1,55	1,91
5	Number of enterprises collaborating in the field of innovation with other organizations, units	237	1000	1030	1055	1120

Table 24 shows that the number of innovative enterprises and the level of activity in the field of innovation are increasing every year (3230; 10.6 respectively).

However, according to the Committee on Statistics of the Republic of Kazakhstan, the innovative activity of Kazakhstani enterprises remains low: 9,6% in 2017 and 10.6% in 2018. For comparison: in Russia - 10.5%. Belarus - 21.7, Kyrgyzstan - 7.4, in Ukraine - 18.9% in 2017 [117].

Kazakhstan is significantly lags behind leading industrial countries (in Germany, innovation activity is within 70%, Canada - 65%, Belgium - 60%, Ireland, Denmark, Finland - 55-57%). This indicator is in the range of 20-40% in most countries of Central and Eastern Europe. The next table (table 25) shows the interests of domestic companies regarding knowledge-intensive activities.

Table 25 - Number of organizations performing R&D in the republic of Kazakhstan for 2014-2018 [117]

№	Region	2014	2015	2016	2017	2018	Tendencies increase / decrease
1	Republic of Kazakhstan	392	390	383	386	384	-2
2	Akmola region	11	11	9	11	11	0
3	Aktobe region	14	14	14	16	16	0
4	Almaty region	13	11	10	11	9	-2
5	Atyrau region	9	10	11	10	10	0
6	West-Kazakhstan region	9	7	8	8	10	+2
7	Zhambyl region	11	11	11	11	9	-2
8	Karaganda region	31	32	33	29	28	-1
9	Kostanay region	13	14	13	14	12	-2
10	Kyzylorda region	6	8	10	8	7	-1
11	Mangistau region	7	5	7	6	6	0
12	Pavlodar region	11	9	10	11	14	+3
13	North-Kazakhstan region	3	4	5	5	5	0
14	Turkestan region	5	4	5	6	6	0
15	East-Kazakhstan region	30	30	35	34	35	+1
16	Nur-Sultan city	59	53	55	62	60	-2
17	Almaty city	148	152	133	131	135	+4
18	Shymkent city	12	15	14	13	11	-2

As table 25 shows, the increase in the number of organizations occurred in six regions of the republic: in Akmola, Aktobe, Almaty, Kostanay, Pavlodar regions and in the city of Astana. The decrease occurred in six regions - in Atyrau, East Kazakhstan, Karaganda, Mangystau, Kyzylorda regions, and Almaty city. In other regions, the network of scientific organizations has not changed. Almaty and Nur-Sultan are the leaders due to the high concentration of higher education and scientific organizations in these cities.

Technological update at domestic enterprises is largely based on the borrowing of foreign technologies and equipment. For these purposes, from 2013 to 2017, enterprises spent up to 72% of all innovative investments [117]. At the same time, scientific research and preparation of production for the release of new products, the introduction of new services or methods of production account for slightly more than 5%. This data indicates that Kazakhstani business prefers to purchase ready-made equipment, machines, mechanisms, rather than investing in the implementation of domestic scientific developments. However, the money is not spent on preparing for a new product. This is evidenced by a fairly low share of companies' costs that were targeted to producing an innovation, not exceeding 7% over the past five years. By the way, in 2018 it decreased to 1%.

There is a lack of interaction between science, universities, and industry. Kazakhstani producers don\`t have proper experience in bringing scientific developments to the level of market goods. The national innovation system is not holistic. The links of the chain are torn from each other, and each solves its own tasks. The mechanism of transition of the created innovative products to industrial production has not been thought out. In particular, among all organizations of science, research institutes form the basis, while the number of project-oriented and engineering organizations remains at a low level. Research institutes do not cooperate with business representatives of these industries. As a result, they don\`t offer products or services desired by industries. In addition, there is a relatively low level of development of these sectors [71, p. 26]. An additional factor that lags behind the development of high-tech project implementation is an immature project management system. The national project management system in the country only begins to form. Since all the transformations in the republic over the past 20 years have taken place by the active participation of the state, the absence of such support impacts to failure or slow development of innovation and high-tech projects especially. In this regard, one of the main reasons for the poor distribution of project management is the lack of attention to this issue from public authorities. The government just start to pay attention to PM development. In addition, a number of domestic companies use the methods and tools of project management. But these are mainly large companies or project-based organizations. There is a lack of experience and practice in managing high-tech projects in Kazakhstan. Local project managers often execute their projects based on the "Iron triangle approach" focused on time, cost and scope dimensions.

Thus, analysis of domestic infrastructure for the implementation of high-tech projects lets to assume that the environment for technological development is not advanced and doesn\`t provide appropriate support. High-tech project management is affected by the development of innovative systems and PM maturity levels. To sum up, there is a lack of funding from government and legislative support that allows avoiding bureaucratic processes; lack of qualified specialists with experience in managing innovative projects; an absence of communication system between participants of innovative infrastructure and effective mechanisms for ensuring demand for high-tech projects. Thus, the needs of the domestic market for high-tech products are met by foreign manufacturers. The innovative policy doesn`t focus on the requirements, wants, and needs of industries. This fact keeps companies outside the main processes of creating innovation. In turn, government business support programs sometimes include processes that are too complex and don`t allow a wide range of entrepreneurs to participate in these programs.

2.2 Evaluation of high-tech project success in the context of industry

Statistical data indicates that the success rate of high-tech venturing projects is only about 20%, so striving for becoming one of the lucky 20% is the most concern of many project stakeholders [126]. New product development in the context of high-tech manufacturing cannot be effective without the use of a project management approach [127]. Therefore, the study evaluates the impact of project management on high-tech project success. Thus, this paragraph analyses the next issues: the level of high-tech project success in the Republic of Kazakhstan, the critical PM knowledge areas that affect high-tech project success, processes performed by local managers affect project success.

Sample and data collection. The study uses a questionnaire for gathering data about the success dimensions of projects. In addition, projects from the official database of NATD (reorganized to QaztechVenture) were used for measuring high-tech project success in the Republic of Kazakhstan. Thus, the study uses primary and secondary information for calculations. The primary data was collected from domestic organizations that implement high-tech projects. The list of organizations involved in the survey is described in Appendix E. The secondary data was obtained from the base of the Science Committee, Special economic zone “Innovative technology park” and NATD.

The structure of organizations engaged in a survey is depicted in figure 17.

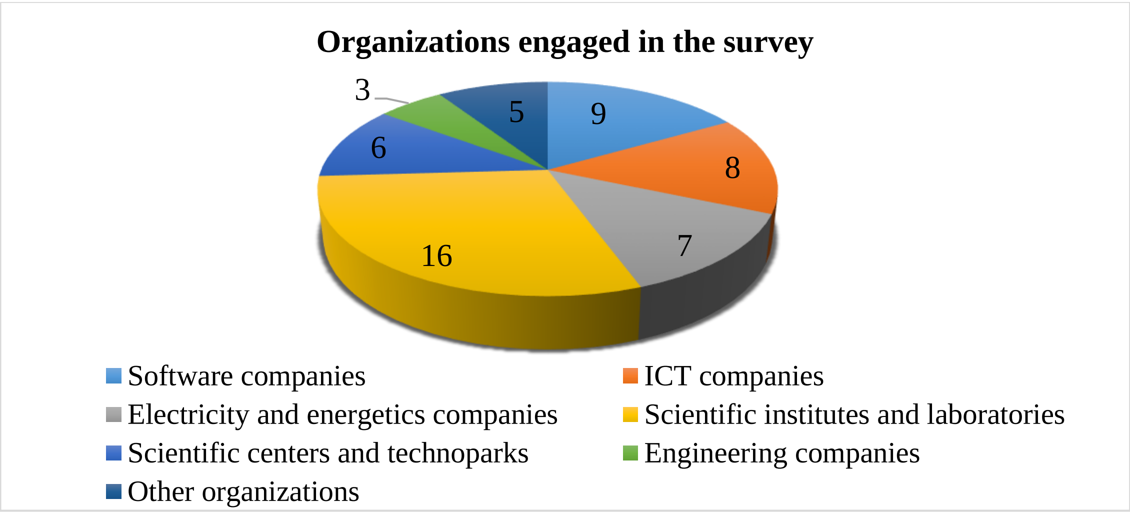

Figure 17 – The share of groups of the organizations engaged in research

Note – Compiled by author based on own research

Questionnaire performed by project managers and supervisors of these organizations who run projects in the sphere of green energy, nanotechnology, chemical technology, biotechnology, engineering, communications and information technologies (further IT), etc. during 2016-2019. The goal of the survey is to build a model. Therefore, questionnaire is prepared on the base of the research model and aimed to collect data regarding planning and project success. Detailed structure of the questionnaire presented in Appendix D.

Firstly, project supervisors were asked about cost and schedule overrun which is evaluated by percentage from the planned level. For example, the project supervisor plans to spend 5 million dollars for the project, but exceeds the budget to 7,5 million dollars. The cost overrun will be 50%. Secondly, project supervisors were asked to evaluate customer satisfaction level from1 to 10 (from low to high level). It is worth noting that data about the above-mentioned success dimensions for 16 nanotechnology projects were derived from the science report of the National nanotechnology laboratory of open type. Questionnaires that had at least 85% of completed data were included in the analysis in order to increase the reliability of gathered data. Finally, 172 questionnaires remained for analysis. The next table (table 26) shows the qualitative characteristics of the research sample.

Table 26 – Research sample details

№	Project type	Total amount	Actual quantity	Percentage of projects, %
1	Green energy projects	24	22	12,8
2	Nanotechnology projects	21	19	11
3	Biotechnology projects	19	18	10,5
4	Engineering projects	39	33	19,2
5	Chemical technology projects	19	11	6,4
6	IT projects	32	31	18
7	Communications	35	28	16,3
8	Nuclear energy projects	11	10	5,81
9	Total	217	172	100
	Note – Compiled by author based on own research			

As table 26 shows, the average percentage of valid questionnaires from each industry is 12,5%. Therefore, the study uses the results of projects amount of which exceed 10%. The study decides that it`s quite enough for an adequate comparison of chosen industries. Chemical technology and nuclear energy projects are don`t consider in the analysis due to their insufficient quantity.

As depicted in table 26, finally 151 projects were chosen for evaluation. These projects were chosen according to the suggested classification of high-tech projects described in the theoretical part of the research work. R&D projects don`t include for research sample due to the unavailability of data.

Conducting research and results. Regression analysis was used for evaluating the success level of high-tech projects. Datasheet in Excel is presented in Appendix F. The results of the calculations are shown in table 27.

Table 27 – Calculations of dependent variables (project success)

№	Project type	Average PQ index	Cost overrun, %		Schedule overrun, %		Customer satisfaction (1-10)	
			R	Mean	R	Mean	R	Mean
1	Green energy projects	3,6	0,4	45,13	0,4	6,1	0,6	7,2
2	Nanotechnology projects	3.1	0,5	61,9	0,5	6,8	0,7	7
3	Biotechnology projects	4,0	0,6	19,8	0,6	1,8	0,7	8,5
4	Engineering projects	3,9	0,5	29,5	0,5	3,9	0,9	7,2
5	IT projects	4,5	0,5	12,2	0,4	2,8	0,7	8,5
6	Communications	3,8	0,7	21,8	0,5	8,6	0,9	7,3
Note – Compiled by author based on own research								

Results show the score of project success indicators for 6 groups of high-tech projects and the correlation of these indicators with the PQ index. As described earlier, this index shows the average use intensity of PM processes. Thus, it means that actively using PM ensures project success growth.

Figures 18-19 show the results of cost overrun and schedule overrun evaluation for chosen projects.

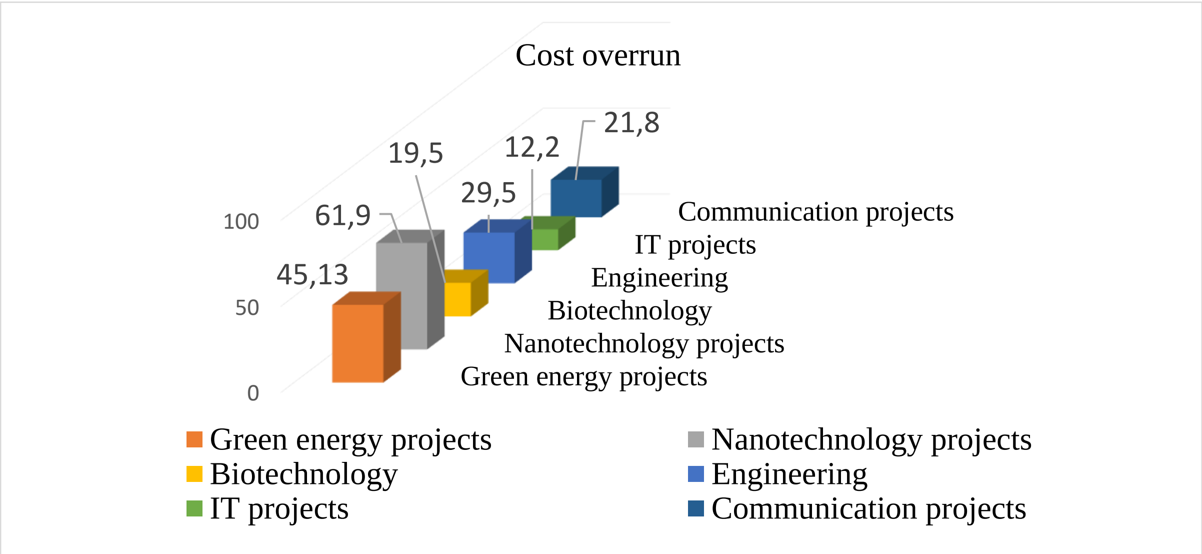

Figure 18 – The level of cost overrun for chosen projects, %

Note – Compiled by author based on own research

As depicted in figure 18, IT projects have the lowest level of cost overrun (12,2%). The highest level of cost overrun is achieved by nanotechnology projects (61,9%). It means that nanotechnology projects exceed their planned budget. As the study explained before, projects those significantly exceed planned cost are move away from project success.

The next figure (figure 19) helps to assume which projects achieve project management success.

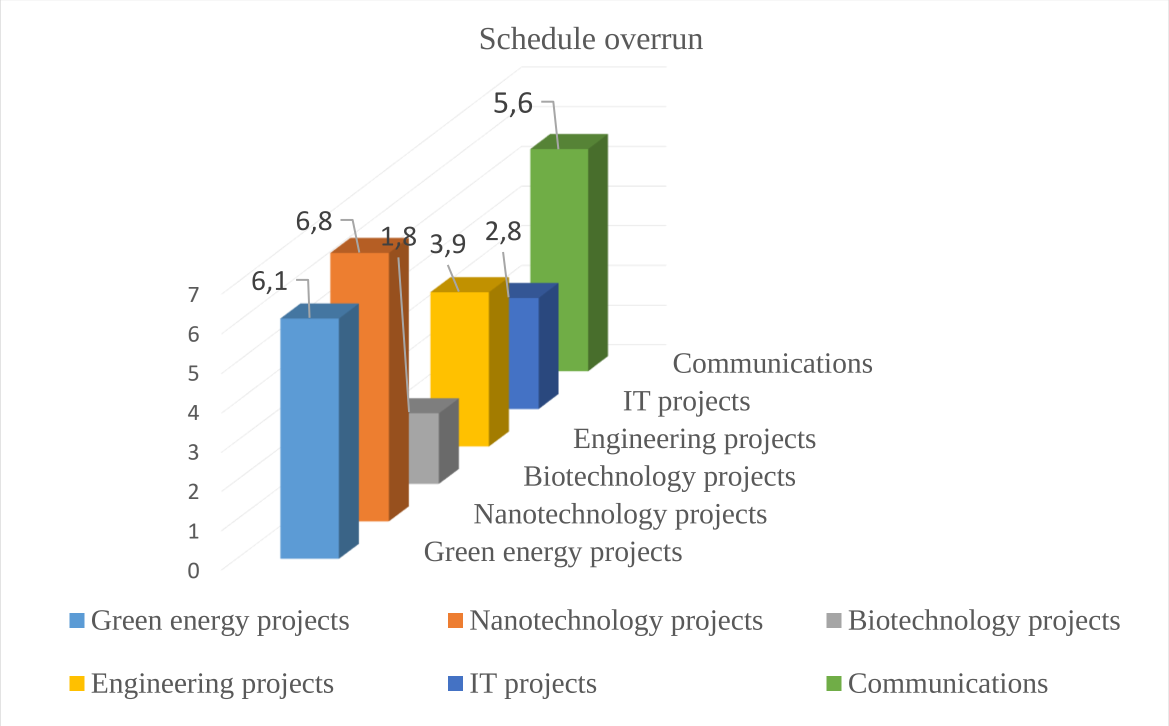

Figure 19 – The level of schedule overrun for chosen projects, %

Note – Compiled by author based on own research

These findings led us to state that IT-projects more successful from the viewpoint of project management than others due to the fact, that they have the lowest level of cost overrun. It means that these projects often complete according to the planned budget and schedule. The reason for this may be the maturity of PM in the software industry. This will be clear in the next paragraph which includes an analysis of PM processes performed by local project managers. In addition, biotechnology projects have the lowest score of schedule overrun and a low level of cost overrun after IT-projects.

The worst results in cost overrun is achieved by nanotechnology projects (61,9%). In addition, these projects show one of the worst results in schedule overrun (6,8%). These findings let to state that nanotechnology projects are the most unsuccessful projects from the viewpoint of project management success.

Green energy projects project management success better than the nanotechnology project level. Green energy projects show a high schedule overrun (6,2%) and cost overrun (45,13%) after nanotechnology projects. These facts show that green energy projects in our country are not much successful and government or responsible structures should make efforts for improving this situation.

Further, the study analyses project owner success which shown in figure 20.

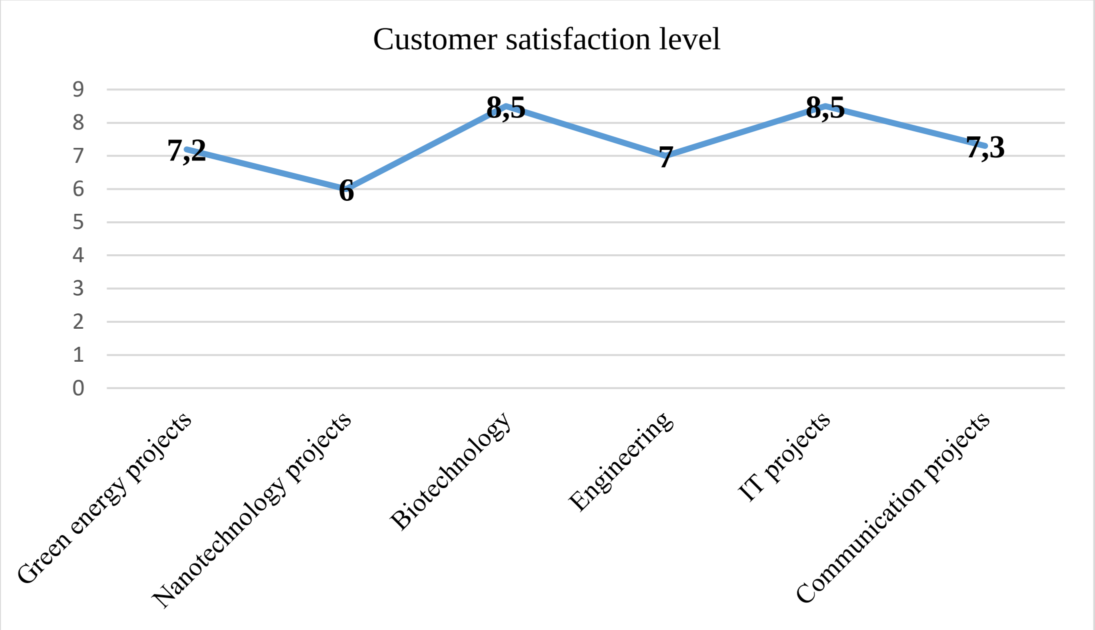

Figure 20 – The level of Customer satisfaction for high-tech projects

Note – Compiled by author based on own research

As figure 20 shows, the highest level of customer satisfaction achieved by IT projects (8,5) and Biotechnology projects (8,5). It means that they are successful for the project owners. Moreover, a high level of customer satisfaction shows the quality of the project and its outcome. The worst score is gained by nanotechnology projects (6) and engineering projects (7). It may be explained by the high preferences and requirements of the customer from these projects. In addition, nanotechnology and engineering projects are often implemented by using absolutely new technologies and methods that complicate the project execution process. It is worth noting that these projects relatively new for our domestic market. Therefore, bad results may occur due to a lack of experience in managing this kind of project. The results of the success measurement for chosen projects are depicted in the next table (table 28).

Table 28 - The results of high-tech project success evaluation

№	Project type	**Project management success**		**Project owner success**
		Cost overrun, % (allowed max 15%)	Schedule overrun, %	Customer satisfaction (the max score is 10)
1	2	3	4	5

Continuation of table 28

1	2	3	4	5
1	IT project	12,2	2,8	8,5
2	Biotechnology project	19,8	1,8	8,5
3	Communications projects	21,8	5,6	7,3
4	Engineering projects	29,5	3,9	7
5	Green energy projects	45,13	6,1	7,2
6	Nanotechnology project	61,9	6,8	6
Note - Compiled by author based on own research				

Thus, as depicted in table 28, the study may assume that project management success and project owner success achieved only by IT projects. Because customer satisfaction level higher than 7 shows project owner success and the level of cost overrun and schedule overrun less than 15% show project management success. The gap 15% cost and schedule overrun may be allowed due to the complexity of high-tech projects.

Project owner success is achieved by all projects except nanotechnology projects. These results don’t mean that all nanotechnology projects are unsuccessful. The study shows the average meaning of indicators. Detailed consideration of separate projects can show their real success level in a simple way. Therefore, the study was chosen 3 kinds of high-tech projects for further evaluation. They are from the software, engineering, and nanotechnology industry. Detailed information about investigated projects is depicted in table 29.

Table 29 - Characteristics of investigated projects

№	Project type	Title	Organization	Coding
1	IT project	Development of virtual 3D heart model with elements of augmented and virtual reality technologies	JSC “International information technology university”	Project I
2	Green energy project	Organization of small-scale production of energy-saving gas-discharge lamps with increased glow intensity based on new technologies	Project based organization LTD “Berkut technology”	Project G
3	Nanotechnology project	Obtaining nanomaterials by pulsed plasma spraying and their application in production	Nanotechnology laboratory	Project N
Note - Compiled by author based on own research				

As depicted in table 29, these projects were chosen from different industries. Further, the study considers these projects as Project I, Project G and Project N.

Firstly, we describe the features and characteristics of these projects. The main idea of Project I is to develop a software application based on 3D visualization technologies and augmented reality, which allows studying the work and diseases of the heart and cardiovascular system of the human body. This application is useful for students of medical colleges and universities, as part of the retraining and advanced training of medical workers, as well as for any interested users.

The main advantages of this project:

1. Ease of use. This is one of the most important criteria. This program runs for several hours every day. Therefore, it is fast and convenient.
2. The use of modern web technologies that provide interactivity, speed, and convenience.
3. Accounting system. Generate quarterly and other reports to evaluate the overall situation in the program functioning, to evaluate the performance of the program.

The goal of the project should be achieved through the effective use of interdisciplinary communications and advanced innovations in the field of information technology, namely in the field of software development. This project funded and supported by a foreign organizations. The obtained result of the project is a special program that will be used in the medical sphere. The planned budget of this project was 21 253 000 tg. and the planned schedule was 6 months. The project team completed this project with planned costs, but late for two weeks.

Project G was chosen from the green energy sphere. The aim of this project is the organization and launching of small-scale production of energy-saving gas-discharge lamps with increased luminous intensity. The following works should be performed on the project:

- Launching of testing samples of energy-saving gas-discharge lamps with increased luminescence intensity and obtaining prototypes of products;
- Obtaining a patent, a certificate of conformity for lamps, preparation of a data sheet and manuals for the operation of the product;
- The completion of work on the promotion of products, etc.

The planned budget of Project G is 70 000 000 tg. and the planned schedule is 24 months. The project team exceeded the budget for 10 000 000 tg. and completed the project later for 3 months.

Project N aimed to obtain nanomaterials by pulsed plasma spraying and their application in production. Project implemented by using unique methods and equipment never used before. These facts influenced on the complexity of the project. Project N was implemented with budget 39 472 000 tg. during 16 months. Project team completed the project over budget and time. This fact shows some made omissions or mistakes during project implementation. It may be result of pure project management, ignoring project execution rules, work of unexperienced project manager or the absence of project management knowledge. Because the project fail often linked with PM factor. This will be clear during discussion dedicated to project management processes evaluation. The detailed calculations for investigated projects are shown in table 30.

Table 30 - Evaluation of project success level for individual projects

Project	Cost overrun			Schedule overrun			Customer satisfaction (1-10)
	Planned cost, mln. tg.	Actual cost, mln. tg.	Cost overrun, %	Planned schedule, mth	Actual schedule	Schedule overrun, %	
Project I	21	21	0	6	6,5	8	10
Project G	70	80	14	24	27	12,5	7
Project N	34	39,5	16	12	16	33	8
Note - Compiled by author based on own research							

As table 30 shows, better results of cost overrun (0), schedule overrun (8%) and customer satisfaction (10) were achieved by Project I. Project management success is achieved by all projects. For a clear understanding of the results of project management success, the study presents the calculations of cost overrun and schedule overrun for each project. Firstly, the study calculates project management success dimensions for Project I.

Project management success for Project I:

$C_o=(C_a-C_p)*100/C_p=(21-21)*100/21=0(\%)$
$S_o=(S_a-S_p)*100/S_p=(6,5-6)*100/6=8,33(\%)$
$C_o<15\%; S_o<15\%$

where, C_o - cost overrun, C_a - actual cost of project, C_p - planned cost of project, S_o - schedule overrun, S_a - actual schedule, S_p - planned schedule.

Thus, described above calculations show that Project I achieved project management success because the levels of cost overrun and schedule overrun less than 15% are considered as successful for high-tech projects due to their specific features like complexity, high risk, and uncertainty level, etc.

Calculations for Project G are described below:

$C_o=(C_a-C_p)*100/C_p=(80-70)*100/70=14,2(\%)$
$S_o=(S_a-S_p)*100/S_p=(27-24)*100/24=12,5(\%)$
$C_o<15\%; S_o<15\%$

The results show that Project G achieved project management success. Cost overrun and schedule overrun are less than 15%. Project managers who execute this project didn’t complete it in planned time and budget. They spend more money and time due to different reasons that should be investigated by the project team. An analysis may show a list of problems related to using PM tools. Because a project that was run by a clear understanding and implementing of PM methodology should correspond to success requirements completely.

Calculations for Project N shows the next results:

$C_o=(C_a-C_p)*100/C_p=(39,5-34)*100/34=16,1(\%)$
$S_o=(S_a-S_p)*100/S_p=(16-12)*100/12=33,33(\%)$
$C_o>15\%;\ S_o>15\%$

As results show, Project N didn’t achieve project success due to high level of cost overrun and schedule overrun. It means that project managers have over budget spending that reduces the chances to complete projects successfully. In addition, they closed the project too late. Results above 15% are considered unacceptable for high-tech project success.

The next figure shows the project owner's success results (figure 21).

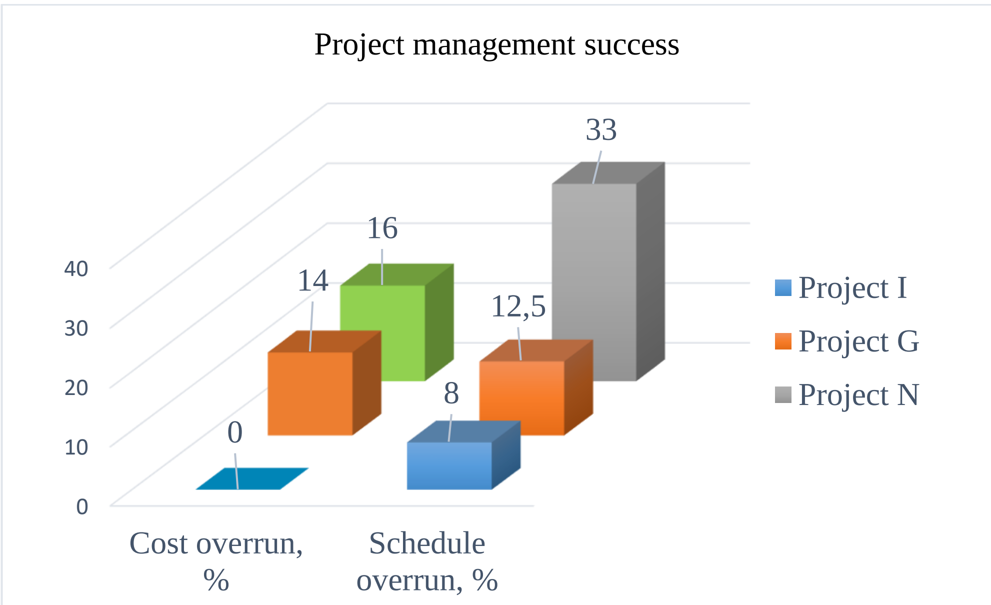

Figure 21 - Project management success evaluation results

Note - Compiled by author based on own research

As figure 21 shows, Project I is the most successful among others on the viewpoint of project management success. This is maybe due to actively using PM processes by mentioned project managers. On the other hand, it`s well-known that the software industry was one of the first to use project management. Calculations for project owner success help to clarify previous findings and complement pieces of knowledge about project success.

Project owner success identified by using a scale ranging from 1 to 10. The results related to the chosen 3 projects are depicted in table 31.

Table 31 - Results for measuring project owner success

№	Project	Customer satisfaction									
		Very low			Low			High		Very high	
1	Project I	1	2	3	4	5	6	7	8	9	**10**
2	Project G	1	2	3	4	5	6	**7**	8	9	10
3	Project N	1	2	3	4	5	6	7	**8**	9	10
Project owner success								+	+	+	+
Note - Compiled by author based on own research											

Thus, as depicted in table 31, all projects show a proper level of customer satisfaction that ranged for 4 groups. Projects that exceed 7 accepted as successful in the viewpoint of the project owner.

Projects that show a high score in customer satisfaction highly evaluated by end-users of projects. The final score of success dimensions of studied projects are depicted in table 32.

Table 32 - Project success score

Project	Cost overrun, %	Schedule overrun, %	Customer satisfaction level	The best score
Project I	0	8	10	1
Project G	14	12,5	7	2
Project N	16	33	8	3
Note - Compiled by author based on own research				

As table 32 shows, the customer satisfaction level is relatively high than in other dimensions. The score is derived from the expert assessment. Due to the difficulty of getting answers from real customers, data about this success dimension gathered from project managers. Moreover, this practice is used by several scholars like Ress-Caldwell and Pinnington [62, P. 212].

To sum up, the project success level for high-tech projects of the Republic of Kazakhstan is measured in the viewpoint of project management success and project owner success. As results show, IT projects are the most successful according to both dimensions (cost overrun - 12,2%, schedule overrun - 2,8%, customer satisfaction - 8,5). The worst results are achieved by nanotechnology projects (cost overrun - 61,9%, schedule overrun - 6,8%, customer satisfaction - 6). Generally, project management success results much lower than project owner success level. The study found that projects with high project management success may fail in project owner success.

On the other hand, both success dimensions found highly correlated with PM processes use intensity. Thus, further, the study concentrates on processes of project management that affect project success. Data gathered from project managers about using the intensity of planning processes gives total vision about obtained project success results.

2.3 Assessment of high-tech projects` critical success processes based on PMBOK standard

The inconsistency of information about high-tech project management in the Republic of Kazakhstan creates a need for investigation of local PM practices. It is worth noting that PM elements entered the domestic market since its independence in the 1990s and the local research in this field gained an interest in the early 2000s [128]. The actual process of promoting PM began in 2003 and it demonstrates slow dynamics because academic training in Project Management is carried out in the Republic only since 2008 [129].

Therefore, it`s difficult to discuss the features of domestic high-tech project management. Primarily, the research work identifies the maturity of using PM tools, especially, PM processes and organizational support processes used by local project managers for clarifying the features of high-tech project management.

Secondly, the study identifies the critical success processes that affect high-tech project success. Listed above tasks were achieved by the suggested model that measures the relation between PM processes use intensity and project success dimensions. The survey organized for collecting data about the extent of use of PM processes. Project managers who participated in the survey were asked about the extent of the use of 16 planning processes. They evaluate it through scale ranging from 1 to 5 Likert scale, where 1 is the worst result and 5 is the best result.

Project managers evaluate the use intensity of each process according to PMBOK standard. It means that project managers asked about the extent of use PM processes described in this standard. The best results show that the project team actively uses the process. The list of investigated PM processes was presented in theoretical chapter of this work. For a clear understanding of the calculation process, the next table shows the sample of collected data on the example of Green energy projects (table 33).

Table 33 - Sample of collected data for Green energy projects

№	Project	Process 1	Process 2	Process 3	Process …	Process 16	PQ index (Average meaning)
1	Project 1	5	5	1	…	1	3,8
2	Project 2	5	5	4	…	4	4,0
3	Project 3	5	4	4	…	4	3,3
4	Project 4	5	5	4	…	5	4,9
5	Project 5	5	5	5	…	5	5
6	Project 6	4	4	3	…	3	3,5
7	Project 7	5	5	1	…	4	3,4
…	…	…	…	…	…	…	…
22	Project 22	5	3	1	…	4	3,1
Note - compiled by author based on own research							

According to table 33, detailed information about the extent of use investigated 16 PM processes by project managers who run Green energy projects shows that their scores are different. It means that they use PM processes differently. Datasheet helps to identify the average use intensity of each 16 processes that are called PQ index. The maximum possible PQ index is 5. The higher index shows the high quality of performing PM processes. As the results show, the project manager of Project 4 actively uses PM processes. It may help to achieve the highest level of project success. The next table compares the success results of listed above Green energy projects for checking this statement (table 34).

Table 34 - Comparing project success results with PQ index of Green energy projects

№	Project	PQ index	Cost overrun	Schedule overrun	Customer Satisfaction	Success level
1	Project 1	3,8	33	12	5	Low
2	Project 2	4,0	15	5	8	High
3	Project 3	3,3	70	0	4	Low
4	Project 4	4,9	-20	0	9	High
5	Project 5	5	0	0	10	High
6	Project 6	3,5	150	5	5	Low
7	Project 7	3,4	70	0	8	Medium
…	…	…	…	…	…	…
22	Project 22	3,1	27	0	5	Low
	Average	3,6	45,13	6,1	7,2	
	Note - Compiled by author based on own research					

The highest level of PQ index provides high level of project success dimensions. Thus, the Project 4 that has PQ index 4,9 shows the highest level of success. As depicted in table 32, this project is completed in time and spent less than planned budget, in addition, was satisfied a customer. The next table shows the detailed PQ index for all investigated high-tech projects (table 35).

Table 35 - PQ index for high-tech project groups

Indicator	Green energy projects	Nanotech-y projects	Biotech-y projects	Engineering projects	IT projects	Comm-s projects
N	22	19	16	33	31	28
PQ index	3,6	3.1	4,0	3,9	4,5	3,8
Cost overrun, %	45,13	61,9	19,8	29,5	12,2	21,8
Schedule overrun, %	6,1	6,8	1,8	3,9	2,8	8,6
Customer satisfaction	7,2	7	8,5	7,2	8,5	7,3
Note - Compiled by author based on own research						

Nanotechnology projects` PQ overall index is lower than in all projects. It means that managers who run nanotechnology projects make little use of project management tools.

Projects with high PQ index like IT projects (4,5) and Biotechnology projects (4,0) have a high level of success dimensions like cost and schedule overrun lower than 15%, customer satisfaction level higher than 7 by Likert scale.

The detailed data analysis presents the processes that often performed by each industry`s project managers. This information depicted in table 36.

Table 36 – PQ index of processes for high-tech projects by industry

№	Planning processes	PQ index/ Green energy projects (n=22)	PQ index/ Nanotech-projects (n=19)	PQ index/ Biotech-nology projects (n=16)	PQ index / Enginee-ring projects (n=33)	PQ index / IT projects (n=31)	PQ index / Communi-cation projects (n=28)
1	Project plan development	4,7 +	3,9 +	4,6 +	4,5 +	4,7 +	4,3
2	Scope planning	3,8 -	3,6	4,5	3,0 -	4,7 +	3,6
3	Scope definition	2,6 -	1,4 -	3,3 -	3,6	4,4	2,9 -
4	Activity definition	4,1	3,5	4,7 +	4,3	4,7 +	4,1
5	Activity duration estimating	3,2	3,5	3,9	4,2	4,5	4,0
6	Schedule development	3,4	3,0	4,0	3,5	4,3	3,7
7	Resource planning	3,4	3,2	4,0	3,8	4,5	3,8
8	Cost estimating	4,4 +	3,5	4,4	4,3	4,6 +	4,3
9	Cost budgeting	4,6 +	3,7 +	4,7 +	4,5 +	4,9 +	4,8 +
10	Quality planning	3,0	2.1 -	3,9	3,7	4,3	3,6
11	Organizational planning	4,3	3,6	4,5	4,2	4,6	4,4 +
12	Staff acquisition	3,4	2,7	3,7	3,7	4,3	3,7
13	Communication planning	2,7 -	2,2	3,8	3,5	4,0 -	3,7
14	Risk management planning	2,6 -	1,8 -	3,3 -	2,9 -	3,9 -	3,0 -
15	Procurement planning	3,9	2,3	4,0	3,9	4,1	3,4 -
16	Stakeholder planning	3,4	3,2	3,9	4,3	4,6	4,1
Note – Compiled by author on the base of own research							

Table 36 shows essential differences between chosen industries in performing project management planning processes in detail. For example, IT-project managers perform cost budgeting, cost estimating, scope planning, schedule, quality and communication processes much better than other projects. These findings explain the best results of IT projects during measuring success dimensions like cost, schedule overrun and customer satisfaction. Data from this table (table 33) shows specific processes used by project managers from each high-tech industries. Moreover, these findings help to clarify which knowledge areas are specific for particular types of high-tech projects.

An interesting finding is that the study found general processes that often used or ignored by all high-tech project managers. Precisely, processes often used by all project managers are plan development and cost budgeting. Then less used processes are scope definition and risk management.

Further, CSP was identified by calculating multi-variable regression. For each run of the regression analysis, the linear coefficients (beta) were used to evaluate the importance of a planning process on a project success variable (Appendix F).

A P-value less than 0,05 shows the significance of the results and lets to accept the process as a critical (table 37).

Table 37 - CSP for each type of high-tech project

Process	PQ index/ Green energy projects (n=22)	PQ index/ Nanotech-projects (n=19)	PQ index/ Biotech-nology projects (n=16)	PQ index / Enginee-ring projects (n=33)	PQ index / IT projects (n=31)	PQ index / Communi-cation projects (n=28)
Project plan development	+	+	+	+	+	+
Scope planning			+			
Scope definition		+	+	+	+	
Activity definition	+			+	+	
Activity duration estimating	+				+	
Schedule development		+		+	+	+
Resource planning			+			+
Cost estimating	+			+	+	
Cost budgeting						+
Quality planning	+		+			+
Organizational planning					+	
Staff acquisition		+				
Communication planning	+					+
Risk management planning		+		+		
Procurement planning		+				
Stakeholder planning				+		
Note – Compiled by author on the base of own research						

As table 37 shows, regression analysis helps to reveal CSP for each project. It means that using these processes increases the level of project success.

Further research focuses on a detailed explanation of critical planning processes for each project type. The specific processes for Green energy projects are shown in figure 22.

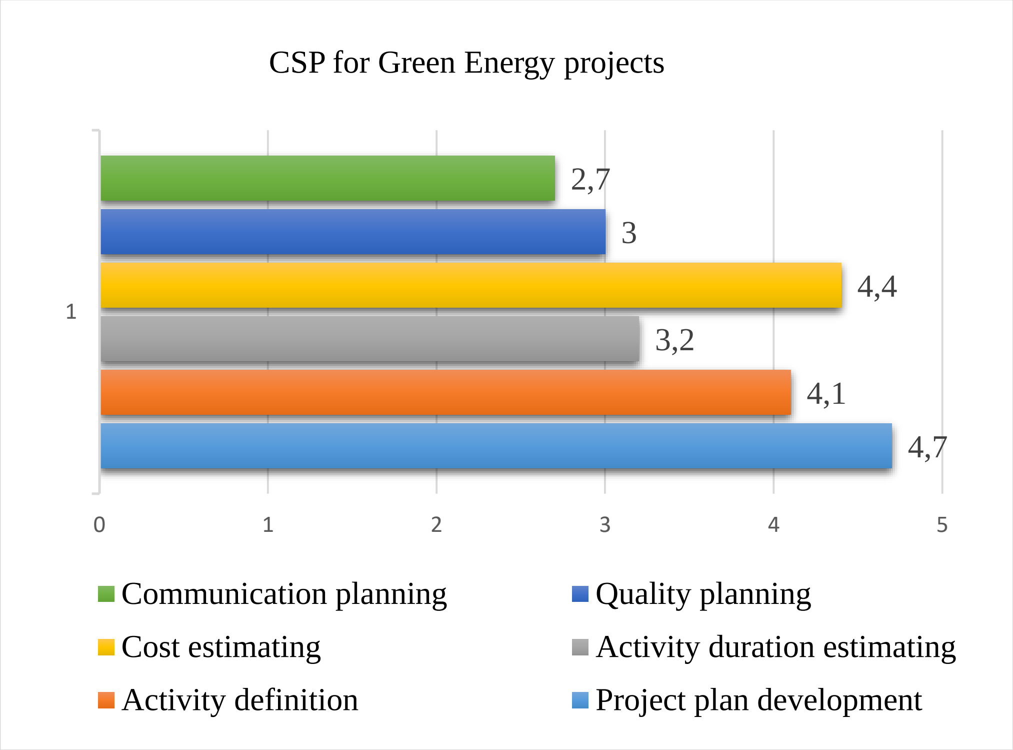

Figure 22 - CSP for Green Energy projects

Note - Compiled by author based on own research

Green energy projects are highly impacted by depicted above processes, therefore, project managers should focus on them. It is worth noting that project plan development is a less used process despite its importance. For example, it was clarified that managers who run green energy projects pay more attention to activity duration estimating, schedule development and cost estimating.

The study explains these findings as follows - derived processes are components of the “Golden Triangle” (cost, schedule, quality) that well-known and often used by managers from all over the world. In addition, the least used processes of PM are risk management, quality planning, and communication planning. These processes are ignored despite their importance for high-tech projects.

We should note that the use of these processes is essential and necessary for projects that are implemented through using high-technologies, like the production of renewable energy.

As figure 21 shows, there are 5 processes from 4 knowledge areas that strongly affect green energy project success (table 38).

Table 38 – Basic PM knowledge areas affect green energy project success

№	Planning processes	PMPQ index	Knowledge area
1	Activity definition	3.6	Project schedule management
2	Activity duration estimating	4.0	
3	Risk management planning	2.5	Project risk management
4	Quality planning	2.6	Project quality management
5	Communication planning	2.6	Project Communication management
Note – compiled by author on the base of own research			

Thus, table 38 shows, project schedule management, and project communication management have the highest impact on green energy projects success. Moreover, project risk management and quality management are critical knowledge areas for green energy projects too. These findings led us to suggest tools and techniques from revealed 4 knowledge areas for improving the efficiency of the project. We may state that using tools from these knowledge areas increases the success of investigated projects, because of the high level of p-value.

The next figure shows the critical planning processes for a project manager that execute Nanotechnology projects (figure 23).

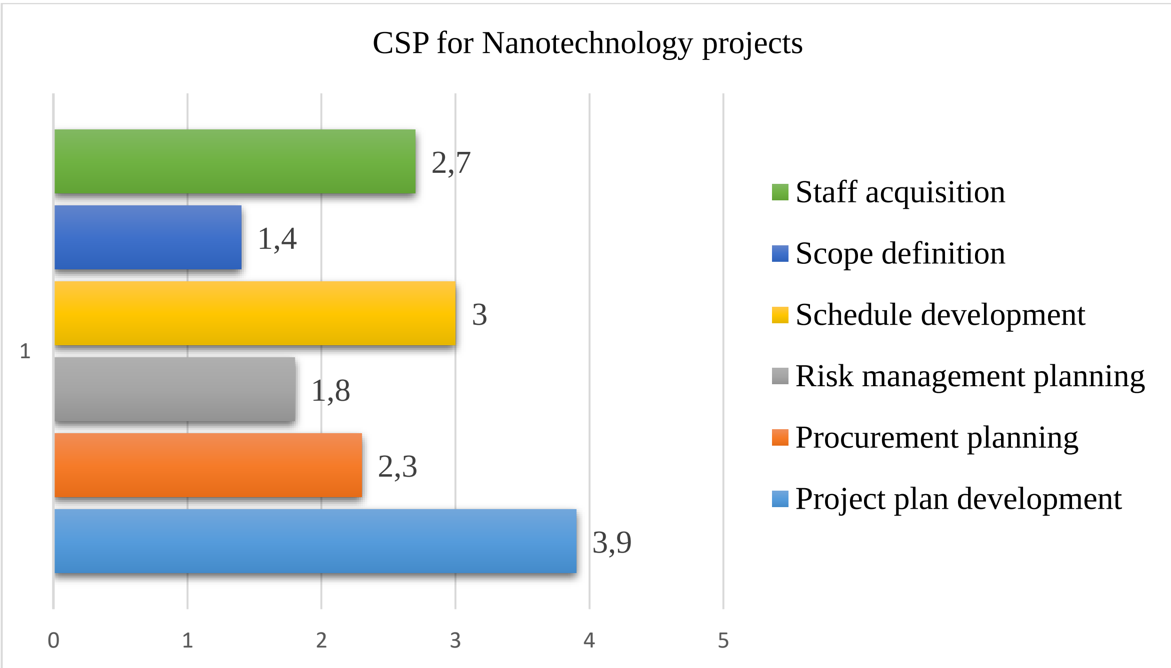

Figure 23 - CSP for Nanotechnology projects

Note - Compiled by author based on own research

Project efficiency evaluation has also revealed critical processes for Nanotechnology and biotechnology projects. They are “Procurement planning”, “Schedule development”, “Project plan development”, “Staff acquisition”, “Scope definition”.

The figure 24 represents the CSP for Biotechnology projects.

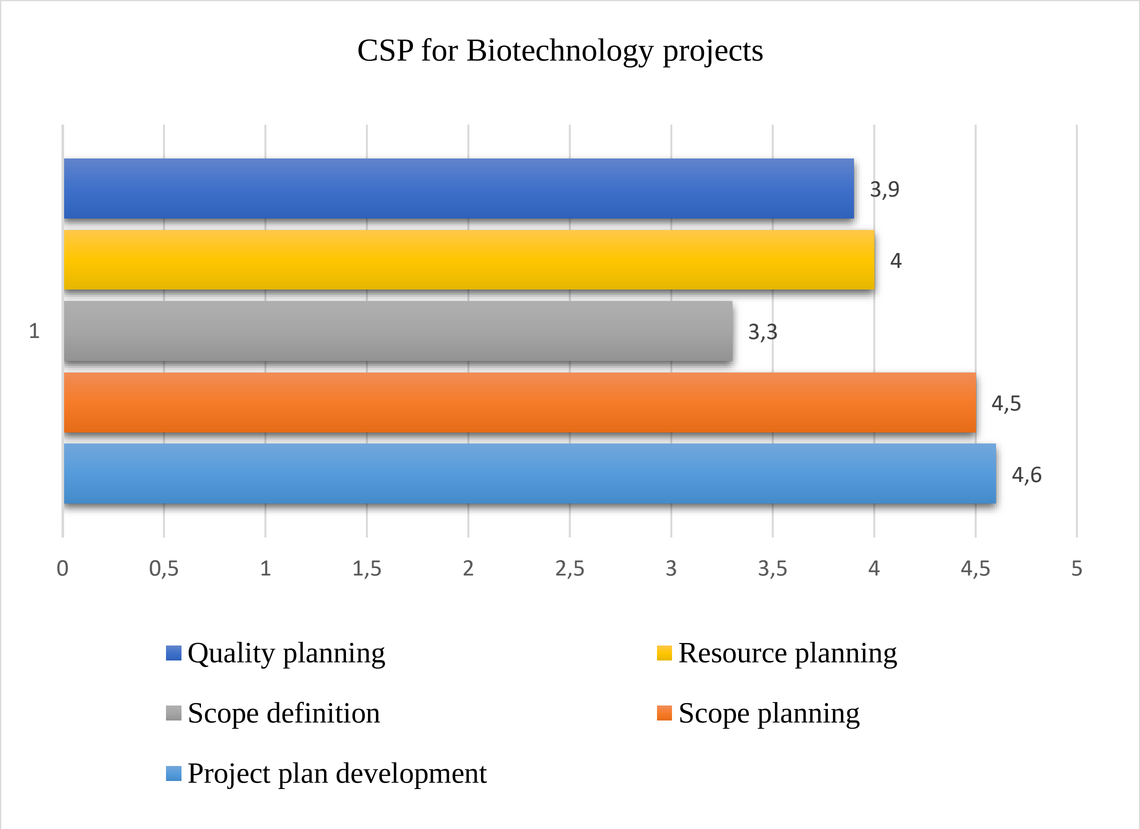

Figure 24 - CSP for Biotechnology projects

Note - Compiled by author based on own research

Specific processes for Biotechnology projects are: “Scope definition,” “Quality planning,” “Project plan development,” “Scope planning”. Three of them have high use intensity among project managers who run Biotechnology projects, but “Scope definition” stills quite low. These processes belong to certain PM knowledge areas shown in table 39.

Table 39 – Basic PM knowledge areas affect Engineering project success

№	Planning processes	PMPQ index	Knowledge area
1	Project plan development	4,5	Integration management
2	Activity definition	4,3	Schedule management
3	Scope definition	3,6	Scope management
4	Cost estimating	4,3	Cost management
5	Cost budgeting	4,5	
6	Identify Stakeholder	4,3	Stakeholder management
	Note – compiled by author on the base of own research		

CSP for Engineering projects are depicted in figure 25.

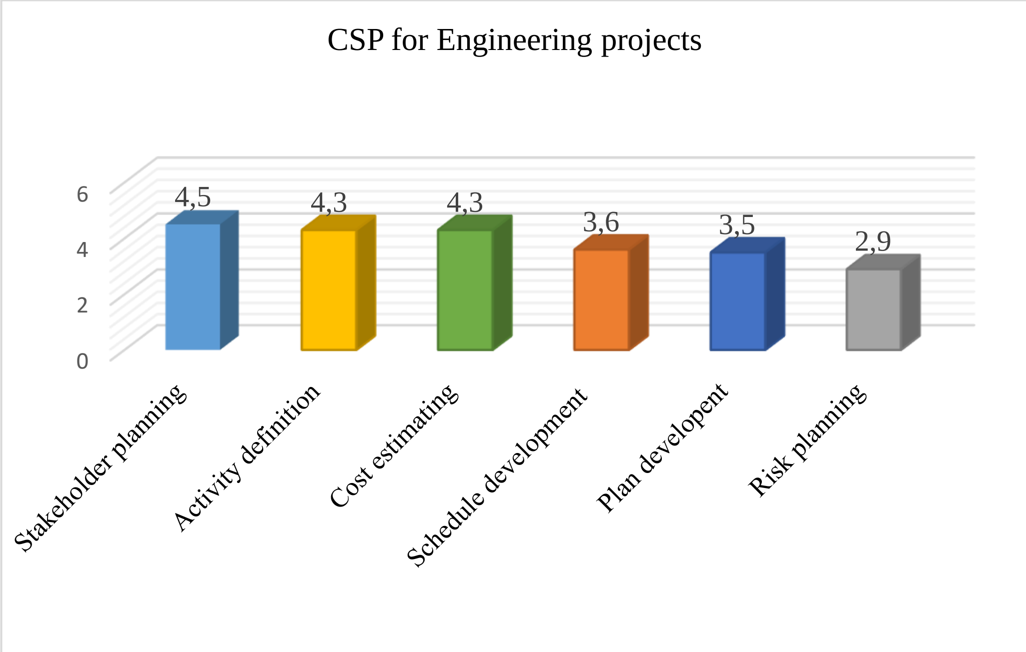

Figure 25 - CSP for Engineering projects

Note - Compiled by author based on own research

As figure 25 shows, Engineering projects highly affected by 5 PM knowledge areas that intensively performed by project managers except for scope management. The next figure (figure 26) shows critical processes for IT-projects.

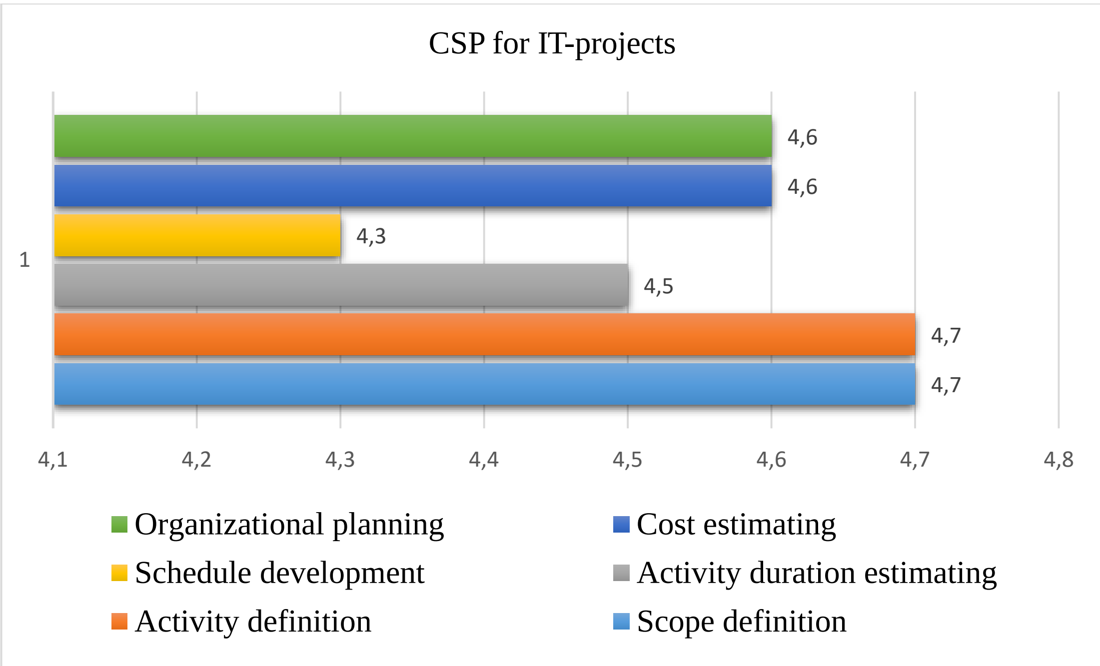

Figure 26 - CSP for IT-projects

Note - Compiled by author based on own research

As depicted in figure 26, IT-projects have the highest extent of use PM processes. It`s not a surprising fact. Because its worldwide known that PM tools actively used and well developed in the area of software [123, P. 121]. All the revealed CSP actively performed by project managers who run these projects in the software industry. The critical knowledge areas for IT-projects are scope management, schedule management, human resource management.

Figure 27 shows CSP for Communications projects.

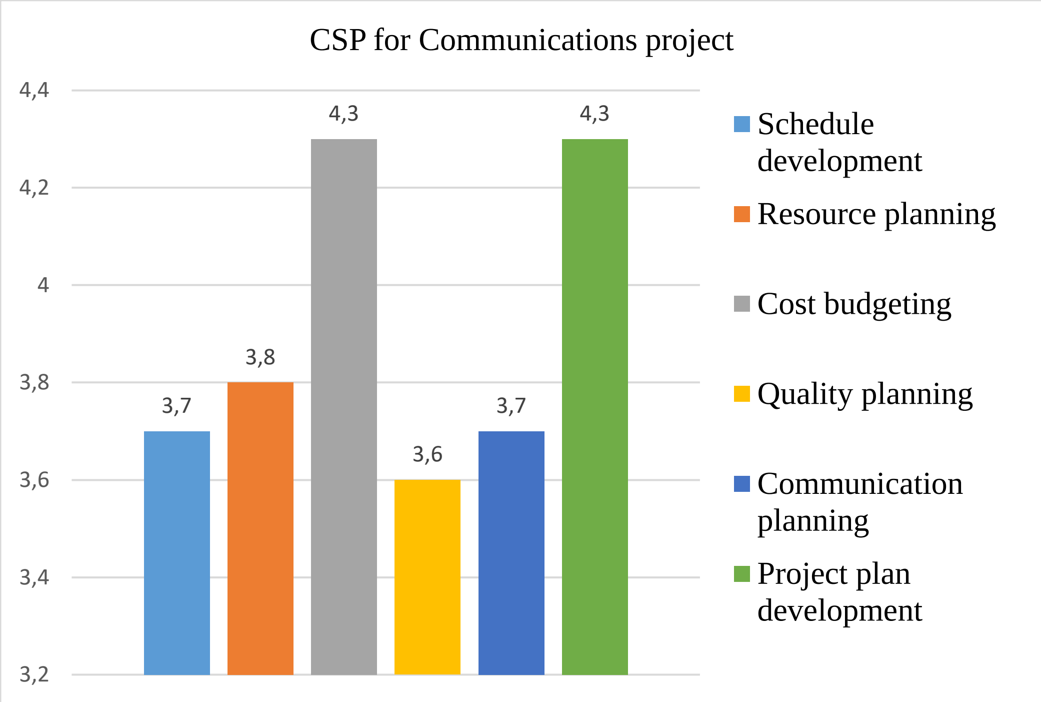

Figure 27 - CSP for Communications projects

Note - Compiled by author based on own research

Figure 27 presents critical knowledge areas for IT-projects. They are integration management, scope management, quality management, cost management, schedule management.

The calculations will help to identify a list of tools and techniques for managing a particular type of high-tech project. Suggestions based on the analysis described above will be presented in the next chapter. In this regard, it`s essential to clarify the use of the intensity of PM tools by domestic project managers.

The data collected will show the level of maturity of domestic companies regarding the application of project management. Thus, the study focuses on organizational support level analysis. The PQ index of organizational support is measured by the average extent of use of organizational support processes by project managers of the Republic of Kazakhstan.

The data was collected using the same methodology and survey described in the theoretical part of the dissertation work. Companies that take part in an investigation are local representatives from business structures, scientific institutes, project-oriented companies, universities, etc. The analysis of support processes shown in table 40.

Table 40 – Organizational support processes used by project managers of the Republic of Kazakhstan

№	Organizational support processes	Average use intensity (max core-5) (n=172)
1	Extent of existence of project`s procedures	3.8
2	Project manager assignment	3.7
3	Organizational projects resource planning	3.5
4	Involvement of the project manager during the initiation stage	3.4
5	Extent of use of organizational projects data warehouse	3.4
6	Extent of use of new project tools and techniques	3.2
7	Project-based organization	3.0
8	Communication between the project manager and the organization during the planning phase	2.9
9	Organizational projects risk management	2.6
10	Extent of organizational project`s quality management	2.5
11	Extent of use of standard project management software	2.3
12	Extent of supportive project organizational structure	2.3
13	Regular project management training programs	2.2
14	Project office involvement	2.1
15	Existence of interactive inter-departmental project planning groups	2.1
16	Existence of project success measurement	1.9
17	Extent of refreshing project procedures	1.9
Note – Compiled by author based on own research		

As depicted in table 40, project managers are supported by their organizations, but not at proper level and the manner in the Republic of Kazakhstan. For example, in developing countries like Israel and Japan average score is more than 3 [82, p. 460].

As table 40 shows, the extent of existence of project`s procedures is the most used process by project managers in Kazakh companies (average score - 4), when such important point like the extent of supportive project organizational structure is ignored by companies, and it`s achieved worse results (average score - 2.3).

Kazakhstan is a young developing country that tries to use new techniques and approaches in all spheres of business. It can motivate companies to use modern technics and new tools for managing high-tech projects (average score - 3.3). The use of organizational projects data warehouse in domestic companies show a good result. The reason for this finding may be due to the fact that our companies less experienced in PM and try to learn from previous mistakes and pay more attention to saving data about projects for using their experience in the future.

Probably the same level of communication between the project manager and the organization during the planning phase and project office involvement in Kazakhstan may explain in a next way: lack of experience motivates and pushes organizations to actively participate in managing projects, support managers. Another interesting finding that the existence of project success measurement is the most failed process by local project managers. It may be explained by ignorance of project success evaluation methods, lack of experience.

Results show that critical knowledge areas for high-tech project success in the Republic of Kazakhstan are project integration and scope management, communications management, risk, and quality management. Moreover, the study identifies critical support processes for high-tech project management that depicted in table 41.

Table 41 - Critical processes for high-tech project success management in the Republic of Kazakhstan

№	Organizational support process	Score	P-value
1	Project manager assignment	3.7	0.001**
2	Extent of use of standard project management software	2.3	0.001**
3	Communication between the project manager and the organization during the planning phase	2.9	0.001**
4	Extent of supportive project organizational structure	2.3	0.001**
5	Extent of use of new project tools and techniques	3.2	0.001**
6	Existence of interactive inter-departmental project planning groups	2.1	0.001**
7	Extent of use of organizational projects data warehouse	3.4	0.009**
8	Project office involvement	2.1	0.013*
Note - *p≤0.05: **p≤0.001 (High significance) Compiled by author based on own research			

As depicted in table 41, the next critical processes performed by local managers have sufficient influence on high-tech project success: using project management software, the existence of the project-based enterprise, supportive organizational structure, support on planning and using new tools. They identified through using the p-value indicator. Precisely, score p≤0.05: **p≤0.001 means that results are significant. Calculations and datasheet are attached in Appendix F. Performing these processes by project managers ensure high-tech project success achievement. But frustrating finding of this evaluation is that such important processes less used by domestic project managers. For example, 5 from 7 critical processes don`t achieve a score of 3. It means that local companies implementing high-tech projects most often assign a project manager and try to save data about implemented projects, but ignore other critical processes. Ignoring these processes lags behind the development of high-tech project success management.

To sum up, conducted analysis reveals a strong connection between project management processes and project success. Project managers that actively use PM processes achieve success. Also, it becomes clear that findings from the evaluation of critical success processes will help to suggest tools and techniques from revealed knowledge areas in the next paragraph. Project managers may find these tools from each critical knowledge area those described in the PMBOK Guide.

An assessment of the relationship between PM processes and success indicators of high-tech projects revealed that the PQ-index of the project, reflecting the intensity of use of PM processes, is highly correlated with such success indicators as deviation from cost and timing, customer satisfaction level (R = 0.6; R = 0.5; R = 8, respectively). According to the calculations, IT projects have the highest PQ index (4.5), which explains the high level of success. And the PQ index of nanotechnology projects is one of the lowest (3.8), which explains the low level of success. Thus, it became clear that the intensive use of PM processes increases the level of success of high-tech projects.

3 IMPROVING THE HIGH-TECH PROJECT SUCCESS MANAGEMENT IN KAZAKHSTAN

3.1 Prospective approaches to the improvement of infrastructure for high-tech project implementation based on foreign experience

Successfully implemented high-tech projects are an essential mechanism for achieving sustainable development. Managing them in a proper manner brings a lot of benefits. Therefore, the study investigates the features of such projects and prepares several ways of improving their management.

Previous analysis that dedicated to innovative infrastructure investigation reveals a set of barriers that lags behind the development of high-tech projects. The basic barriers were the immature innovative system with incoherent infrastructure and lack of specific PM knowledge and practice which expressed by an inability to successfully manage projects. Analysis of PM processes used by domestic project managers shows that they rarely apply PM tools when managing projects. Thus, the study suggests several approaches to the improvement of domestic high-tech project management.

Firstly, the study suggests the complex of recommendations that includes several approaches to infrastructure improvements for high-tech project implementation (figure 28).

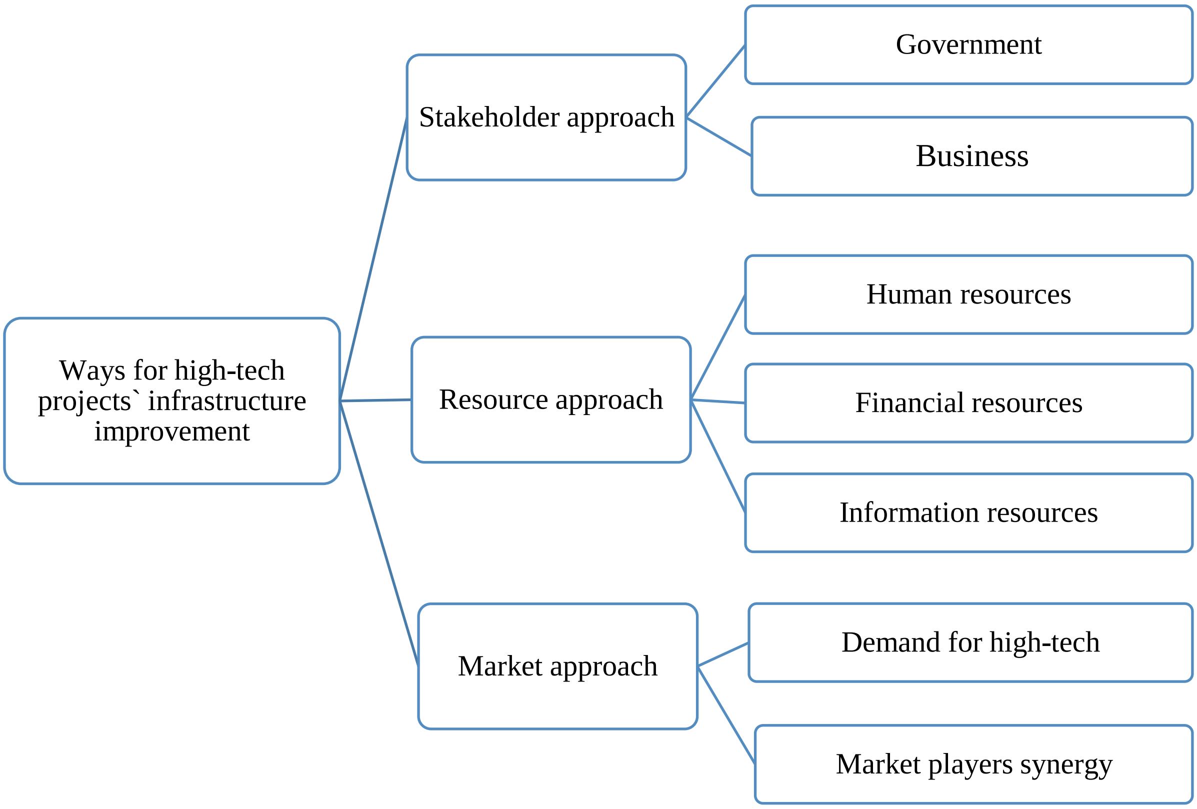

Figure 28 - Ways for improving infrastructure for high-tech project implementation

Note - Compiled by author based on own research

Figure 28 shows the basic approaches that include 3 directions aimed to improve the high-tech projects` infrastructure functioning - stakeholder approach, resource approach, and market approach.

Stakeholder approach. The stakeholder approach consist of two major players like government and business. The study describes their role and prospective approaches for improving them.

The contribution of government may be reflected in several directions of support depicted in table 29.

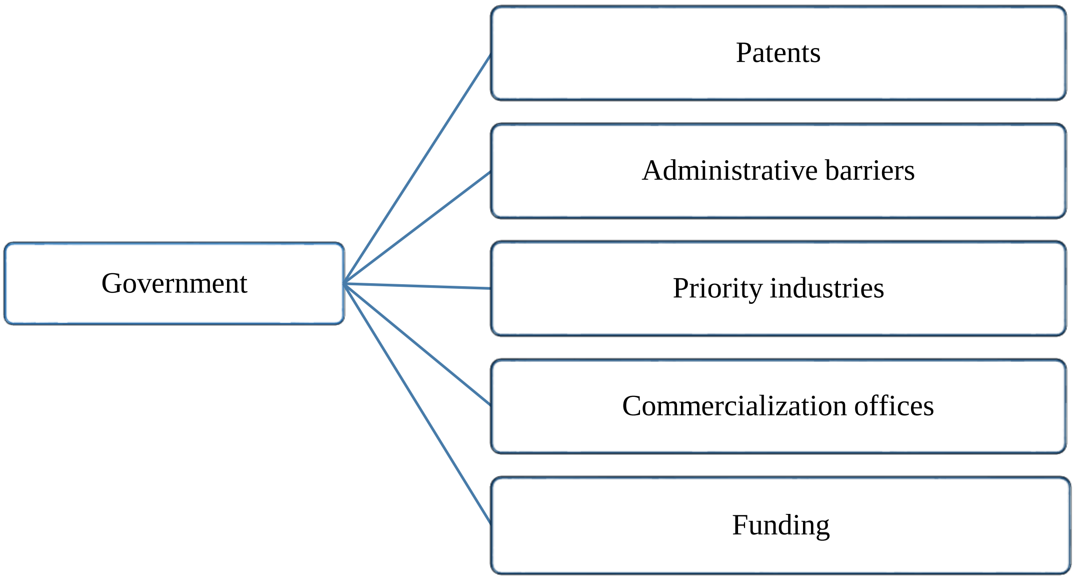

Figure 29 - Directions for improving the state support of infrastructure development for high-tech projects

Note - Compiled by author based on own research

As figure 29 shows, state support should be directed to increasing listed above objectives. Precisely, the next activities should be done by the government in order to high-tech infrastructure development:

1. Improving the system of intellectual property protection like patents. It may be ensured by making patents profitable as in many developed countries. The states need an information system that will include data about domestic patents and connect local producers with the foreign patent world. It introduces the specifics of patenting abroad and show the features of international patents. Domestic producers will recognize the foreign practice, world tendencies and actual demand for patents.

2. To develop a mechanism for increasing the level of introduction of research and development into production. For doing this to expand the system of state grants and reducing administrative barriers.

3. To increase the productive orientation of the elements of the innovation infrastructure, as a priority of the agro-industrial complex, medicine, etc. For example, agroindustry and biotechnology have a huge potential for high-tech projects development. The government may highlight these industries as major for funding or

other kind of support. It may be possible through determining the mechanism of supporting by technoparks the companies that implement high-tech projects in these fields.

4. To expand the legal framework of the development offices, commercialization centers in the regions. To create an organizational-economical mechanism for commercialization of scientific developments.

5. An activation of innovative entrepreneurship and diversification of methods of state stimulation of R&D development by preparing a new policy.

Figure 30 reflects the directions of business improvements for high-tech project infrastructure development.

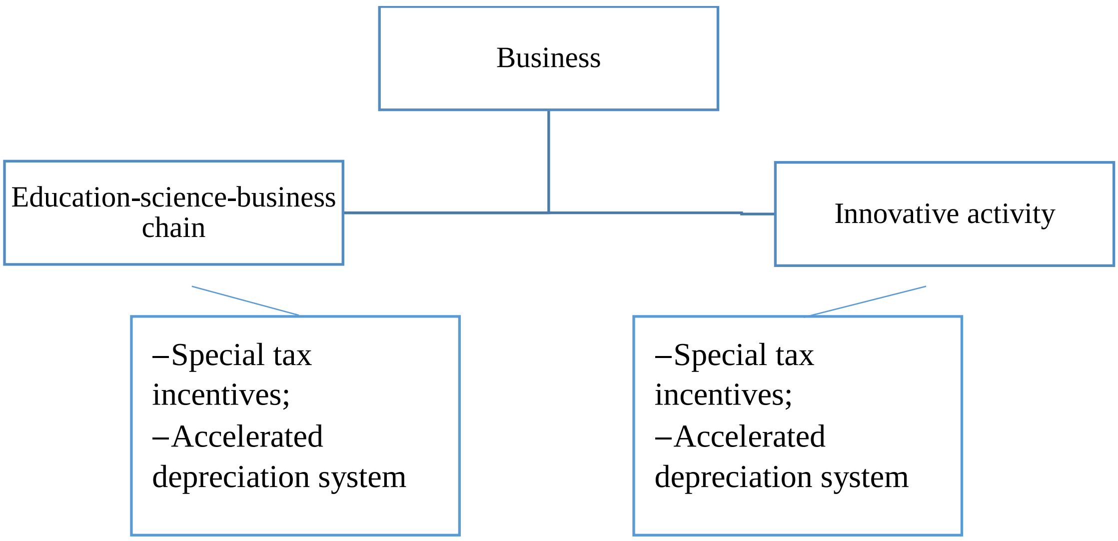

Figure 30 - Directions for improving the business support of high-tech project infrastructure development

Note - Compiled by author based on own research

As figure 30 shows, the next measures are proposed as effective for establishment of “education -science - business” chain:

1. The national companies should be engaged in the state's technological development. In Switzerland, for example, most patents and inventions are registered per capita. Because the state, business, and educational institutions are joining together to create technology parks and research centers. Industrial giants actively participate and invest in the opening of research centers and innovative developments. This practice may contribute to the establishment of an innovative economy for the sustainable development of the Republic of Kazakhstan [130].

2. In the United States, university income is not limited to educational services. The universities have endowment funds supported by graduates. For example, the Harvard University endowment fund is $ 37.1 billion, Yale - $ 27.2 billion, Stanford - $ 24.8 billion [131]. Universities invest this money, and they spend profit on infrastructure development, grants and creation of venture funds. As a result, it is not so difficult for startups in the USA to find financing, they don`t depend on government

funding. Our domestic universities like Al-Farabi Kazakh National University, State law university, Narxoz University, Kazakh National Research Technical University named after K. I. Satpayev and others have such endowment funds. But they don`t focus on supporting high-tech projects and start-ups. These funds should change their activity to the side of venturing and funding prospective projects.

3. To ensure the cooperative projects that include partners from the business environment. For example, tenders for grant financing of projects may be put forward by the condition of the partnership of a research institute or project-based organization applying with a business representative.

4. Using the cluster approach. Ensuring the development of joint research and development projects for cluster members (involving research institutes, educational institutions, and enterprises). To attract domestic scientists, business representatives and other stakeholders to joint cooperation by supporting them. The study uses Project G from the green energy industry evaluated in the previous paragraph for developing cluster design. The figure depicted below shows the example of cluster building for high-tech project implementation (figure 31).

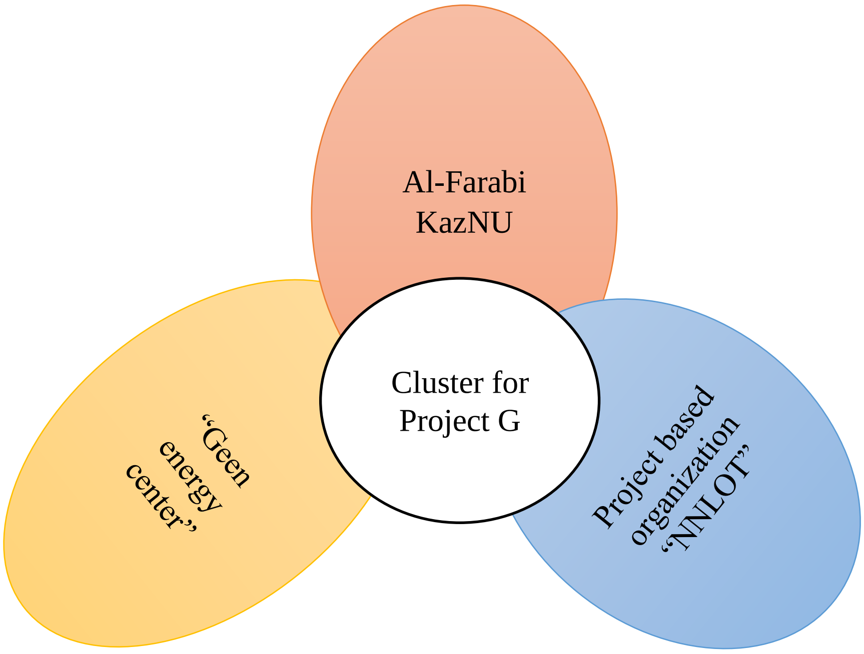

Figure 31 - Cluster design for Project G from Green energy industry

Note - Compiled by author based on own research

As figure 31 shows, the design of the cluster for Project G discussed in the previous chapter includes 3 components like Al-Farabi KazNU, project-based organization "NNLOT" and "Green energy center" concentrated in the university campus. A cluster may include more than three elements. It depends on project type, complexity, and stakeholders.

It is worth noting that clusters should aimed at achieving effective cooperation of organizations - suppliers of equipment and components, specialized products and services, research and educational organizations in the framework of territorial production clusters. This practice is started to be introduced in the Republic of Kazakhstan, but not completely. If some organizations were able to integrate science and education with production, a few amounts of them may organize a close locations and cooperate with suppliers.

1. To use the Triple Helix model for integrating education science and business. An application of this model for the high-tech projects is shown in figure 32.

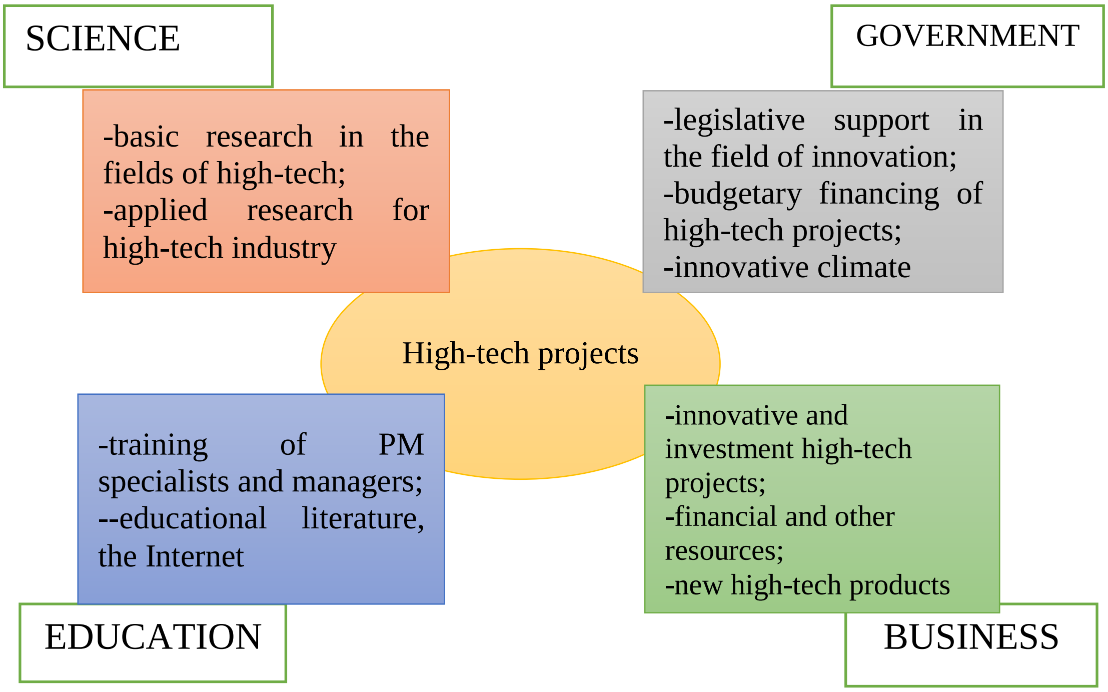

Figure 32 - Innovative partnerships in science, education, state and business for high-tech project implementation

Note - Compiled by author based on own research

This partnership depicted in figure 32 was called the Triple Helix model abroad. This model includes all major partners - the power, business, science, and education complex (research universities). Each of them will ensure, in particular, the necessity of participation in the initial stage of the innovation economy [132].

The "triple spiral" may be used for ensuring step-by-step high-tech project implementation as a result of the constructive interaction of the scientific and educational complex, business and state. Initially, there are two spirals of interaction between higher education institutions (science) and business, business and government, etc., which are combined into a "triple spiral" Thus, the role of any institution is clearly regulated: Business function in the "Triple Helix" formula is production, government is the source of contractual relationships that provide stable relationships, and the scientific and educational complex is a source of knowledge and technology. The using this model may bring the next benefits for high-tech projects` infrastructure development

- strengthening the role of the scientific and educational complex as the leader of business and power relations;

- expansion of traditional functions of each of the three-dimensional spirals in the format "partially taking up another's role". Institutions that are ready to change are ready to accept non-traditional functions.

Ways for improving the innovative activity of the business:

1. Implementation of regressive corporate income tax for satisfying business representatives. The government can encourage business to the side of innovative activity and motivate to explore new products. Such taxes are included in Japan, South Korea, and the United Kingdom. The corporate income tax is reduced to 10% - in Japan, 7% - in South Korea and -1% - in the UK. Foreign experience defense that it was the provision of tax benefits in countries such as Ireland, China, and Israel that caused rapid economic growth and the reorientation of their economies to high-tech industries [133].

2. Granting credits for innovation purposes, deductions the resources from the tax of the enterprise for a certain period of time necessary for the implementation of innovative projects. This step will allow the company to perform smaller projects without looking for different sources of financial support.

3. "Tax breaks" for enterprises earning profits from implementing high-tech and innovative projects. Increasing the number of innovation projects to increase the number of vacation days. This method is common in the United States. Many firms seeking tax exemption are interested in innovative projects. It`s important to develop specific mechanisms that will attract companies to create innovative products.

4. Introduction of a simplified personal income tax on dividends of individuals and legal entities acquiring shares of innovation companies accepted in South Korea and Malaysia. This discount will enable the company to attract additional capital by issuing shares to innovation companies.

5. Reducing corporate income tax to legal entities that have been engaged in research and innovation development, intangible assets included in intellectual property and earned their income. This kind of tax will allow producing more scientific products. The examples of using such kind of measures exist in Japan, the USA, Canada, and Sweden.

6. Partial taxation of innovation companies in special accounts shall be taxed on subsequent occasions if the entity uses such funds for innovative purposes. This type of tax is used in Finland and Germany. In those states, the simplified income tax rate is between 20% and 5%.

7. Application of accelerated depreciation method to enterprises within the innovation infrastructure. So in Japan, an accelerated depreciation system is introduced to companies that use energy-efficient equipment or are rationalizing their resources and operating with non-environmental equipment. Its size reaches 10% to 50%.

8. Creation of an engineering center with a pilot site for the development of new products (prototypes and batches), improvement of existing technologies at enterprises and adaptation of the best world technologies to the conditions of existing enterprises.

Resource approach. This approach consists of three directions like human, information and financial resources.

The study suggests the next ways for improving human resources potential:

1. Reconsidering the system of material motivation for scientific personnel. Today, the mechanism of stimulating science personnel in the country is ineffective and can`t contribute to the development of an innovative environment. In other words, talented and creative young people are eager to engage in business rather than science. And if the government is able to attract these qualified staff to science and use their mental advances in the field of innovation, it may stop the active “brain drain” phenomena. For example, for the first time, China entered the top 20, whereby the end of 2018 the number of specialists engaged in science and innovation will exceed 6 million. Such a large army of scientists and innovators is nowhere else. They achieved such results by improving the motivation system of Chinese scientific staff. Exempt from taxes scientific staff. This mechanism will give an impetus to enterprises' scientific personnel and their involvement in research and production.

2. Lack of experience of domestic specialists forced to invite foreign specialists. It is necessary to attract advanced human resources from various high-tech industries. For example, the UK constantly attracts IT specialists from around the world, therefore, it announced the simplified issuance of visas to foreign founders of startups in the spring of 2019. Kazakhstan may attract PM specialists, human resources from different innovative structures and industries, investors through special offers and attracting programs. In addition, government and responsible structures may assign agreements with world-leading organizations for training domestic specialists.

3. Improving the quality and modernization of the training system by moving to active involvement of production specialists in the educational process; the formation of opportunities for the introduction of advanced scientific results in the activities of enterprises by reorienting scientific research conducted technological tasks set by enterprises and the inclusion of the results of these scientific studies in the content of the taught disciplines.

Information resources. Information resources are legislative norms and laws that regulate and coordinate the activity of organizations involved in high-tech project implementation, and the process of exchange of information. The measures that help to increase this direction are:

– To develop an interactive information system like a database that will connect all participants of innovative activity in the Republic of Kazakhstan. For example, project owners that win the financial support for the particular high-tech project will be involved in a virtual system where connected project teams, business-incubators, technoparks, outsourcing, and marketing agencies, supplying organizations, commercialization centers, etc. The project manager will be connected with specific divisions or assigned specialists from mentioned above organizations. This helps to increase communication between market players.

– To prepare a specific policy and state programs for supporting high-tech project implementation. For example, Russia adopted a law dedicated to the development of high-technologies at the national level. The United States developed a strategic plan to support high-tech industries in 2012 [134]. This plan increased the innovative potential of the USA market and provided leadership in producing high-tech products. Such legislative measures help to develop own high-tech production and proper execution of high-tech projects.

– To develop specific digital areas for communication of business representatives and producers of innovations where will be presented information about an order for specific products or services published by companies. Such a platform may increase information exchange between all participants of domestic innovative system. This suggestion derived from investigation of the USA experience. There are acts the National Advanced Manufacturing Portal that serves consumers and producers of innovative products.

Financial resources. Financial resources imply funding made by different organizations. Suggestions in this regard directed to several stakeholders depicted in figure 33.

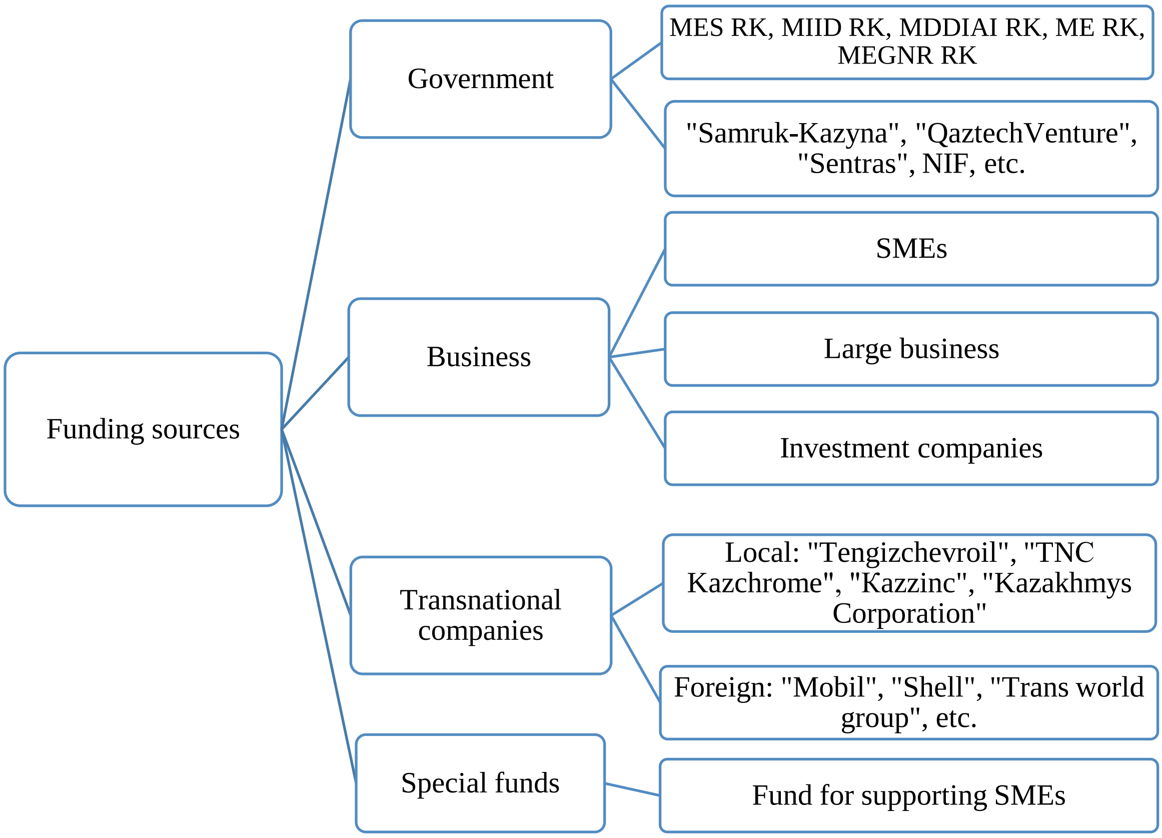

Figure 33 - Funding sources for high-tech projects in the Republic of Kazakhstan

Note - Compiled by author based on own research

As figure 33 shows, domestic high-tech projects have several sources of funding like government, business, and transnational companies. The different organizations may be fund and support high-tech projects. There is a huge role of the state that may coordinate the funding system by developing interactive web-platform where scientific developments will be commercialized through participating in competition for funding.

Market approach.

Increasing demand for high-tech products. The most developed countries among EU members like Germany, Finland, Belgium, Sweden, Great Britain, the Netherlands, and Norway have a huge experience in stimulating demand for innovative products and services. The study suggests using their practice in the domestic market. Precisely, the study suggests:

1. To systematically solve the issue of ensuring demand for innovations through the development of a public procurement mechanism. This mechanism should ensure domestic technology parks and research institutes to produce high-tech products (goods and services) ordered by quasi-public sector entities. In this regard, annual competitions should be held to attract domestic and foreign start-up companies to solve existing specific technological problems with the participation of large national companies. The immediate form of stimulating demand for innovation in government procurement. Authorities and governments act as buyers of innovation, either for their own needs or in combination with private participants in order to stimulate private demand. Using public procurement to meet public needs through high-tech product or service consumption stimulates the demand for innovations and increases the number of high-tech products.

2. To analyze the foreign experience helps to reveal and to adopt two approaches of stimulating private demand for innovations in the Republic of Kazakhstan that depicted in figure 34.

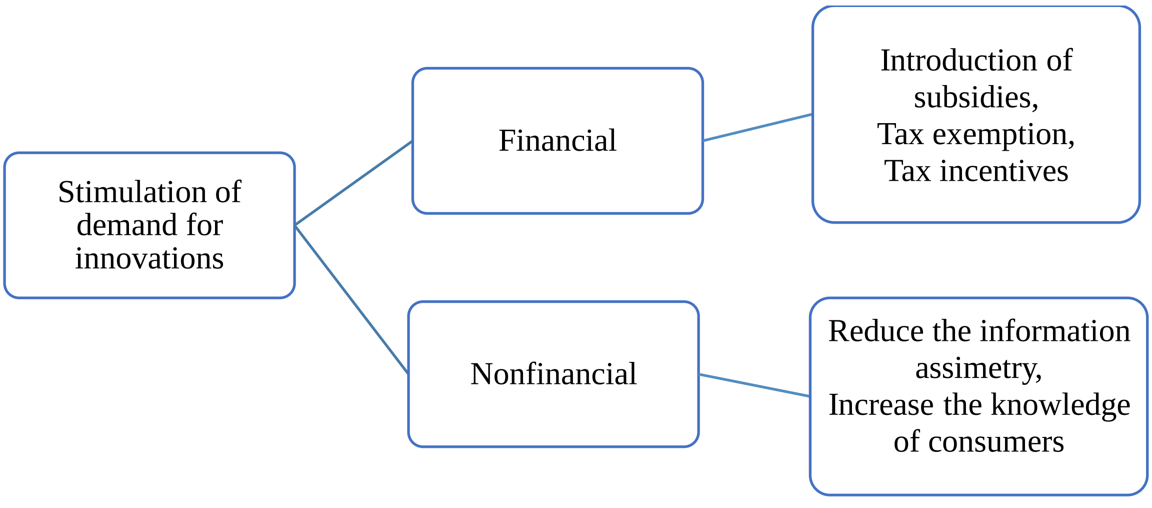

Figure 34 - Suggested approaches for stimulating private demand for innovations in the Republic of Kazakhstan

Note - Compiled by author based on own research

Thus, the study suggests increasing the demand for innovative products and services by using financial and nonfinancial tools that help to attract potential consumers. For example, tax incentives will help innovations to enter the market with fewer expenses and barriers. In addition, increase the knowledge of consumers about launched innovation help to easily accepts it in the market.

1. Obligation by the state each particular research organization to communicate with specific enterprises. The key point here is that the research organization will be able to win grants for two or three years. This measure may solve complex problems. The research organization will suggest a project that satisfies the needs of the business representatives. In addition, it may solve the problem of the absence of demand for innovations. The government should develop a mechanism for organizing this. It may prepare an official list of business companies classified by industry or acting area. On the other hand, research organizations may have a choice of looking for their own business representative.

2. To develop a specific policy that aimed to increase the demand for innovations. For example, the European Commission prepared such a policy called “Lead market Initiative” (LMI) and succeed in increasing the demand level [134, P. 73]. The study suggests adopting its policy according to our domestic market conditions. LMI differs from other policies by focusing on particular promising sectors of the economy that have great potential for developing innovative products and services.

The study extracts 4 directions of LMI policy and adopts it in accordance with the specifics of our domestic market that depicted in table 42.

Table 42 - Ways for increasing demand for the results of high-tech projects in the Republic of Kazakhstan adopted from EU practice

Legislative and regulatory measures	State procurements	Development of standardization, labeling and certification	Improving the exchange of information between producers and consumers
Law, decree aimed at accelerating innovation and removing barriers to producing and launching innovations in domestic market like ensuring companies from high-tech industries by free tax years.	Improving the system of publishing state order for innovative products or services in special platform that helps to establish cooperation of suppliers (manufacturers) and consumers	Their distribution throughout the entire production chain, from raw materials to final products aimed to provide quality, transparency and consumer confidence regarding to produced innovation	Promoting market transparency and awareness of consumers about product or service. These activities may include business services, financial support, etc.

Note - Compiled by author based on own research

As table 42 shows, the study suggests using basic four tools like Legislative and regulatory measures, state procurements, development of standardization, labeling and certification and improving the exchange of information between producers and consumers. The combined use of these measures provides a high level of demand for the results of high-tech projects in the Republic of Kazakhstan.

1. It`s necessary to explore trends of global innovative systems and demand in the world arena. Domestic scientists and researchers should try to produce goods and services desired by the foreign market too. It`s very important to direct your project to the side of global demand. It increases the chances of high-tech project success and the level of demand.

Improving market synergy. Given that the development of each innovation infrastructure is closely related to the development of other elements, positive changes can be achieved only through their comprehensive support and synergistic effect. It will be possible with implementing the next activities:

– Creation of scientific and innovative complexes in each region of the country. These complexes include higher education institutions, scientific research institutes, scientific centers, and other educational organizations, consulting, financing, marketing, advertising-exhibition companies, technology parks and technology business incubators that focused on services of patenting and licensing, intellectual property protection and support of innovation activities oriented at the development of new ideas and developments. These complexes should be open, available and supportive for all participants engaged in innovative and technological activity.

– Enhancing the efficiency of the elements within the infrastructure can be achieved by improving their interaction. In addition, each element of the infrastructure should strive for its own initiative and increase its communication with other elements. It`s important to establish inter-organizational communication that helps to coordinate a particular project by joint support. High-tech projects funded by the government or another institution should be able to rely on other participants of innovative systems like business incubators, technoparks, business representatives in the form of informational, financial, organizational, promotional support, etc. Government or responsible structures may develop a specific plan or map for coordination of complex support of particular projects. For example, the activity of development institutions should be directed to the side of serving the project. Particularly, development institutions that may invest should focus on funding one project, and other institutions should conduct researches related to the project, share risks, etc. In addition, they will give grants for SMEs when executing complex innovative projects.

– Optimization of Venture funds activity. To use the foreign experience for this. For example, the activity of the “Yozma State Venture Fund” may be a true example of successful venture funding practice. “Samruk-Kazyna” is engaged in the same activities. But the process of getting support from the fund is too bureaucratic. It is necessary to simplify this process and gradually transfer the activities of the fund to the private sector. In addition, it`s very important to move from state financing to attracting investments.

– Considering the zones of Kazakhstan as equal to the developed countries and introducing the use of those countries' policies in the regions. For example, the economic potential of the Zhambyl region and the economy of Japan can be considered equal. Because the Zhambyl region and Japan have no mineral resources. Trying to develop the features of the innovative policy of Japan in the Zhambyl region. The main reason for considering Zhambyl and Japan as equal is that Japan's innovation is a leading state in the world and the Zhambyl region is one of the most innovative regions in Kazakhstan. Thus, we may choose several innovative regions in our country and try to use foreign experience in these regions.

– Using the experience of the Novosibirsk and Belarusian technology parks to optimize the activities of local technology parks. 192 companies of high-tech park in Belarus exported $ 1 billion worth of products and IT services and attracted more than $ 100 million worth of foreign investment in 2017 [135]. The key to their success is focused on cooperation with business representatives. All important programs and guidelines in technoparks are prepared by the participation of companies. Technoparks are pay high attention to the wants and needs of business representatives and protect their interests. Our technoparks should keep in mind and try to apply this practice in the domestic market.

Today, the Novosibirsk technopark is considered one of the best technopolises in the world, which still correlates with the real needs of the market. It has huge export potential. They export their own products for billions of dollars. They had a critical scientific mass, an environment, a critical industrial mass, and education.

Novosibirsk Academic Campus is a Novosibirsk university, more than 40 universities around, 4 technoparks that produce a huge amount of pharmaceuticals, provide world-class medical services, have created an IT and technopark that are actively working and bring multimillion-dollar profits.

Almaty has the same platform and conditions, but the problem is how to put it together correctly for creating demand. The government should invite specialists from Novosibirsk academic campus, study their experience, build a partnership with them and try to apply their experience in the domestic market. It should be a strategic goal that aimed to increase the functioning and effectiveness of the innovative system components like technoparks, business incubators, business structures, etc.

To sum up, for the implementation of high-tech projects, an analysis of domestic infrastructure has led to the conclusion that it is still not mature enough and is not able to provide adequate support for the development of the high-tech market. The reasons for this were the following factors: the lack of systematic communication between market participants, expressed by the ineffective connection between science, production and business, such key elements of the innovation system - the state, business incubators, technological infrastructure, regulatory framework, and human resources. Thus, the study assumes that there is huge role of government in the development of an effective mechanism for innovative systems and technological infrastructure. Experience of government stimulation of breakthrough research by OECD member states shows that a 1% increase in government spending on R&D by 0.85% increases the likelihood of successful innovations and increases the share of new products in turnover by 0.7%.

In this case, the state affects the formation and development of economic activity in technologically advanced sectors through direct or indirect support measures [71, p. 21]. Therefore, the first challenge for the government in this direction is increasing

R&D costs level. It will be the first step towards overcoming barriers of technological development. The domestic innovative system and its infrastructure require an integrated approach to improvement.

3.2 Recommendations for improving high-tech projects success management

As revealed from the analysis, project success level depends on project management planning processes use intensity. Their strong correlation is calculated and defended in the previous chapter. This paragraph discusses the suggestions for managing the success of high-tech projects. More precisely, the study describes the critical knowledge areas for each type of high-tech project and appropriate PM tools for them, prepare a specific algorithm for managing each group of high-tech projects. Table 43 shows the specific PM processes that mostly affect green energy project efficiency.

Table 43 - Critical PM knowledge areas affect high-tech project success in the Republic of Kazakhstan

	PM knowledge area	Green energy projects	Nanotechnology project	Biotechnology project	IT-project	Engineering project	Comm-s project
1	Integration management	+	+	+		+	+
2	Scope management		+	+	+	+	
3	Schedule management	+	+	+	+	+	+
4	Cost management	+			+	+	+
5	Quality management	+		+			+
6	HR management		+		+		
7	Communication management	+					+
8	Risk management		+				
9	Procurement management		+				
10	Stakeholder management					+	
	Note - Compiled by author based on own research						

As table 43 shows, revealed critical PM knowledge areas for each high-tech project help to identify proper tools of PM and algorithm of processes that should be performed by project managers from different industries. The study revealed that each knowledge area has its own instrument using of which will increase the high-tech project success. An algorithm of processes for Green energy projects is presented in figure 35.

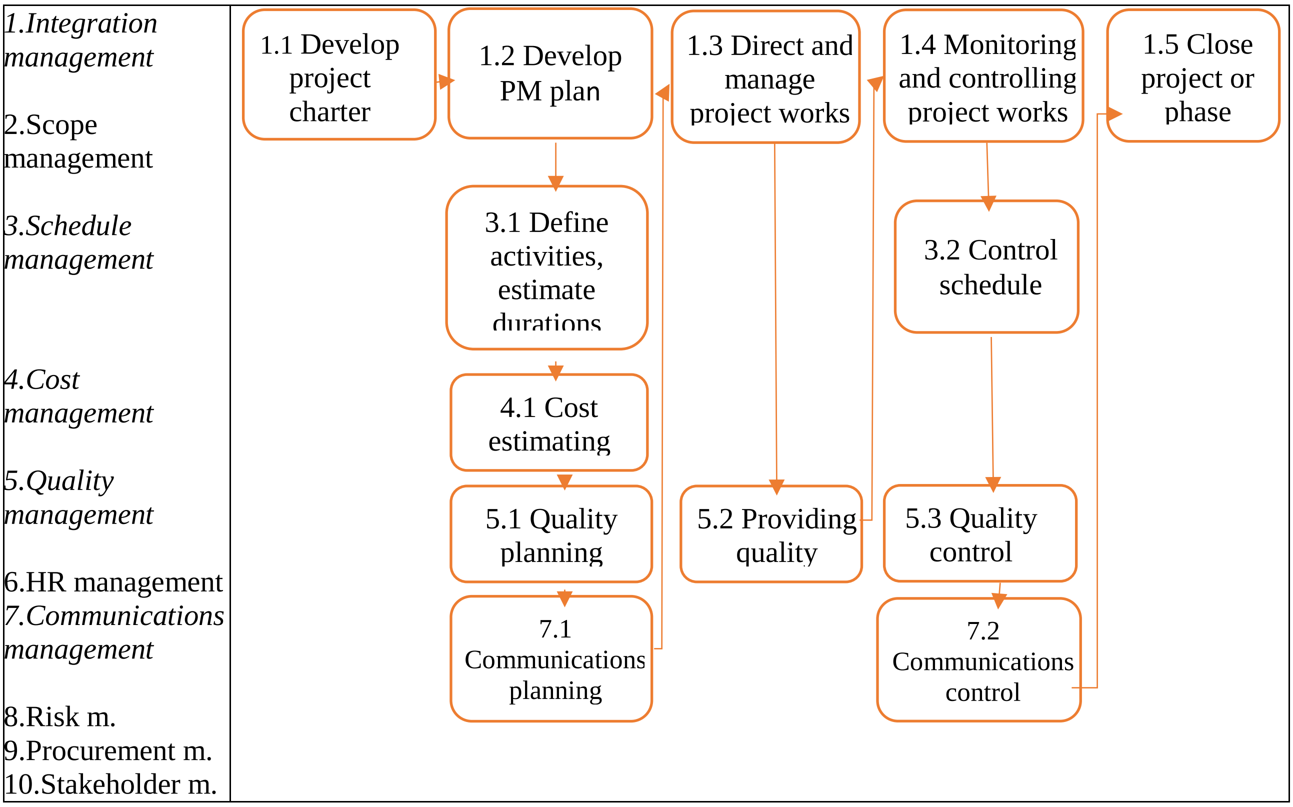

Figure 35 - Suggested algorithm of PM processes for Green energy projects

Note - Compiled by author based on own research

According to figure 35, revealed processes should be performed step by step for achieving high results in project success dimensions. The most valuable finding of research work is the existence of specific tools and methods that may be used when the project managers perform these processes. For example, a process titled “1.1 Develop project charter” should be performed in the next way depicted in figure 36.

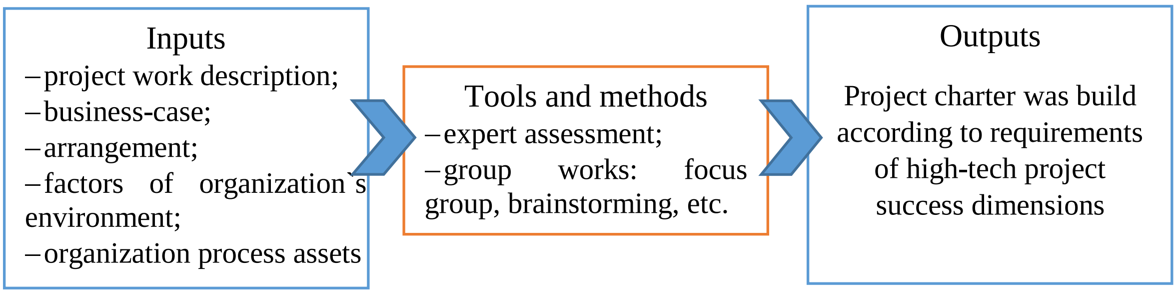

Figure 36 - The scheme for performing process “1.1 Develop project charter”

Note - Compiled by author based on [34]

Inputs depicted in figure 36 means actions that should be performed by the project manager in the beginning stage of the described process. Tools and methods are used for achieving outputs in the form of a project charter that help to achieve green energy project success. A brief description of tools and methods for the developed algorithm for Green energy projects is depicted in table 44.

Table 44 - Tools and methods of PM for managing Green energy project success in the Republic of Kazakhstan

Process	Tools and methods	Description
1.1	Expert assessment, brainstorming	Professionals from aimed area engaged in building Green energy project charter developed by group works.
1.2	Network diagram, critical path method	Precisely identify each work necessary for achieving Green energy project goal
1.3	Information system of PM, expert assessment	Help to manage Green energy project according to plan due to achieving goal
1.4	Analytical methods and Information system of PM	Used for checking and reporting the performance of processes planned for achieving project goals
1.5	Expert assessment, analytical methods	Close all operations of all group of processes for formal completing the Green energy project
3.1	Gantt Chart, Planning and prioritization method, Work breakdown structure	Tools that greatly simplifies project management by timeframes and makes it possible to always keep employees under control.
3.2	Performance analysis, Microsoft Project, scheduling tool, schedule compression	Control the implementation of Green energy project in time and changings in schedule of the project
4.1	Evaluation of analogue, parametric assessment, reserve analysis, cost of quality, value sum	The methods aimed to implement a project in accordance with planned budget
5.1	Benchmarking, selective control, planning experiments, 7 tools of quality	Prepare control list of quality, metrics for quality, plan of quality management and improvements for the total quality
5.2	QIM (Quality Inspection Management), TQM (Total Quality Management), Quality audit, analysis of processes	Provide appropriate quality level required by Green energy projects
5.3	Pareto chart, The Cause and Effect Diagram, Control charts, Scatter diagrams, inspection, selective control	List of tools that helps to critically analyze and control the quality level of Green energy project. They build by using proper data about quality.
7.1	Communications technologies, communications models	Help to develop proper approach and plan for Green energy project communications by taking into account interests of stakeholders in information
7.2	Systems of information management, Expert assessment	Monitor and control communications during lifecycle of Green energy project due to stakeholder satisfaction in information
Note - Compiled by author based on own research		

Table 44 shows the basic tools and methods used for performing CSP of Green energy projects. The list of tools was derived from the PMBOK Guide and was presented in a brief description.

The next figure presents an algorithm for Nanotechnology projects (figure 37).

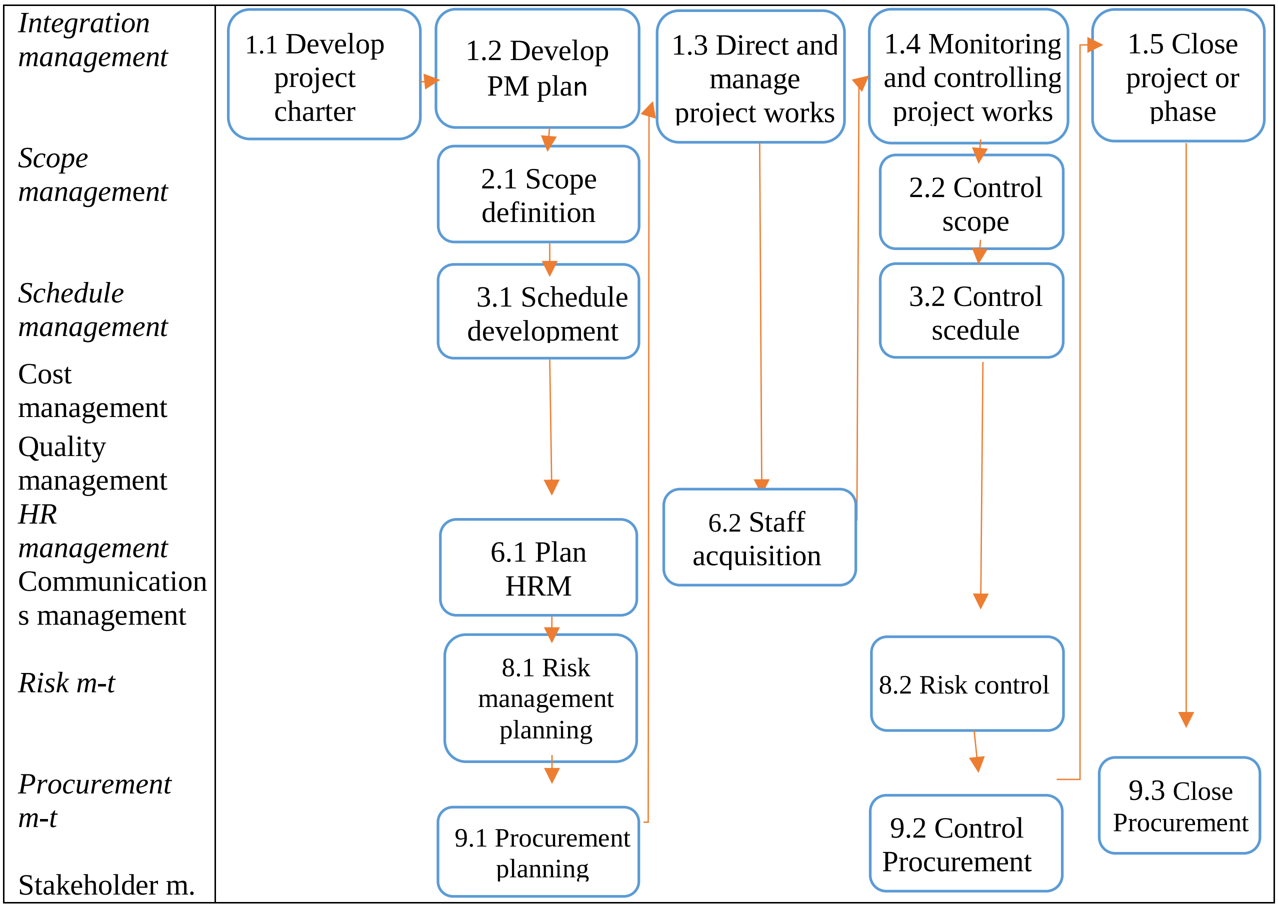

Figure 37 - Suggested algorithm of PM processes for Nanotechnology projects

Note - Compiled by author based on own research

As figure 37 shows, the Nanotechnology project success may be achieved by performing 16 priority processes. Depicted above algorithm of PM processes shows how to manage Nanotechnology projects for increasing success dimensions. The next table shows the basic tools and methods of a PM that should be used in combination with the mentioned algorithm (table 45).

Table 45 - Tools and methods of PM for managing Nanotechnology project success in the Republic of Kazakhstan

Process	Tools and methods	Description
1	2	3
1.1-1.5	Repeated	Repeated
2.1	WBS, interview, focus-group, questionnaires, surveys,	Clarify the scope and direction of project through managing requirements of stakeholders

Continuation of table 45

1	2	3
2.2	Inspection, analysis of deviations	Monitor the current situation of project scope and changes that occur after implementation of planning
3.1-3.2	Repeated	Repeated
6.1	Organizational charts and job descriptions, expert assessment	Identify the role of each project team member, responsibility areas and required qualification levels
6.2	Virtual teams, staff assessment tools, conflict management	Provide availability of qualified staff that ready for team work in order to achieve Nanotechnology project goals
8.1	Expert assessment, quantitative analysis, qualitative analysis	Show how to manage the risks of Nanotechnology project
8.2	Risk map, reevaluating the risks, reserve analysis, risk audit	Process that responds to the risks, identifies and monitors them for evaluating the effectiveness of risk management
9.1-9.3	Repeated	Repeated
Note - Compiled by author based on own research		

As table 45 shows, the main accenting processes for project managers who execute Nanotechnology projects are management of scope, schedule, human resources, risk, and procurement. It doesn`t mean that they may ignore other processes of PM. Project managers just should pay more attention to revealed processes form the suggested algorithm. Figure 38 shows the algorithm of processes for Biotechnology projects.

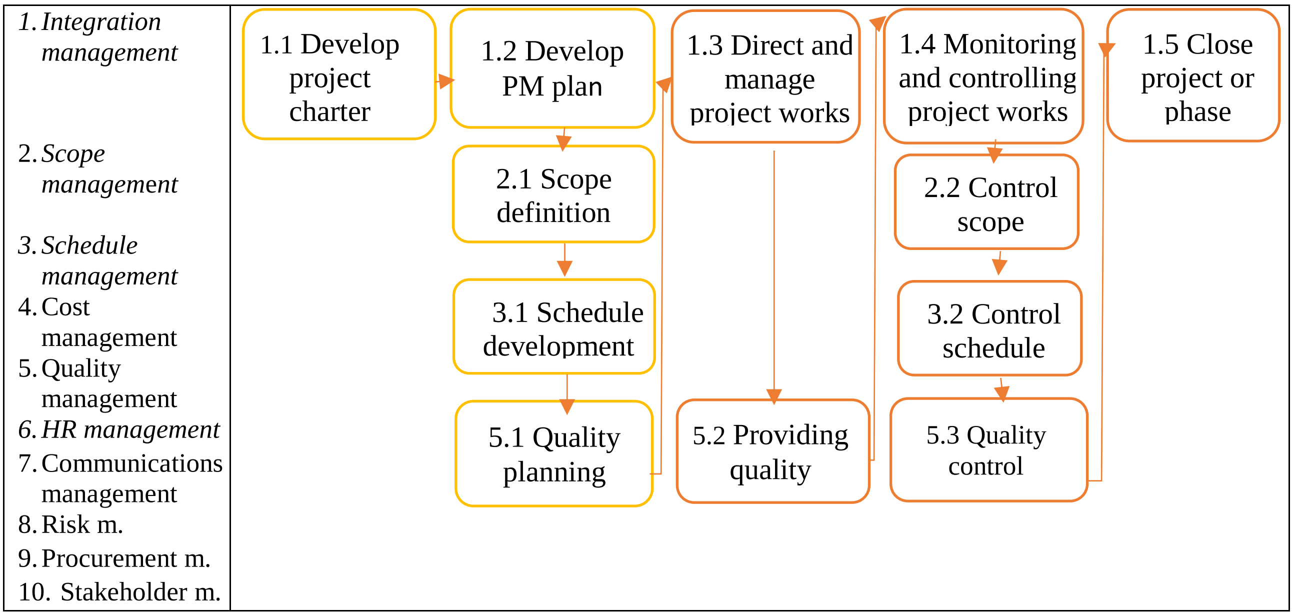

Figure 38 - Suggested algorithm of PM processes for Biotechnology projects

Note - Compiled by author based on own research

Suggested algorithm includes processes from 4 knowledge areas: integration, scope, schedule and quality management.

The study presents PM tools and methods from revealed knowledge areas for managing Biotechnology projects (table 46).

Table 46 - Tools and methods of PM for managing Biotechnology project success

Process	Tools and methods	Description
1.1-1.5	Expert assessment, brainstorming, network diagram, critical path method, Information system, Analytical methods	Used for execution of integration management processes in proper manner for achieving project success
2.1-2.2	WBS, interview, focus-group, questionnaires, inspection, survey, benchmarking, document analysis,	Define the scope of Biotechnology project that includes basic objectives and priority directions
3.1-3.2	Network diagram, critical path method, Gantt Chart, Planning and prioritization method, Work breakdown structure	Precisely identify each necessary work, its duration and performance by project team in time
5.1-5.3	Quality audit, Pareto chart, The Cause and Effect Diagram, Control charts	Quantitative and qualitative methods that measure the level of quality
Note - Compiled by author based on own research		

According to table 46, Biotechnology project management tools and methods repeated with previous high-tech projects and include integration, schedule, scope and quality management. An algorithm for engineering project is shown in figure 39.

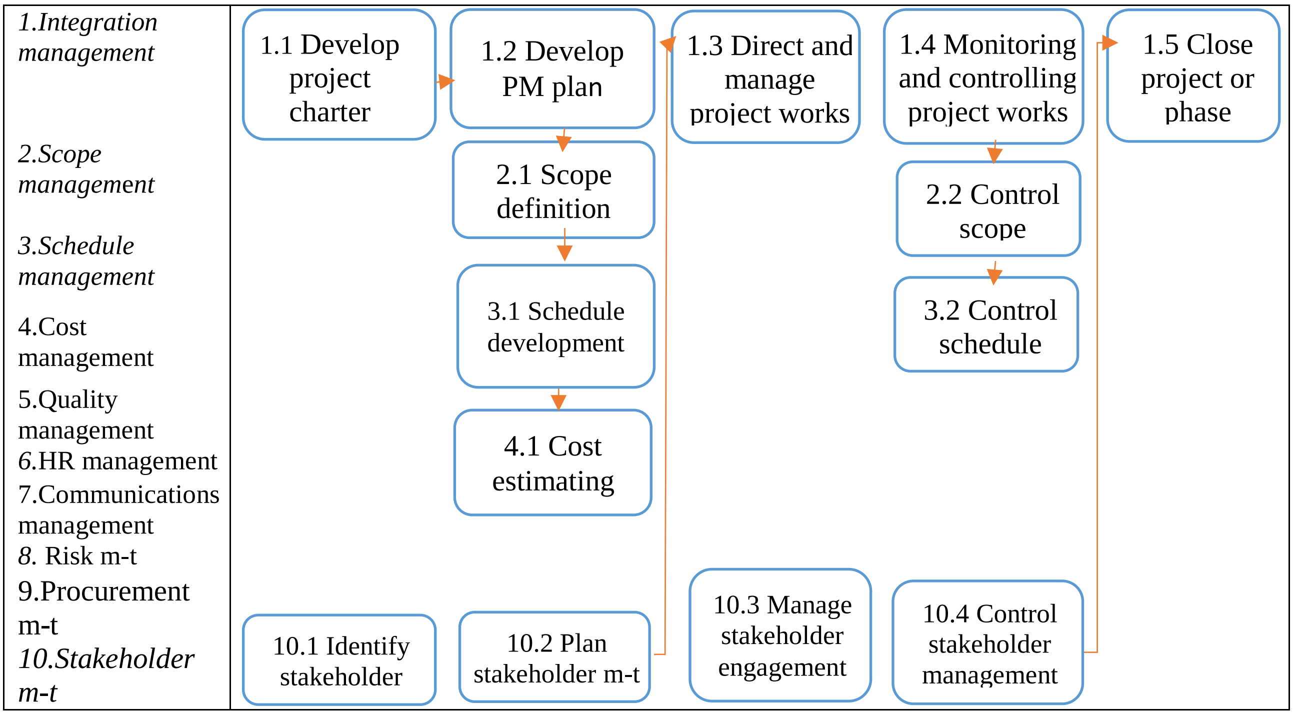

Figure 39 - Suggested algorithm of PM processes for Engineering projects

Note - Compiled by author based on own research

Engineering projects differ from other high-tech projects by sufficient influence of stakeholder management knowledge area.

The tools and methods of PM necessary for fulfilling the suggested algorithm is presented in table 47.

Table 47 - Tools and methods of PM for managing Engineering project success

Process	Tools and methods	Description
1.1-1.5	Expert assessment, brainstorming, network diagram, critical path method, Information system, Analytical methods	Used for execution of integration management processes in proper manner for achieving project success
2.1-2.2	WBS, interview, focus-group, questionnaires, inspection, survey, benchmarking, document analysis,	Define the scope of Biotechnology project that includes basic objectives and priority directions
3.1-3.2	Network diagram, critical path method, Gantt Chart, Planning and prioritization method, Work breakdown structure	Precisely identify each necessary work, its duration and performance by project team in time
4.1	Evaluation of analogue, parametric assessment, reserve analysis, cost of quality, value sum	The methods aimed to implement a project in accordance with planned budget
10.1-10.4	Stakeholder map, influence matrix, trigger identification, model of Mitchel, Journal of changes	Identify the role of different stakeholders and their influence on project management, Monitor stakeholder relationships
Note - Compiled by author based on own research		

High influence of stakeholder management processes to Engineering projects may explained by high requirements for engineering products. The next figure presents an algorithm for IT-projects (figure 40).

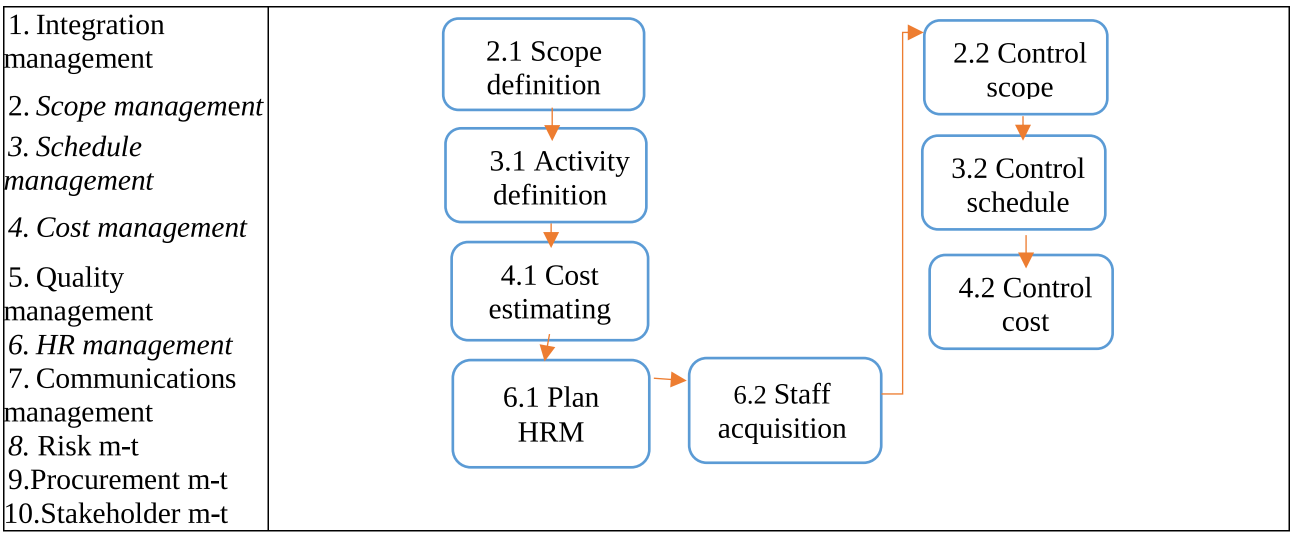

Figure 40 - Suggested algorithm of PM processes for IT projects

Note - Compiled by author based on own research

As figure 40 shows, IT-project algorithm differs by adding HR management that may explained by huge role of qualified IT-specialists. The tools and methods appropriate for managing these projects are depicted in table 48.

Table 48 - Tools and methods of PM for managing IT-project success

Process	Tools and methods	Description
2.1-2.2	WBS, interview, focus-group, inspection, survey, benchmarking,	Define the scope of Biotechnology project that includes basic objectives and priority directions
3.1-3.2	Network diagram, critical path method, Gantt Chart, Planning and prioritization method, Work breakdown structure	Precisely identify each necessary work, its duration and performance by project team in time
4.1	Evaluation of analogue, parametric assessment, reserve analysis, cost of quality, value sum	The methods aimed to implement a project in accordance with planned budget
6.1-6.2	Organizational charts and job descriptions, expert assessment	Identify the role of each project team member, responsibility areas and required qualification levels
Note - Compiled by author based on own research		

Using mentioned above tools and methods of PM helps to increase the success level of IT-projects. An algorithm for Communications projects depicted in figure 41.

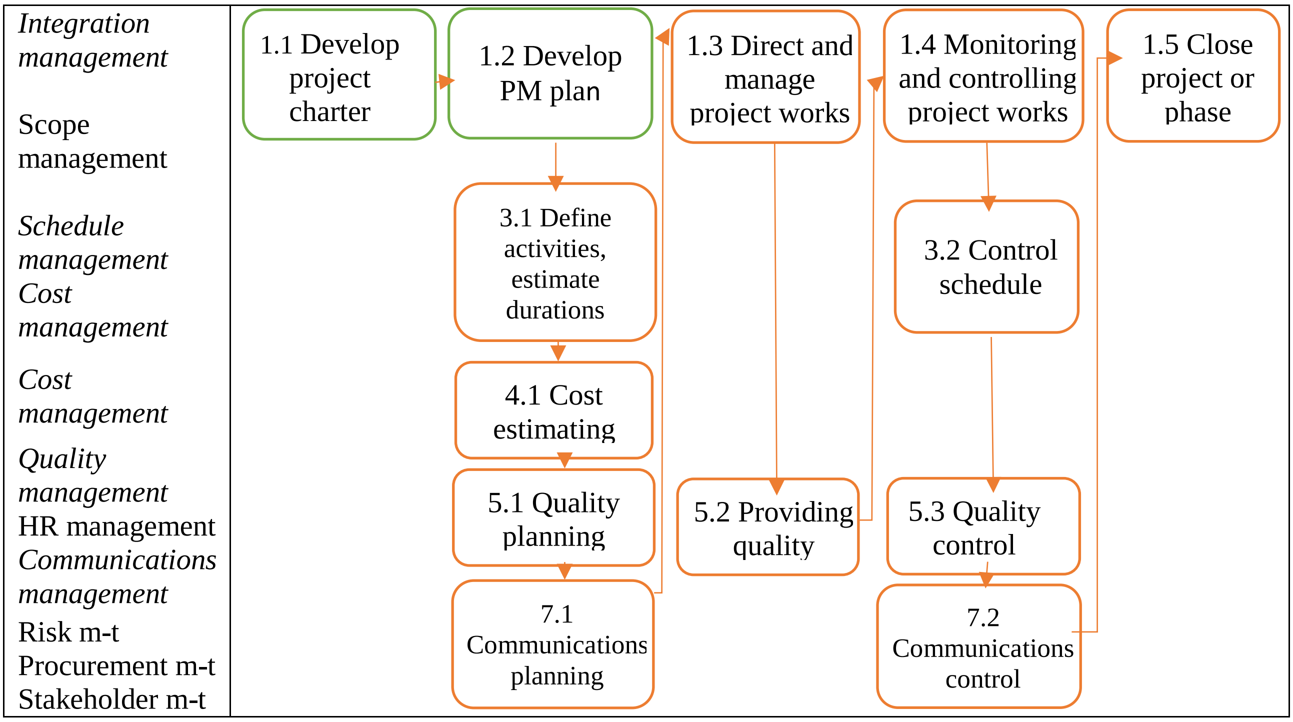

Figure 41 - Suggested algorithm of PM processes for Communications projects

Note - Compiled by author based on own research

As figure 41 shows, Communications projects should be managed by prioritizing 13 PM processes for achieving success.

Thus, each algorithm of PM processes has a specific scheme that shows the actions, which should be performed by project managers from investigated scopes. Further, the study discusses PM tools and methods that should be used during engineering project, IT-project and Communications project execution management, because such description for other types of high-tech projects was discussed before (table 49).

Table 49 - PM tools and methods for managing Communications projects based on PMBOK

Process	Tools and methods	Description
1.1-1.5	Expert assessment, brainstorming, network diagram, critical path method, Information system, Analytical methods	Used for execution of integration management processes in proper manner for achieving project success
3.1-3.2	Network diagram, critical path method, Gantt Chart, Planning and prioritization method, Work breakdown structure	Precisely identify each necessary work, its duration and performance by project team in time
4.1	Evaluation of analogue, parametric assessment, reserve analysis, cost of quality, value sum	The methods aimed to implement a project in accordance with planned budget
5.1	Benchmarking, selective control, planning experiments, 7 tools of quality	Prepare control list of quality, metrics for quality, plan of quality management and improvements for the total quality
5.2	QIM (Quality Inspection Management), TQM (Total Quality Management), Quality audit, analysis of processes	Provide appropriate quality level required by Green energy projects
5.3	Pareto chart, The Cause and Effect Diagram, Control charts, Scatter diagrams, inspection, selective control	List of tools that helps to critically analyze and control the quality level of Green energy project. They build by using proper data about quality.
7.1	Communications technologies, communications models	Help to develop proper approach and plan for Green energy project communications by taking into account interests of stakeholders in information
7.2	Systems of information management, Expert assessment	Monitor and control communications during lifecycle of Green energy project due to stakeholder satisfaction in information
Note - Compiled by author based on own research		

According to table 49, properly used tools and methods of a PM that listed above increase the success level of high-tech projects. Therefore, project managers should pay attention to these tools and techniques and use them in their daily work. In addition, PMBOK includes outputs and inputs for each revealed process that shows step by step activities should be performed by project managers. The study presents only the common of them due to the huge amount of data.

In this regard, the study presents the results of using an algorithm for a Green energy project called “Project G” and discussed in the previous chapter of this research work. Figure 42 shows an algorithm and tools used by the research team of this project.

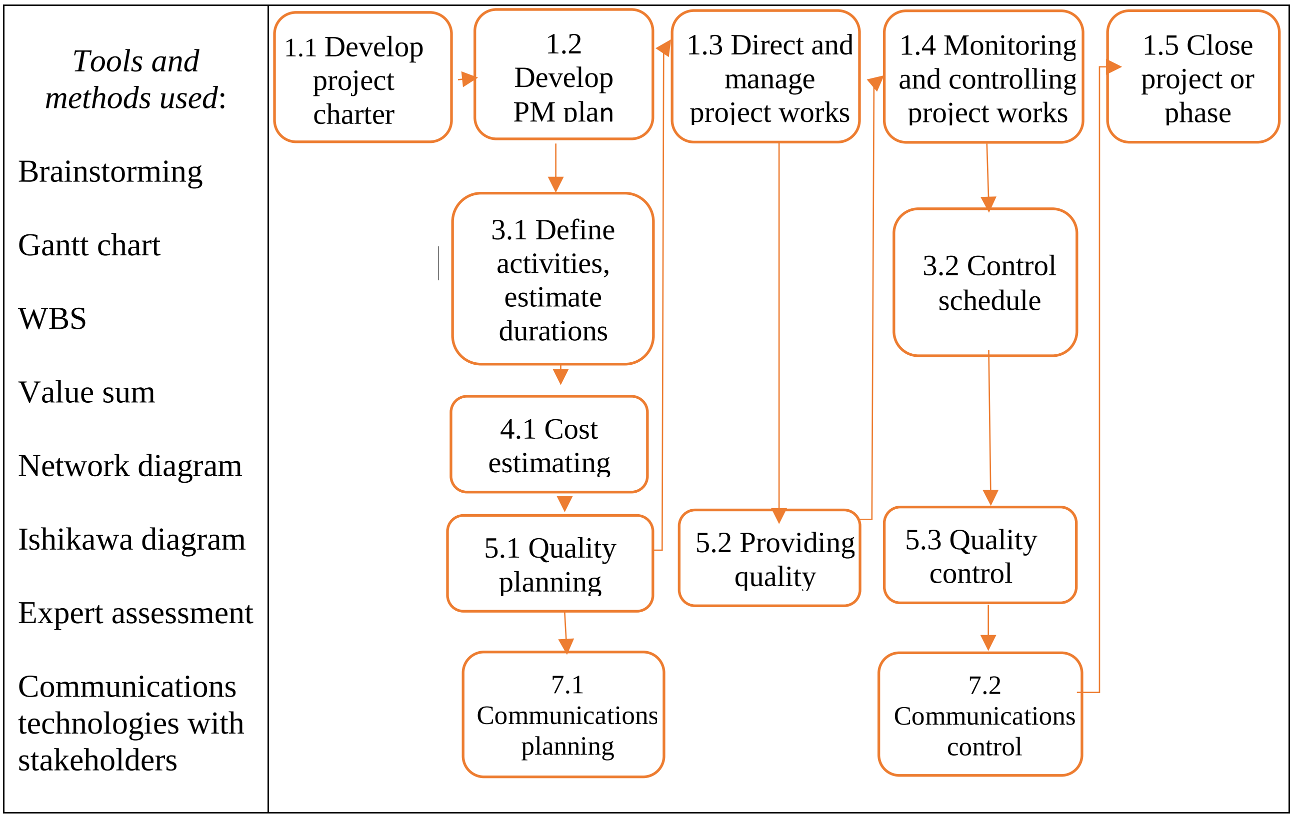

Figure 42 - Used algorithm of PM processes for Project G

Note - Compiled by author based on own research

As figure 42 shows, the study applies the suggested algorithm for Project G and used the recommended list of tools for managing this project during the reporting period. The success dimensions were measured before the application of algorithm and PM tools, then after using research suggestions. The results of these observations are depicted in table 50.

Table 50 - Results of success dimensions for “Project G” affected by using recommended algorithm of processes

Period	Project success dimensions		
	Cost overrun	Schedule overrun	Customer satisfaction
1st year	14	12,5	7
2nd year	5,5	0	9

Note - Compiled by author based on own research

As table 50 shows the results of success dimensions like schedule and cost overrun, customer satisfaction has improved after applying PM tools. Precisely, the schedule overrun is has improved to an absolutely level, cost overrun has improved about more than half, and customer satisfaction has improved for two points. These results let to assume that the suggested algorithm and recommended PM tools are effective for Project G.

Further, the study presents the algorithm used for Project I from the software industry (figure 43).

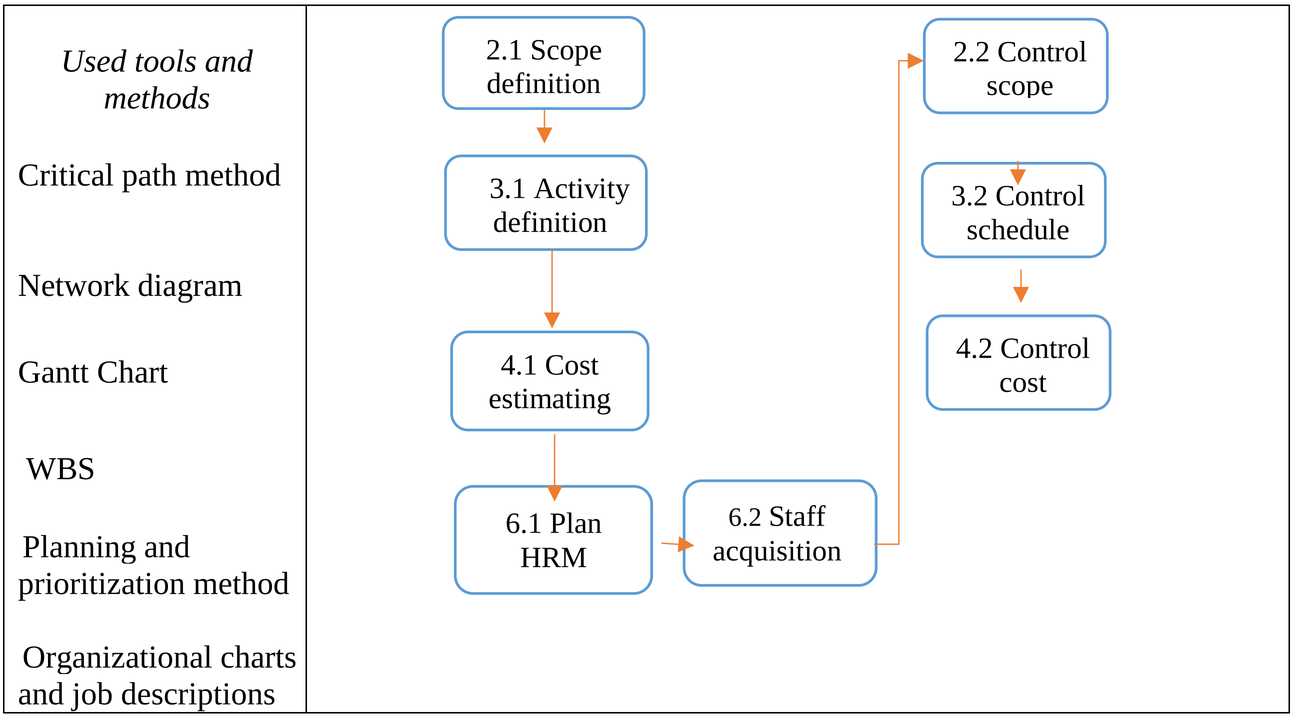

Figure 43 - Used algorithm of PM processes for Project I

Note - Compiled by author based on own research

As figure 43 shows, the project team of Project I used mentioned above algorithm during project implementation in compliance with suggested tools of PM. As a result, success dimensions of this project are increased too (table 51).

Table 51 - Results of success dimensions for "Project I" affected by using recommended algorithm of processes

Period	Project success dimensions		
	Cost overrun	Schedule overrun	Customer satisfaction
1st year	0	8	10
2nd year	-7	0	10

Note - Compiled by author based on own research

As table 51 shows the results of success dimensions like schedule and cost overrun have increased after applying the suggested algorithm. Precisely, the schedule overrun is has improved for 8%, cost overrun has improved for 7%, and customer satisfaction stills at the same score. These results let to assume that the suggested algorithm and recommended PM tools were effective for Project I too.
Further, the study considers general recommendations that help to increase high-tech project success. In this regard, the study uses the findings of Zwikael [136] who conducted a literature analysis that helps to reveal critical success factors for high-tech projects during the analysis of 9 literature sources (table 52).

Table 52 - Frequencies of CSF in project management literature

Critical Success Factor	1	2	3	4	5	6	7	8	9	
Project plan	+		+	+	+		+	+	+	7
Stakeholder management	+	+	+	+	-	-	+	+	-	6
Project requirement and objectives	+	-	+	-	+	+	-	+	-	5
Adequate spending	-	+	-	+	+	+	+	-	-	5
Technical tasks	+	-	-	+	+	+	-	-	-	4
Communication	+	-	-	+	+	-	+	-	-	4
Project strategy	-	+	+	-	-	-	-	+	-	3
Trouble-shooting	+	-	-	-	-	+	-	-	-	2
High-quality processes	-	+	-	+	-	-	-	-	-	2
Ownership	-	-	+	+	-	-	-	-	-	2
Goal commitment of project team	-	-	-	+	+	-	-	-	-	2
Customer acceptance	+	-	-	-	-	-	-	-	-	1
Realistic expectations	-	-	+	-	-	-	-	-	-	1
Smaller project milestones	-	-	+	-	-	-	-	-	-	1
On-site project manager	-	-	-	-	+	-	-	-	-	1
Note - Source [136, 137-142]										

As table 52 shows, the most cited CSF for projects are project plan and stakeholder management. PM planning processes were analyzed and tools for managing them were suggested in previous discussions. By the way, stakeholder management comparatively new knowledge area and less considered one in the study. Therefore, the research recommendations include tools and methods from the stakeholder knowledge area.

On the other hand, stakeholder management area often identified as critical for high-tech projects. Therefore, the study suggests the technics for proper management of stakeholder relations.

Stakeholder and Sponsor Relationship Management. One common denominator for successful process improvement projects has to do with project stakeholders; specifically, the ability of the project manager to negotiate and successfully manage the intricate nature of the numerous affected stakeholders of a project. Stakeholders have a huge, if not the greatest impact on projects. Therefore, stakeholder and sponsor relationship management is a vital component of ensuring project success which includes the acceptance and implementation of team recommendations. The keyword is "relationship." This implies more than simply identifying or "managing" stakeholders.

A relationship is an emotional connection between people. To have successful process improvement projects, project managers must understand this emotional connection and therefore focus on improving their own interpersonal skill set. Otherwise, sponsors or other stakeholders might continuously challenge the method or approach used to manage the project.

One of the first actions that a project manager should take is to identify the various categories of stakeholders. The International Institute for Learning's Stakeholder Relationship Skills for Project Managers course identifies four major categories of stakeholders: governing bodies, project teams, auxiliary bodies, and clients [143].

Once specific stakeholders are identified, a project manager should take it one step further and develop categories for stakeholder assessment. What are the various variables or dimensions that can give clues as to how to handle complex stakeholder relationships? Are stakeholders supportive of or are they against the project? Do they have a great deal of power or influence? Does open conflict exist between stakeholders that might affect the project?

Once those dimensions are identified, the project manager can then do a quick assessment of the stakeholders, prioritize where to focus, and develop a plan to address and improve those stakeholder relationships. Variables or dimensions can be added or changed in this matrix, as necessary, as can stakeholder groups. Ratings can be done using any type of scale or weighting scheme.

Thus, once stakeholders are identified, assessed, and prioritized, a project manager simply needs to use various interpersonal skills to actively work on and improve those stakeholder relationships, thus helping the project team to be more successful. The Stakeholder Relationship Skills for Project Managers lists many considerations for ways to improve relationships including:

– Persuade others to adopt and support the project or your point of view using promoting and negotiation skills;

– Inspire others to work enthusiastically toward project objectives through influencing, facilitating, and mentoring efforts;

– Instill trust in your desire and ability to achieve win/-in results through communication and managing change;

– Enable accurate diagnosis and appropriate response to “special” project needs through creative problem solving and networking [143].

Stakeholder relationship management is of vital importance to the success of high-tech projects. Without stakeholder support, even the best projects with the most capable project managers run the risk of failure. Project managers should proactively spend time, throughout the project, working on improving stakeholder relationships, using various and appropriate interpersonal skills techniques.

The literature reveals that team ground rules will be an appropriate tool for personnel recruitment. Team Ground Rules. Projects of any kind can become troublesome very quickly. When dealing with numerous stakeholder groups, team members, levels of expertise, and various departments, it is inevitable that problems will arise. Process improvement (PI) projects, by their very nature, are quite susceptible to problems. A PI project is usually assembled because results are currently not good enough. Processes almost always cut across departments within an organization, so PI projects are usually comprised of cross-functional team members. It’s not uncommon for some of these departments, or silos, to have differing viewpoints and objectives, or they may simply not like each other very much. This is where problems begin to arise.

Various challenges, conflicts, and issues happen with every project. It is how those problems are addressed that will impact the project and team. A project manager needs some kind of tool or technique to help him or her deal with these issues effectively. The answer is simple: ground rules.

Ground Rules. The Silver Bullet to Successful Project Facilitation. Ground rules are just what you think they are; a set of rules on how the team will interact, make decisions, and handle issues that must be addressed and resolved. The key to the successful application of ground rules is simple; they must actually be developed and then used by the project manager. The reason ground rules are so effective for a project manager is that they enable the project manager to remove himself from the issue and address the conflict or situation without unnecessary or harmful emotion. In essence, the project manager becomes the facilitator of the ground rules document; nothing more, nothing less [144].

It is best to establish ground rules at the kick-off meeting before the team tries to work together. The project manager should begin a list of ground rules topics but allow the team to add to the list. The team should be kept involved and consensus gained on how each issue will be handled that is, what the “ground rule” will be for that potential issue.

The project manager should even develop ground rules specific to the project’s sponsor so that he or she is actively involved at the appropriate level. Then, when problems arise (and they always will), simply refer to the ground rules. It’s that easy.

The study suggests the use of experience in managing innovative projects. Because both projects have the same features like high levels of risk, difficulty, science intensity, etc. Moreover, to create new products requires the initiation of relevant projects, which can be called innovative. Managers must have the appropriate tools to successfully implement such projects. First of all, the initial stage of any project should include an assessment of the project environment. Tools that work efficiently in one project and in a particular environment may not be effective in another project and in other conditions.

Thus, it became clear that complex project management tools and technics may increase the level of high-tech project success. Each group of the project has its own critical success knowledge areas as revealed by the study. The most cited knowledge areas for high-tech projects are “integration management”, “scope management”, “schedule management” and “cost management” when such important of them like “risk management” and “quality management” stills less used. Project managers should use the algorithms suggested by the study when to execute high-tech projects.

CONCLUSION

The next conclusions were prepared as the results of the dissertation work:

1. As an analysis of the terminological apparatus showed, the lack of a generally accepted definition of a high-tech project and the fragmentation of classifications made it difficult to determine a sample of projects for research in this area. In this regard, the definition of “high-tech project” was developed, which describes it as a high-tech, high-risk project, limited in time and resources, implemented in both traditional and high-tech industries using advanced technologies.

2. Systematization of various groups of high-tech projects allowed to develop an approach based on classification, according to industry characteristics and the level of high technology. By industry, high-tech projects were divided into the following types: projects in the field of nanotechnology, biotechnology, green energy, chemical technology, engineering, communications, nuclear energy, IT projects, R&D projects. Based on the knowledge-based nature, high-tech projects were divided into the following groups: medium-tech projects (R&D costs are below 4.5% of total costs), high-tech projects (R&D costs are between 4.5% -5% of total costs), super high-tech (costs R&D costs are above 5% of total costs).

3. A methodological approach to assessing the success of a project has been developed, which allows to evaluate project management indicators and project customer satisfaction. Project management success is measured by performance indicators such as time and cost overruns. They are calculated by the formulas: $Co = (Ca-Cp) * 100 / Cp$ and $So = (Sa-Sp) * 100 / Sp$. The percentage of deviation from the planned budget and project timeline shows the success level of the project manager. Thus, the success indicators of project management should correspond to the following parameters: $Co < 15\%$; $So < 15\%$. In turn, the level of customer satisfaction reflects the success of the customer of the project and is evaluated on a Likert scale from 1 to 10, where the highest result shows a high level of success of a high-tech project.

4. Systematization and concretization of project management standards for the management of high-tech projects made it possible to distinguish two of them - PMBOK and P2M. As a result of a comparative analysis of the characteristics of the two standards, PMBOK was identified as the most suitable for managing the success of high-tech projects in view of the availability of such areas of knowledge as quality, risk and stakeholder management. In addition, this standard is one of the most common standards in the Republic of Kazakhstan, which contains step-by-step instructions for use. In this regard, the process approach, which is described in the standard, was used to assess the success of high-tech projects.

5. An analysis of global trends in high technology and project management has shown that in many developed countries (USA, Japan, Germany and Israel) project management is seen as an advanced tool for quickly and efficiently bringing innovations to the market. A huge number of foreign countries are developing their own project management standards, an example of which Kazakhstan has followed. As for high-tech projects, their number is growing every year: their share in the total world production in 2018 amounted to 16%.

6. In general, poor knowledge of this topic is accompanied by a lack of experience in this area and the immaturity of project management in the Republic of Kazakhstan, which reinforces the challenges and problems in managing high-tech projects. As the results of the study showed, most organizations in the Republic of Kazakhstan lack experience in working with technologies and project management. Project management is still ignored by many domestic companies due to a lack of understanding of its fundamentals and functionality. It`s necessary to attract and increase the number of certified professionals among yang undergraduates.

7. For the implementation of high-tech projects, an analysis of domestic infrastructure has led to the conclusion that it is still not mature enough and is not able to provide adequate support for the development of the high-tech market. The reasons for this were the following factors: the lack of systematic communication between market participants, expressed by the ineffective connection between science, production and business; the absence of synergy between such key elements of the innovation system like the state, business incubators, technological infrastructure, regulatory framework and human resources.

8. High-tech project implementation affected by the development of the innovative system and PM maturity levels. The demand for the domestic market for high-tech products is met by foreign manufacturers. The innovative policy doesn`t focus on the requirements, wants, and needs of industries of the Republic of Kazakhstan. This fact keeps companies outside the main processes of creating innovation. In turn, government business support programs sometimes include processes that are too complex and don`t allow a wide range of entrepreneurs to participate in these programs.

9. The experience of government stimulation of breakthrough research within the OECD shows that an increase in government spending on R&D by 1% increases the likelihood of successful innovations by 0.85% and increases the share of new products in turnover by 0.7% [71]. The state influences the formation and development of economic activity in technologically advanced sectors through direct or indirect support measures. Therefore, the necessary measure to increase the innovative activity of market participants in this direction is to increase the level of R&D costs.

10. The developed economic and mathematical model of the study made it possible to assess the level of success of high-tech projects in the Republic of Kazakhstan, as well as to identify a close relationship between the application of PM processes and project success indicators in organizations of the Republic of Kazakhstan implementing high-tech projects. According to the calculations, IT-projects showed the highest level of success, reaching the following indicators: deviation from the cost - 12.2%; deviation from the deadlines - 2.8%; customer satisfaction - 8.5, where the deviation from the cost and terms of less than 15% allows us to consider the project as having achieved success, and a customer satisfaction level above 7 on the Likert scale means that the project has achieved success from the perspective of the project owner. In turn, projects in the field of nanotechnology showed the lowest success result.

11. An assessment of the relationship between PM processes and success indicators of high-tech projects revealed that the PQ-index of the project, reflecting the intensity of use of PM processes, is highly correlated with such success indicators as deviation from cost and timing, customer satisfaction level ($R = 0.6$; $R = 0.5$; $R = 8$, respectively). According to the calculations, IT projects have the highest PQ index (4.5), which explains the high level of success. And the PQ index of nanotechnology projects is one of the lowest (3.8), which explains the low level of success. Thus, it became clear that the intensive use of PM processes increases the level of success of high-tech projects.

12. According to the results of the regression analysis, critical processes were identified for each type of high-tech projects. For example, projects in the field of green energy are sensitive to such processes as “quality planning”, “risk planning”, “cost estimation”. These processes are critical, that is, they affect the success indicators of projects in the field of green energy more than other processes; allow to identify the following PM knowledge areas as critical and important for the implementation of these projects: “Cost Management”, “Quality Management”, “Risk Management”.

13. An algorithm for the application of processes for each type of high-tech projects was proposed based on the calculations. According to the suggested algorithm, specific processes and a set of PM tools should be performed by project managers for achieving success. The most mentioned knowledge areas of PM for high-tech projects are “integration management”, “scope management”, “schedule management” and “cost management”, but such important of them like “risk management” and “quality management” still insignificant. The reason for this is the low level of PQ index that shows the use intensity of PM processes. The low score of the PQ index (less than 3) for mentioned above processes prevents to reveal them as critical for project success dimensions.

14. To sum up, it became clear that complex project management tools and methods may increase the level of high-tech project success. Each group of projects has its own critical success knowledge areas and the proper PM technics as revealed by the study. The common tools and methods that were revealed as critical for vast types of high-tech projects are “Network diagram”, “WBS”, “Expert assessment”, “Critical path method”, “Gant diagram” and “Information system”. Project managers should use the tools and methods of PM suggested by the study when to manage high-tech projects.

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APPENDIX A

“Халықаралық ақпараттық технологиялар университеті” АҚ

АО "Международный университет информационных технологий"

JSC “International Information Technology University”

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Алматы қ. г.Алматы

В Диссертационный совет по группе специальностей «6D050600 - Экономика», «6D051300 - Мировая экономика», «6D051700 - Инновационный менеджмент», «6D090900 - Логистика», «6D051800 - Управление проектами» и «6D051000 - Государственное и местное управление»

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Акт

о внедрении результатов диссертационного исследования

Кожахметовой А.К. на тему «Evaluation of high-tech project success in the Republic of Kazakhstan based on international standards of project management»

Настоящим подтверждаю, что результаты диссертационного исследования Кожахметовой А.К. были использованы в ходе реализации проекта, финансируемого КН МОН РК на 2018-2020 гг. на тему «РАЗРАБОТКА ВИРТУАЛЬНЫХ ЭЛЕКТРОННЫХ ЛАБОРАТОРИЙ С ЭЛЕМЕНТАМИ ТЕХНОЛОГИЙ ДОПОЛНЕННОЙ И ВИРТУАЛЬНОЙ РЕАЛЬНОСТЕЙ ДЛЯ ИЗУЧЕНИЯ ФИЗИКИ В СРЕДНИХ ОБРАЗОВАТЕЛЬНЫХ УЧРЕЖДЕНИЯХ», а именно:

– Методологический подход к оценке критериев успеха проектов в сфере программного обеспечения;

– Результаты сравнительного анализа международных стандартов по управлению высокотехнологичными проектами, IT-проектами в том числе;

– Выводы регрессионного анализа, выявившего ряд критических процессов проектного менеджмента согласно стандарту PMBOK. В частности, были определены критические процессы, способствующие успеху IT-проектов в Республике Казахстан;

– Рекомендации по усовершенствованию управления проектами в сфере высоких технологий, изложенные в третьей главе диссертационного исследования.

Руководитель проекта
Проректор по научной
и международной деятельности АО МУИТ,
PhD **Дайнеко Е.А.**

001765

APPENDIX B

ҚАЗАҚСТАН РЕСПУБЛИКАСЫНЫҢ
БІЛІМ ЖӘНЕ ҒЫЛЫМ МИНИСТРЛІГІ

ӘЛ-ФАРАБИ атындағы
ҚАЗАҚ ҰЛТТЫҚ УНИВЕРСИТЕТІ

АШЫҚ ТҮРДЕГІ ҰЛТТЫҚ
НАНОТЕХНОЛОГИЯЛЫҚ ЗЕРТХАНА

МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ
РЕСПУБЛИКИ КАЗАХСТАН

КАЗАХСКИЙ НАЦИОНАЛЬНЫЙ
УНИВЕРСИТЕТ им. АЛЬ-ФАРАБИ

НАЦИОНАЛЬНАЯ НАНОТЕХНОЛОГИЧЕСКАЯ
ЛАБОРАТОРИЯ ОТКРЫТОГО ТИПА

050012, г. Алматы, Толе би 96 а. Тел./Факс: 7(727)3773511

Исх. № 173 от 23.12.2019.

В Диссертационный совет по группе специальностей
«6D050600 - Экономика»,«6D051300 - Мировая экономика», «6D051700 - Инновационный менеджмент», «6D090900 - Логистика», «6D051800 - Управление проектами» и «6D051000 - Государственное и местное управление»

050040, г. Алматы, пр. аль-Фараби, 71

Акт
о практическом применении результатов диссертационного исследования

Настоящим Актом подтверждается, что результаты диссертационного исследования Кожахметовой А.К. на тему: «Evaluation of high-techproject success in the Republic of Kazakhstan based on international standards of project management» были тщательно изучены и использованы при реализации проекта, финансируемого МОН РК «Получение наноматериалов методом импульсного плазменного распыления и их применение в производстве» ИРН № AP05130108.

Результаты качественного и количественного исследования, представленного во второй главе, в частности, итоги анализа критических процессов проектного менеджмента, воздействующих на показатели успеха, были использованы при оценке качества проектных работ.

Выводы и предложения, указанные в третьей главе, были применены в процессе реализации проекта, так как в данной главе были описаны специфические методы и инструменты по управлению проектами в сфере нанотехнологий.

Руководитель проекта **Жукешов А.М.**

APPENDIX C

ҚАЗАҚСТАН РЕСПУБЛИКАСЫНЫҢ БІЛІМ ЖӘНЕ ҒЫЛЫМ МИНИСТРЛІГІ

ӘЛ-ФАРАБИ атындағы ҚАЗАҚ ҰЛТТЫҚ УНИВЕРСИТЕТІ

АШЫҚ ТҮРДЕГІ ҰЛТТЫҚ НАНОТЕХНОЛОГИЯЛЫҚ ЗЕРТХАНА

МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РЕСПУБЛИКИ КАЗАХСТАН

КАЗАХСКИЙ НАЦИОНАЛЬНЫЙ УНИВЕРСИТЕТ им. АЛЬ-ФАРАБИ

НАЦИОНАЛЬНАЯ НАНОТЕХНОЛОГИЧЕСКАЯ ЛАБОРАТОРИЯ ОТКРЫТОГО ТИПА

050012, г. Алматы, Толе би 96 а. Тел./Факс: 7(727) 3773511

№ 181 от 26.12.2019г.

В Диссертационный совет по группе специальностей «6D050600 - Экономика», «6D051300 - Мировая экономика», «6D051700 - Инновационный менеджмент», «6D090900 - Логистика», «6D051800 - Управление проектами» и «6D051000 - Государственное и местное управление»

050040, г. Алматы, пр. аль-Фараби, 71

Справка о внедрении результатов диссертационного исследования

Настоящим подтверждаем, что результаты диссертационного исследования Кожахметовой А.К. на тему: «Evaluation of high-tech project success in the Republic of Kazakhstan based on international standards of project management» обладают актуальностью, представляют практический интерес и были использованы в проектной деятельности ДГП на ПХВ «Национальная нанотехнологичнская лаборатория открытого типа» (далее ННЛОТ) при КазНУ имени аль-Фараби.

Основной целью ННЛОТ является создание научно-технологической и образовательной инфраструктуры с международным участием для развития нанонауки, нанотехнологии и наноинженерии в РК до мирового уровня и максимального приближения прикладной нанонауки к производству и бизнесу.

Выводы, полученные в диссертации, были использованы в ходе реализации высокотехнологичного проекта № 0298-17-ГК «Организация мелкосерийного производства энергосберегающих газоразрядных ламп повышенной интенсивности свечения на основе новых технологий», финансируемого АО «Фонд науки». Подтверждаем, что Кожахметова А.К. входит в состав команды проекта и является специалистом по коммерциализации.

Директор ННЛОТ **Муратов М.М.**

APPENDIX D

Project management processes assessment questionnaire

Please indicate the most suitable answer for each planning product as it relates to the projects you are currently involved in, according to the following scale:

5- The product is always obtained.
4- The product is quite frequently obtained.
3- The product is frequently obtained.
2- The product is seldom obtained.
1- The product is hardly ever obtained.
A- The product is irrelevant to the projects I am currently involved in.
B- B- I do not know whether the product is obtained.

№	Planning product	Never				Always	Irrelevant	Do not know
Part A – planning processes								
1	Project plan development	1	2	3	4	**5**	A	B
2	Scope planning	1	2	3	4	***5***	A	B
3	Scope definition	1	2	3	4	**5**	A	B
4	Activity definition	1	2	3	4	**5**	A	B
5	Activity sequencing	1	2	3	4	**5**	A	B
6	Activity duration estimating	1	2	3	4	**5**	A	B
7	Schedule development	1	2	3	4	**5**	A	B
8	Resource planning	1	2	3	4	**5**	A	B
9	Cost estimating	1	2	3	4	**5**	A	B
10	Cost budgeting	1	2	3	4	**5**	A	B
11	Quality planning	1	2	3	4	**5**	A	B
12	Staff acquisition	1	2	3	4	**5**	A	B
13	Communication planning	1	2	3	4	**5**	A	B
14	Risk management planning	1	2	3	4	**5**	A	B
15	Procurement planning	1	2	3	4	**5**	A	B
16	Stakeholder planning	1	2	3	4	**5**	A	B

Please indicate the most suitable answer for each measurement according to exceeding percent from planned index

№	Measure	%
1	Cost Overrun	
2	Schedule Overrun	

Please indicate the most suitable answer according to the following scale:

№	Measure	Low degree									High degree
1	Customer satisfaction	1	2	3	4	5	6	7	8	9	10

APPENDIX E

LIST OF COMPANIES INVOLVED IN SURVEY

№	Organization	Industry	Number of projects
1	JSC “Kazakhstan electricity grid operating company”	Energy	4
2	JSC “Kazatomprom”	Atomic energy	2
3	SRI of ecological problems	Ecology, energy	1
4	Kazakhstan scientific research and design institute of fuel and energy systems JSC “Energy”	Energy	2
5	JSC “Samruk-Energy”	Energy	3
6	JSC “Logycom”	Software	
7	Center of IT and Cybersecurity	Software	4
8	LTD “AbiTech”	Software	2
9	Institute of engineering and information technology KBTU	Software, engineering and green energy	3
10	JSC “Berkut Technology”		
11	National Nanotechnology open Laboratory	Nanotechnology	16
12	Technopark of KazNTU named K.I. Satbaev JSC Research and development firm	Engineering, software	5
13	Scientific research institute of New Chemical technologies and materials	Chemical technology and nanotechnology	2+2
14	Research Institute of Cell Biology and Biotechnology ENU named Gumilev	Biotechnology	3
15	SRI problems of biology and biotechnology	Biotechnology	2
16	Center of physico-chemical methods of research and analysis	Chemical technology and nanotechnology	1
17	SRI of experimental and theoretical physics	Engineering	12
18	JSC “Center for Engineering and Technology Transfer”	Communications and software	2
19	Laboratory of engineering profile al-Farabi KazNU	Engineering	6
20	JSC “Kazakhtelecom”	Communications, software	5
21	JSC “Transtelecom”	Communications	6
23	National Laboratory Astana	Biotechnology, engineering, IT	8
24	TOO «PolyTech Electronics»	Energy and engineering	2
25	TOO «КаР-Тел»	Communications	6

26	Research Institute “Energy Saving and Energy Efficient Technologies”	Green energy	2
27	Research Institute “FTB COMPANY”	Technologies	1
28	IEC Telecom Kazakhstan	Communications	2
29	Айсад-Тел	Communications	1
30	Arta	Software	1
31	Galan Techno Engineering	Software and communications	2
32	I-TECH	Engineering and software	3
33	Kazakhstan Research and Design Institute of Fuel and Energy Systems	Energy	1
34	Center for Physical and Chemical Research and Analysis Methods	Nanotechnology	1
35	Other organizations	High-tech	About 60

APPENDIX F

DATASHEET IN EXCEL

for IT projects

IT-projects	Prs 1	Prs 2	Prs 3	Prs 4	Prs 5	Prs 6	Prs 7	Prs 8	Prs 9	Prs 10	Prs 11	Prs 12	Prs 13	Prs 14	Prs 15	Prs 16	Total	PQ index	Cost overrun	Schedule overrun	Cust. Satisf.
Prj. 1	5	5	5	5	5	5	5	5	5	5	5	5	5	5	**5**	5	80	5	-25	0	9
Prj. 2	5	5	3	4	5	4	5	5	4	5	5	5	5	4	3	4	71	4,438	0	25	7
Prj. 3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	80	5	0	0	9
Prj. 4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	80	5	0	5	9
Prj. 5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	80	5	12	0	10
Prj. 6	3	4	3	5	5	4	3	3	4	4	3	4	3	2	2	4	56	3,5	50	10	6
Prj. 7	4	4	3	5	5	5	3	3	5	5	3	4	3	2	2	4	60	3,75	60	0	5
Prj. 8	4	4	3	5	5	5	3	4	5	5	3	5	3	3	2	5	64	4	30	-10	7
Prj. 9	4	4	3	5	5	5	3	4	4	4	3	4	2	2	2	3	57	3,563	25	0	6
Prj. 10	5	4	4	4	4	4	4	5	4	4	4	5	4	4	3	4	66	4,125	30	25	10
Prj. 11	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	80	5	-10	0	10
Prj. 12	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	80	5	0	0	9
Prj. 13	5	5	4	5	4	4	4	4	3	5	4	4	4	5	3	3	66	4,125	0	20	10
Prj. 14	4	4	4	5	5	4	4	4	4	4	3	3	3	2	2	3	58	3,625	0	0	8
Prj. 15	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	79	4,938	0	0	10
Prj. 16	5	5	5	5	5	5	5	5	5	5	4	4	3	3	3	0	67	4,188	0	0	9
Prj. 17	5	4	5	4	4	4	4	5	5	5	4	4	4	3	3	2	65	4,063	0	-34	8
Prj. 18	5	5	5	5	5	5	5	5	5	5	4	5	5	3	3	5	75	4,688	0	20	8
Prj. 19	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	80	5	0	12	8
Prj. 20	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	79	4,938	13	0	10
Prj. 21	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	80	5	19	0	10
Prj. 22	4	4	4	3	3	3	3	4	4	5	3	3	3	2	2	2	52	3,25	35	0	8
Prj. 23	5	5	5	5	3	3	3	4	3	5	4	4	4	4	3	3	63	3,938	0	25	8

Prj. 24	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	80	5	0	0	10
Prj. 25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	62	3,875	0	0	8
Prj. 26	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	80	5	0	-19	10
Prj. 27	5	5	4	4	4	4	4	5	4	5	5	5	5	5	5	5	74	4,625	5	0	9
Prj. 28	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	80	5	75	0	9
Prj. 29	4	4	3	3	3	3	3	3	5	5	3	4	4	3	4	4	58	3,625	20	0	7
Prj. 30	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	80	5	-20	0	10
Prj. 31	5	5	5	4	4	4	4	4	4	**5**	5	5	5	5	5	5	74	4,625	60	7	7
Sum	146	145	137	145	143	139	134	141	142	150	134	142	134	126	120	128	2206	137,9	379	86	264
Mean	4,71	4,68	4,42	4,68	4,61	4,48	4,32	4,55	4,58	4,839	4,323	4,581	4,323	4,065	3,871	4,129	2126	**4,448**	**12,226**	**2,774194**	**8,5161**
St.dev.	0,54	0,48	0,8	0,53	0,62	0,64	0,83	0,64	0,64	0,396	0,823	0,641	0,944	1,209	1,289	1,285		0,592	18,573	12,90476	1,4233
Variances	0,27	0,22	0,63	0,35	0,43	0,44	0,67	0,44	0,37	0,135	0,67	0,373	0,799	1,351	1,532	1,467					

Cost overrun

Регрессионная статистика	
Множественный R	**0,4186256**
R-квадрат	0,1752474
Нормированный R-квадрат	0,1468077
Стандартная ошибка	17,21523
Наблюдения	31

Processes	16		
Sum of the item variances	10,151925		
Variance of total scores	86,135276		
Cronbach`s Alpha	**0,941**	**0,92013**	**0,959088**

Дисперсионный анализ

	df	*SS*	*MS*	*Значимость F*			
Регрессия	1	1826,2139	1826,2139	**0,019086889**			
Остаток	29	8594,5603	296,36415				
Итого	30	10420,774					
	Коэффициенты	*Стандартная ошибка*	*t-статистика*	*Нижние 95%*	*Верхние 95%*	*Нижние 95,0%*	*Верхние 95,0%*
Y-пересечение	80,376955	28,247776	2,845426	22,60376663	138,15014	22,603767	138,15014
PMPQ	-17,792573	7,1676331	-2,4823499	-32,45202888	-3,1331175	-32,452029	-3,1331175

Schedule overrun

Регрессионная статистика			Дисперсионный анализ				
				df	*SS*	*MS*	*Значимость F*
Множественный R	**0,0648755**	Регрессия	1	8,1311807	8,1311807	**0,728791766**	
R-квадрат	0,0042088	Остаток	29	1923,8043	66,338079		
Нормированный R-квадрат	-0,0301288	Итого	30	1931,9355			
Стандартная ошибка	8,1448192						
Наблюдения	31						

Y-пересечение	-0,3927698	13,364505	-0,029389	-27,72625123	26,940712	-27,726251	26,940712
PQ	1,1872433	3,3911296	0,3501026	-5,748395356	8,122882	-5,7483954	8,122882

Customer satisfaction

Регрессионная статистика			Дисперсионный анализ			
Множественный R	**0,7155008**		*df*	*SS*	*MS*	*Значимость F*
R-квадрат	0,5119414	Регрессия	1	35,670757	35,670757	**6,06345E-06**
Нормированный R-квадрат	0,4951118	Остаток	29	34,006662	1,1726435	
Стандартная ошибка	1,0828867	Итого	30	69,677419		
Наблюдения	31					

	Коэффициенты	*Стандартная ошибка*	*t-статистика*	*Нижние 95%*	*Верхние 95%*	*Нижние 95,0%*	*Верхние 95,0%*
Y-пересечение	-2,2895369	1,776865	-1,2885261	-5,92363387	1,34456	-5,9236339	1,34456
PMPQ	2,4866754	0,4508644	5,515351	1,564554178	3,4087966	1,5645542	3,4087966