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SUMY STATE UNIVERSITY

Educational and Scientific Institute for Business Technologies “UAB”

Department of International Economic Relations

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MASTER’S LEVEL QUALIFICATION PAPER

on the topic “INTERNATIONAL COLLABORATION DEVELOPMENT IN NANOTECHNOLOGY AND NANOMATERIALS”

Specialty 292 “International Economic Relations”

Student 2 Course ______________ I.V. Kursenko

group ME.m-91a.an

It is submitted for the Master`s level degree requirements fulfillment.

Master`s level degree qualification paper contains the results of own research. The use of the ideas, results and texts of other authors has a link to the corresponding source ______________ I.V. Kursenko

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TASKS FOR MASTER'S LEVEL DEGREE QUALIFICATION PAPER

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5. The subject of research is is a set of theoretical, methodological and applied aspects of the formation of directions for the development of international cooperation in the field of nanotechnology and nanomaterials.

6. The qualification paper is carried out on materials the data of official statistics, books of domestic and international scientists, articles, domestic and international statistical sites were used.

7. Approximate master's level degree qualification paper plan, terms for submitting chapters to the research advisor and the content of tasks for the accomplished purpose is as follows:

Chapter 1 Insight into nanotechnologies and nanomaterials: essence and prospects of development. 20.11.2020 р.

Chapter 1 deals with the essence and classification of nanotechnologies and nanomaterials, perspectives on nanotechnology development strategies.

Chapter 2 Development of cooperation in the sphere of nanotechnologies and nanomaterisals. 01.12.2020 р.

Chapter 2 deals with the analysis in the global nanotechnology market, international scientific and technical cooperation in the field of nanotechnology and nanomaterials, the main situation and trends in the development of nanotechnology in Ukraine.

Chapter 3 Prospects and scenarios of nanotechnological sphere development. 06.12.2020 р.

Chapter 3 deals with the main directions of state regulation of nanotechnology activities and scenarios for the development of nanotechnology in Ukraine, multifaceted system for assessing the level of development and prospects of domestic nanotechnology, investment attractiveness in the ratio of cooperation between several different fields of activity of nano-technologies and materials.

8. Supervision on work:

Chapter	Full name and position of the advisor	Date, signature	
		task issued by	task accepted by
1			
2			
3			

9. Date of issue of the task: «____»_______20 __

Research Advisor: ______________ V.Y. Shcola

(signature) (full name)

The tasks has been received: ______________ I.V. Kursenko

(signature) (full name)

ABSTRACT

on master’s degree qualification paper on the topic

“INTERNATIONAL COLLABORATION DEVELOPMENT IN NANOTECHNOLOGY AND NANOMATERIALS”

student Kursenko Ihor Viktorovych

The main content of the master’s degree qualification paper is presented in 92 pages, including references consisted of 70 used sources, which are placed on 9 pages. The paper contains 13 tables, 5 figures and 9 formulas.

Keywords: NANOTECHNOLOGY, NANOMATERIALS, DEVELOPMENT, INTERNATIONAL COLLABORATION, INNOVATIONS, INVESTMENTS, UKRAINE.

The objectives of the study are to study international cooperation in the field of nanotechnology and nanomaterials, familiarization with nanochenological processes, Investment attractiveness in the ratio of cooperation in several different areas of nanotechnology and materials, assessment of the level of development and prospects of Ukraine in the field of nanotechnology, development of international cooperation in Ukraine on nanotechnology, analysis of global market of nanotechnology, the main directions of state regulation of nanotechnological activities and scenarios for the development of nanotechnology in Ukraine. The object of research is nanotechnology and nanometries.

The subject of research is the development and prospects of international cooperation in the field of nanotechnology and nanomaterials.

Research methods. To achieve the goals set in the work, the following methods were used: the method of comparative analysis, economic and statistical, cause-and-effect analysis, factor analysis, systemic and complex approach, method of grouping and generalization, abstract-logical.

Information base. When writing the qualification work, the data of official statistics, books of domestic and international scientists, articles, domestic and international statistical sites were used.

The main scientific results of the work are as follows:

1) Revealing the prospects and relevance of the field of nanotechnology and nanomaterials.
2) Definition of international nanotechnological cooperation of individual programs.
3) Revealing the negligence of the domestic authorities towards promising areas of scientific and technological spheres of nanotechnology.
4) Availability of prospects in case of improvement of cooperation of Ukraine on the European Framework Program FPRTD (Framework Programmes for Research and Technological Development).
5) Investigation of the investment attractiveness of a project in the field of nanotechnology.
6) Research of the global market for nanotechnology and nanomaterials.

The results obtained can be used by the Ukrainian authorities to analyze the prospects and implement scientific research and cooperation in the field of nanotechnology and nanometrial.

CONTENT

INTRODUCTION

Relevance of the topic. Currently, a technological revolution is taking place in the world associated with the development and entry into the market of nanotechnology, i.e., the transition to the use of nanoparticles, the size of which exceeds 100 nm. This leads us to the nanoworld - the world of highly efficient technologies, "smart" materials, new devices and drugs, innovations in which can give new knowledge, achievements in many branches of science and industry. International cooperation has a particularly relevant emphasis, since in the case of interaction between most or even all countries of the world, they can significantly accelerate a technological breakthrough, as well as transfer the standard of living to a new level.

Nanotechnology is usually understood as three areas of research:

1. Assembly of new substances, materials and structures from individualized nanometer-sized elements.
2. Synthesis of new materials based on particles with the indicated sizes approximately (1-100 nm).
3. Modification of known substances and structures with the use of nanostructural elements.

Today, with the help of nanotechnology, the following tasks are solved:

- Synthesis of new solids with unusual properties and combinations of properties (including ultra-strong and at the same time elastic metals, fibers and fabrics, plastics, hybrid films of the Langmuir-Blodgett type, self-healing materials, new high-temperature superconductors, etc.).
- Creation of new substances by methods of supramolecular chemistry (including new systems for the delivery of drugs, biocompatible materials, etc.).

- Assembly of nanomachines (nanomotors, nanocomputers, precision nanomanipulators, etc.).

Nanotechnology is one of the fastest growing and most demanded areas of science and technology. The explosive growth of this sector has taken place in recent years, since 2005, more than 60 states have launched national programs to develop this topic. Interest in nanotechnology as a development tool is already noted in almost all industries.

The study of a problem.Questions about the impact of technological factors on economic processes are the subject of research by many scientists including Y. Bazhal, V. Geyets, I. Egorov, N. Kondratyev, I. Odotyuk, M. Tugan-Baranovsky, H. Freeman, Yu Shkvorets, J. Schumpeter. In the past decades, the issues of nanotechnology development, international cooperative development of nanotechnology and the production of nanotechnology products, their impact on economic and social processes, and the implementation of national policies shaping the national nanoindustry have been addressed by G. Azoev, M. Alfimov, Zh. Alferov, Yu. Altman, V. Balabanov, K. Bosso, S. Wang, S. Glazyev, L. Gokhberg, E. Drexler, N. Kobayasi, S. Palmberg, A. Putilin, M. Ratner, M. Rocco, M. Sidnenko, N. Taniguchi, A. Teriohov, Y. Tretyakov, V. Hartman, P. Holister, A. Hulman and others.

In addition, organizations such as the OECD, European Commission, UNIDO, Lux Research, Forfás, CMP Científica and others pay a great deal of attention to nanotechnology innovation in experimental and practical activities. These organizations are responsible for the level of development of statistical accounting and nanotechnology activities, performance in the field of measurement, certification and standardization of nanotechnology products, research results on possible adverse effects of nanotechnology, and human health, the environment and products manufactured using the product. Significant advances have been made in the theoretical and methodological basis of statistical accounting and evaluation. Life safety.

International cooperation in the field of nanotechnology and nanometrial is of great relevance at the moment, which indicates a progressive and promising direction for the country. At the moment, the country is focused on the military-technical path. However, taking into account the factors in which a large number of scientists have left our country and are leaving because of the impossibility of working in a progressive direction in this area. It should be concluded that the prospects for development in the field of nanotechnology are great, it is only necessary to slightly increase budgeting, orientation and investment in this area to see big changes already at this stage.The intensive development of nanotechnologies, their rapid penetration into production and consumption and the associated risks - social, ethical, environmental - determine the relevance of the earliest possible solution to the problem of forming a system of economic and statistical measurements of the scale, structure and dynamics of this technological direction and the corresponding field of activity. The lack of the necessary methodological base and practical tools for this leads to very vague and often contradictory ideas about the state of the nanotechnology sphere, its economic and social effects.

Having gained wide recognition as one of the most promising areas of scientific and technological development, nanotechnology has become the object of priority support in many countries of the world. It is estimated that there is hardly another field of science that has received such significant public investment on a global scale in such a short period of time.

The purpose of qualification paper is to examine the theoretical approaches to development of international collaboration in nanotechnology and nanomaterials. Revealing the prospects and relevance of the field of nanotechnology and nanomaterials, definition of international nanotechnological cooperation of individual programs, revealing the negligence of the domestic authorities towards promising areas of scientific and technological spheres of nanotechnology, availability of prospects in case of improvement of cooperation of Ukraine on the European Framework Program FPRTD (Framework Programmes for Research and Technological Development), investigation of the investment attractiveness of a project in the field of nanotechnology, research of the global market for nanotechnology and nanomaterials.

In accordance with the purpose of the qualification work, the following tasks were set:

- development of international cooperation in the field of nanotechnology and nanomaterials;
- investment attractiveness;
- assessment of prospects and development;
- identifying the state of the sphere of activity on the territory of Ukraine;
- basic concepts and epistimology of this direction;
- main directions of state regulation of nanotechnology activities and scenarios.

The object of the research is processes of development of international cooperation in the field of nanotechnologies and nanomaterials.

The subject of research is a set of theoretical, methodological and applied aspects of the formation of directions for the development of international cooperation in the field of nanotechnology and nanomaterials. Development and prospects of international cooperation in the field of nanotechnology and nanomaterials. To achieve the goals set in the work, the following methods were used: the method of comparative analysis, economic and statistical, cause-and-effect analysis, factor analysis, systemic and complex approach, method of grouping and generalization, abstract-logical.

Information base. When writing the qualification work, the data of official statistics, books of domestic and international scientists, articles, domestic and international statistical sites were used.

1. INSIGHT INTO NANOTECHNOLOGIES AND NANOMATERIALS: ESSENCE AND PROSPECTS OF DEVELOPMENT

1.1 Essence and classification of nanotechnologies

As the literature review shows, nanotechnology is considered today both as a field of research and as a direction of technological development. On the one hand, this reflects modern trends in the relationship between science and technology, and on the other, it generates serious terminological confusion. Contradictions begin already in attempts to designate the area of research in general and to give a definition of the concept of "nanotechnology". Thus, some authors distinguish "nanoscience", which deals with the knowledge of the properties of nanoscale objects and the analysis of their influence on the properties of materials, and "nanotechnology", which aims to develop these properties for the production of structures, devices and systems with the characteristics specified at the molecular level. Sometimes such a division has a purely methodological basis when it comes to the analysis of scientific publications (and then it is said about "nanoscience") or patents (in this case, the concept of "nanotechnology" is used). In practice, it turns out to be almost impossible to distinguish between nanoscience and nanotechnology, therefore, in order to avoid confusion, some researchers suggest limiting [1].

At this stage of the development of the world economy, the implementation of new methods of using innovative technologies is predominant in connection with the resulting increase in production efficiency and improving the quality of services and goods. In this regard, in the current world, nanotechnology is a tool for the formation of new technological progress, which indicates a high growth dynamics. In the case of maximum use of these technologies, there is a possibility of preferential use of 50% of all goods to one degree or another will be based on nanotechnology in production and services by 2025, since this is a priority direction in many countries at this stage of development. Also, these technologies are the key to solving some of the global problems of mankind. In addition, the use of nanotechnology together with some high-tech industries will have an excellent synergistic effect, which will encourage some technological development in the capabilities of production aspects [2].

In the case of considering improving international cooperation in the field of nanotechnology and nanometrial, it is worth considering certain aspects of this area. The polyaspectality of this direction has a fairly large volume, which can affect all areas of activity in technological moments. To define these issues, it is worth clarifying the concepts and essence of the term "nanotechnology". The problem of the unity of concepts and standards in the field of nanotechnology has been repeatedly discussed in foreign and domestic literature. This question is the key to developing a unified approach to understanding the nature and characteristics of their development. The presence of a coherent conceptual apparatus would make it possible to more clearly define the boundaries of the research area and evaluate the scientific, technological and socio-economic trends generated by it. Thus, the term "nanotechnology" will serve as a criterion for further selection of units of observation, referring objects (organizations, research results, goods and services) to the category of nanotechnology [3].

It should also be emphasized that the development of definitions and classifications in the field of nanotechnology is a rather difficult task. First of all, this is due to the “universal” nature of nanotechnology - a poorly structured field with high dynamics of development. We must also take into account the multidisciplinary nature of this field and its ability to adapt to new scientific and technological advances and the needs of the economy and society.

It is worth noting that the term "nanotechnology" was first proposed by the Japanese professor N. Taniguchi in the mid-70s of the last century in his report "On the basic principles of nanotechnology." This term covered a fairly significant set of knowledge, approaches, methods, specific procedures and their materialized results - nanoproducts.

Since then, nanotechnology has become one of the strategic directions of economic development in developed countries, fulfilling development plans and constantly increasing investments in the development of research areas. In addition, nearly all leading-edge product manufacturers such as IBM, HP, Hitachi, Lucent, Mitsubishi, Motorola and NEC have their own nanotechnology research programs [4]. Despite this, the rapid development of the nanotechnological sphere significantly complicates obtaining clear and accurate data on the level of its development in different countries, since each of them uses a specific conceptual and classification apparatus. In this regard, the main problem is determined by the fact that there is no single-faith concept and standards for this direction. Despite the constant discussions of this field of activity by completely different layers of society, at the moment there are significant differences in the treatment of the essence and classification of nanotechnology, which to a certain extent has a great influence in professional cooperation and mutual understanding between different representatives of different sciences and countries. Nanotechnology has long made its way into our lives, this is the key that helps to create completely new devices and materials [5].

From the above, it is worth concluding that our country has potential in the field of innovative technologies, but the country focuses far from developing a promising future.

There is no single definition of nanotechnology and no approved classification. In most cases, the existing terminology equipment is developed under another R&D program and project in the aforementioned area and therefore only reflects a specific function [6].

Only at the end of 2010 was approved the statistical form No. 1-technology (annual) "Report on the creation and use of advanced production technologies", which allows you to get the first generalized information on the level of development of the nanotechnology sector in Ukraine.

The definition of nanotechnology provides guidance on tabulation procedures. Interpret the proposed definition using other methods to explain the essence of nanotechnology. Usually it is a combination of effective ingredients from various existing methods and specific characteristics of nanotechnology. It can be concluded that it can also be used for statistical observations and technological innovation policy [7].

The generalization of the scientific tradition of nanotechnology, the formation of ecological classification devices and the actual definition of "nanotechnology" are very contrary to the points of view associated with the implementation of the theoretical and methodological basis. In most cases, this is confirmed by the following definition - "conceptual alternative". Thus, through a critical analysis of scientific and scientific-practical literature, the following terms can be derived: "Nanotechnology", "products of nanotechnology" and "nanomechanisms" are closely related. In some cases, the boundaries between them are very complex. The term "nanotechnology" is often used in a broader form. In general, nanotechnology includes not only technologies that directly affect nanoscale substances, but also technologies that use nanoproducts to produce macroscopic water. In addition, in the literature, the term "nanotechnology" is often used to describe the complete scientific and technical system that enables the development and commercialization of nanotechnology. In the first case, it is appropriate to use the phrase "using nanotechnology", in the second case, in order to avoid ambiguous interpretation of information [8].

For a better definition of the meaning of "nanotechnology", it should be divided into several categories to summarize the essence of the characteristics (Fig. 1.1).

Although it is impossible to conduct research in the field of nanotechnology without a large amount of theoretical input, the results still have a clear application direction.

For the current wider range of products and the geographical diversification of nanotechnology product production and consumption, it is also important to select primary and secondary indicators that can characterize the research field and are quantitatively based. This is a qualitative expression. data. Therefore, government agencies and individual experts in many countries today are solving the problem of creating effective classification systems for nanotechnology and nanotechnology products [9].

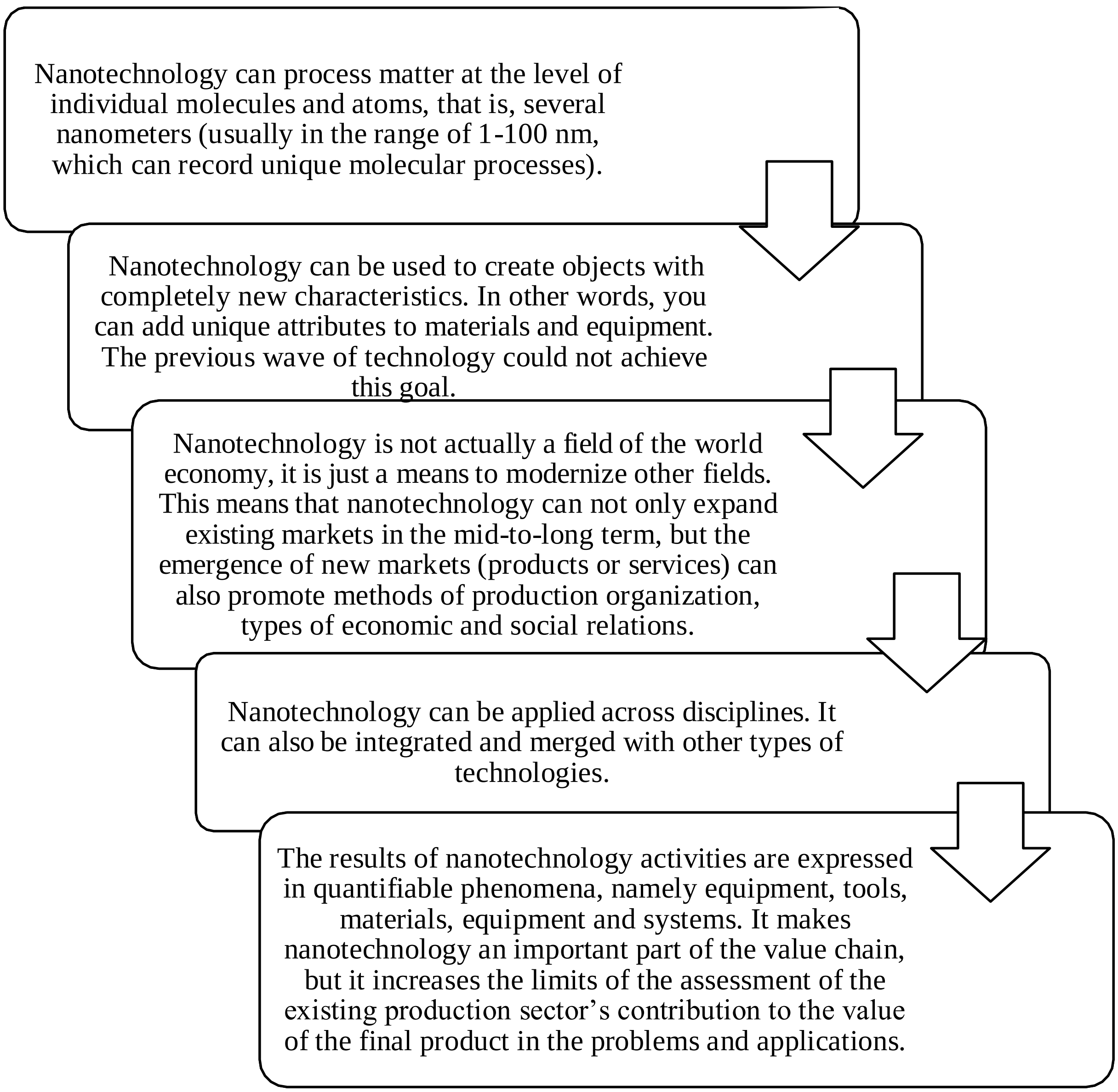


Figure 1.1 Characteristics of nanotechnology

*Source: https://www.nano.gov/nanotech-101/

The main purpose of the development of draft classifications in the field of nanotechnology is determined by the identification and systematization of the basic units of statistical observation, in combination with nanotechnological classification developments can be identified as follows:

• classification of nanotechnology;

• classification of nanotechnology products and services.

A classification of nanotechnology was formed to integrate and systematically describe the main focus areas of the nanotechnology field. The formation of the nanotechnology classification group is divided into several stages (Fig. 1.2) [23].

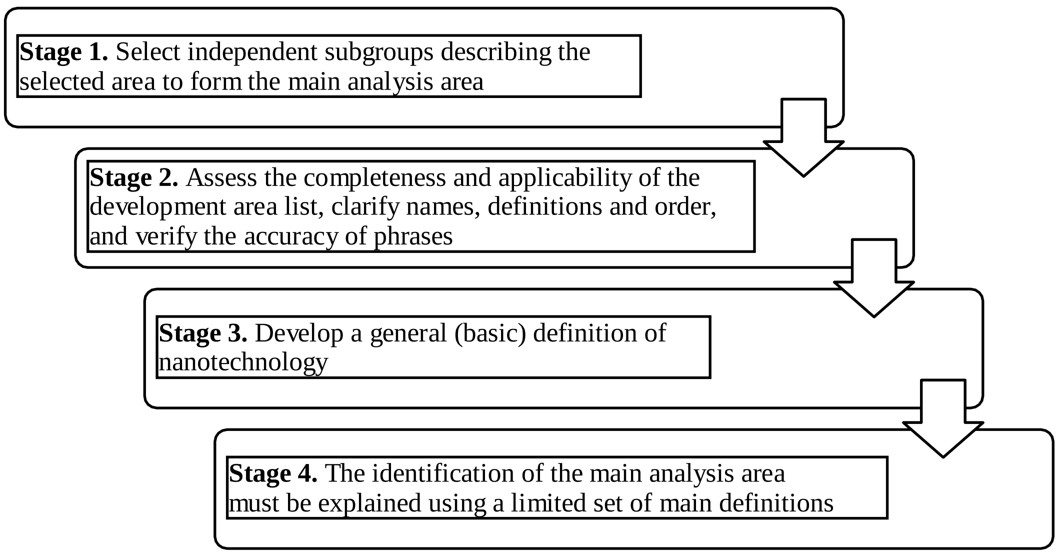


Figure 1.2 Stages to classify the nanotechnology

*Source: https://www.sgu.ru/sites/default/files/method_info/2020/b.m._baloyan_i_dr._nanomaterialy.pdf

The classification of products and services related to nanotechnology is formed based on the product classification of economic activity types for statistical observation. The classification should include a range of products and services produced using nanotechnology, which should be combined in a clearly defined manner or provide unique properties at the molecular and sub-molecular level [10].

In nature and technology, nanoobjects are usually multicomponent systems, and in this case we have to deal with a wide variety of terms: "nanocrystal", "nanophase", "nanosystem", "nanostructure", "nanocomposites", etc.

Because nanotechnology covers an extremely broad class of sciences and has many aspects of development, they can be classified according to many classification criteria [11]. One of the broadest is the classification: Qualification of nanotechnologies (Fig. 1.3).

Purpose	• civil; • military; • special; • double;
Scientific and technological direction	• nanoelectronics; • nanomechanics; • nanomaterials; • nanochemistry;
Belonging to the critical technology	• materials for micro- and nanoelectronics; • precision and nanometric technologies of processing, assembly, control; • microsystem technology; • synthetic superhard materials; • element base of microelectronics and quantum computers; • basic and critical military and special technologies;
Environment of use	• water • air • space • earth surface • biological objects
Basic technical characteristics and parameters	• topological dimensions of nanoelectronics elements • geometric dimensions of structural elements of nanomaterials • surface nanoprocessing parameters: height, roughness, roughness, shape accuracy, etc.
Stage of innovation development	• development of nanoeffects; • creation of means of manipulation with individual atoms of matter; • creation of functional nanoelements of complex technical systems; • creation of complex functional nanostructures, etc.

Figure 1.3 Classification of nanotechnologies

*Source: https://files.stroyinf.ru/Data2/1/4293811/4293811117.htm

The purpose of this classification is, first of all, the solution of problems in the field of accounting, analysis and standardization of scientific, scientific and technical, innovative and industrial activities in the field of nanotechnology. The classification can also be used for selection and examination of projects, evaluation of activities in the field of protection of intellectual property rights, statistical research, unification of scientific and technical or other information in this field. All this should provide a structured description of nanotechnology as a scientific, technological and economic sphere, contribute to the development of priorities, the formation and implementation of evidence-based policy [22].

The main directions of nanotechnology: nanomaterials, nanoelectronics, nanophotonics, nanobiotechnology, nanomedicine, Nanoinstruments (nanodiagnostics), technologies and special equipment for the creation and production of nanomaterials and nanodevices. The classification, which describes the main directions of nanotechnology, is based on the experience of leading international organizations in the field of standardization and statistics and can serve as a tool to describe nanotechnology, the formation of public information resources and reliable statistical information on the state and development of research and development in nanotechnology [12].

This classification allows you to summarize the accumulated information about the subject area, taking into account the characteristics specific to technology in general and nanotechnology in particular. The classification structure allows you to divide the classification features into smaller units and make additions as new properties of technology are identified. That is, such a classification will be able to provide an orderly display of information about nanotechnology, will allow its periodic updating and can be used to create a list of nanotechnologies and products manufactured using them.

The division according to each of the classification features has its advantages and disadvantages. Thus, the classification of nanotechnologies by scientific and technological direction has unconditional advantages over others, as it allows the most complete disclosure of the essence of technology and determine the scope of its use.

Classification on the basis of "purpose" is of some importance for the study and forecasting of the market, as different groups of technologies are characterized by different development trends, due primarily to state policy of their regulation. The classification according to the stage of innovative development of nanoproducts seems to be the least justified for the purposes of further market research, as it has a descriptive, mainly informative character [14].

Also, he tried to identify the proper directions for some areas of activity before the generally accepted distribution of the fundamental sciences (Table 1.1).

Table 1.1 – Identifiers belonging to certain areas of nanotechnology

Sphere	Information
Physics	Scanning probe microscopes; optical microscopes; electronic, magnetic, optical properties of nanostructures; analytical and mechanical devices, etc.
Chemistry / material science	Parts and coating; dendrimeric molecules; nanofibers; porous materials; nanofiber composites; structures based on DNA, etc.
Electronics	Electron and ion beams; multi-ball magnetic sensors; lithography, etc.
Biology	Analysis of biomolecules; biomineralization, biological motors; biocomputers; analysis of cellular processes
Medicine	Obtaining nanoparticles with antibodies / antigens / DNA sections applied to their surface; using nanoparticles for optical signaling about the state of organs and tissues, using magnetic nanoparticles to isolate and heating individual tissue parts, overcoming the body's immune barrier by transferring drugs on nanoparticles; creating and the use of DNA chips, etc.

*Source: https://www.technosphera.ru/lib/book/479?read=1

The classification of Altman M.Yu. on nanotechnology. That is based on the degree of complexity of the structures used and created, based on the incremental variable of objects (Table 1.1). Also, most nanomaterials are used, and not specifically nanotechnologies, which indicates an existing problem in the terminological consensus in the research area [14].

In order to systematize nanotechnology, such a classification feature as scientific and technological directions was chosen. This approach allows to clearly define the boundaries of nanotechnology and to operationalize the basic definition for statistical monitoring and analysis of management data. Analyzing these examples of groupings of areas of nanotechnology, we can conclude that the vast majority of organizations that have studied this issue, identify areas such as nanoelectronics, nanobiotechnology, nanophotonics, nanomedicine, nanomaterials [15].

It is noteworthy that the International Organization for Standardization (ISO) does not single out nanomaterials among the areas of nanotechnology. However, in 2010 the ISO standard on the classification of nanomaterials - Nanotechnologies - Methodology for the classification and categorization of nanomaterials was published. Thus, there is still terminological uncertainty in the field of nanotechnology, in particular the status of the category "nanomaterials", as one part of the standardization organizations refers to this category to the types of nanotechnology, the other - to the components of nanotechnology products [16].

As mentioned earlier, the term "nanotechnology" is closely related to the concept of "nanoproducts". It should be noted that the term "product" is generally defined as a tangible or intangible result of human labor. In the material sphere - a product obtained from raw materials and materials by technological means, as a result of which the properties of the source material change, and the product acquires a new consumer value.

Both nanomaterials and products created with the help of nanotechnologies meet these criteria. In addition, this applies to nanomaterials to a large extent due to the fact that during their creation the starting materials (raw materials) are radically transformed, acquiring and exhibiting completely new properties. In the manufacture of consumer goods using nanomaterials / nanotechnologies, it is nanomaterials that are a component / ingredient of the product, which gives it additional properties without changing the purpose of the product [17].

If the nanotechnology uses an object scale of 100 nm or less, then in the product area this approach is incorrect. In addition to products that directly contain a nanotechnology component, products are produced that do not have such a component, but its production becomes possible only through the introduction of nanotechnology. Today, the identification and quantification of nanotechnology products is very complex. Within the framework of the project of the International Center for the Support of Scientists in the United States, the first attempts were made to catalog existing types of nanotechnology products using the analysis of Internet content [18].

1.2 Nanomaterials: Essence and classification

Nanomaterials are at the forefront of the rapidly evolving field of nanotechnology. Their unique properties are widely used in many areas of human activity. The biological action of nanomaterials is due to the peculiarities of their composition and structure, and the specifics of the organization of living things. Theoretical and practical aspects of research of biological action of nanomaterials are allocated in the work.

In recent decades, the great interest of both scientists and, in general, the world community is chained to nanotechnology, based on the synthesis, assembly and modification of new substances, materials and structures based on elements not exceeding 100 nm. It should be emphasized that the main reason for the separation of phenomena in this field and related concepts is due not so much to the nanoscale objects as their special properties (thermal, magnetic, optical, structural, etc.), as well as methods of obtaining, studying or using nanostructures [19].

The variety of nanomaterials determines the variety of technologies for their production, which are divided into two major groups: nanotechnology "top-down" and nanotechnology "bottom-up". The technological approach "top-down" is based on the fact that the creation of products aims to reduce their size by fragmentation and miniaturization with the transition from micromachining to nanoprocessing. In turn, the technological approach "bottom-up" involves the assembly of products from individual atoms and molecules, as well as atomic-molecular blocks, structural fragments of living cells, etc [20].

It is known that nanotechnology is evolving at several levels, covering materials, equipment and systems. The most promising for scientific knowledge and commercial use at present should be considered the first of themthe level of nanomaterials. First of all, this is due to the fact that nanomaterials contain structural elements in the form of nanoparticles and have qualitatively new properties that allow their integration into fully functioning micro- and macrosystems.

Free (unbound) nanoparticles are found everywhere: some of them are of natural origin (suspension of sand in desert areas of the world, volcanic emission products, smoke particles from forest fires, sea salt nanocrystals, viruses); while soot, exhaust gases, volatile paint particles contain nanoparticles of anthropogenic origin; and the particles of titanium and silicon oxides used in pharmacology or for the production of cosmetic products, the particles of metals or compounds required to control chemical reactions are of industrial origin [25].

In addition, the nanoparticles that make up nanomaterials differ in chemical composition, shape and spatial organization (Buzea, 2007). The composition of nanomaterials includes carbon nanoparticles obtained mainly by engineering methods (fullerenes, nanotubes, graphene, nanosaws, nanowires and others); Non-carbon simple particles based on silicon, magnesium, titanium, gold, silver and other metals; quantum dots, nanorobots; nanoparticles of binary and composite compounds, as well as preparations of nanoparticles of polymers, biopolymers and other complex compounds [26].

The variety of nanomaterials and nanodevices and their scope is so great that it complicates not only the generalization of information about their use, but also limits the ability to predict new areas of application of nanomaterials and nanodevices. However, for biology and medicine, the systematization of areas of use of nanomaterials, based on different properties of nanocomposites and differences in their interaction with biological objects, is an important task. Thus, nanomaterials can act as:

- fluorescent biological labels;
- transport agents for the delivery of drugs and genes;
- biosensors to detect pathogens;
- sensors for protein detection;
- DNA microchips for DNA detection and analysis;
- basics for fabric engineering;
- reagents for separation and purification of biological molecules and cells;
- contrast agents for magnetic resonance imaging;
- markers to quantify cell motility, etc [26].

It should be emphasized that having unique physicochemical properties, nanomaterials and nanocompositions also have a wide range of biological action (Table). Their effect on living organisms, including toxic, due to the high chemical and catalytic activity of the surface of nanoparticles, absent in the same substance, which has a greater dispersion, and the high concentration of nanoparticles in the air with a small amount of sprayed substance.

It should be emphasized that for the vast majority of nanomaterials are not known mechanisms of entry into the body, biocompatibility, biotransformation, translocation in organs and tissues, mechanisms of elimination, and, most importantly, their toxicity [27].

For living organisms, as complex systems, there are several levels of organization: molecular, subcellular, cellular, organismal, population-species, biogeocenotic, biosphere. The influence of nanomaterials to some extent covers all levels of organization of biological systems (Table 1.2).

Table 1.2 – Biological action of nano-substances

Classification	Function
Physicochemical features	Change in physical and chemical properties and biological (including toxic) effects.
Behavior of nanomaterials	Possible binding to nucleic acids, proteins, incorporation into membranes, penetration into cellular structures and, as a result, changes in the functions of biostructures. The processes of transfer of nanoparticles in the environment with air and water flows, their accumulation in soil, bottom sediments can also significantly differ from the behavior of larger particles.
Small size and high variety of nanoparticle shapes	Possible adsorption on nanoparticles of various contaminants and facilitating their transport into the cell, which sharply increases the toxicity of the latter. Many nanomaterials have hydrophobic properties or are electrically charged, which enhances the processes of adsorption on their surface of various toxicants and the ability of the latter to penetrate the natural barriers of the body
High adsorption	It is possible that, due to their small size, nanoparticles may not be recognized by the body's defense systems, not biotransformed and not excreted from the body, which leads to the accumulation of nanomaterials in plant and animal organisms, as well as in microorganisms, to transmission along the food chain and, as a result , to increase their intake into the human body

*Source: https://www.tandfonline.com/doi/full/10.1080/10717544.2017.1375577

In living organisms, the nanostructured level of organization is represented by macromolecules, cell organelles and viruses. For bionanotechnology, the most complex and multifunctional nanostructures are molecular complexes that regulate and control biological systems. For example, proteins - universal nanosized molecular complexes - control molecular transport, metabolism, sensory and informational properties of biological systems [28].

Interaction of nanoparticles with proteins - "protein crown of nanoparticles" - protein molecules on the surface of nanoparticles. Conformational changes in protein molecules arising with the participation of nanoparticles can lead, in particular, to immunological recognition of the complex as "encrypted". In addition, according to various researchers, nanoparticles also cause, for example, the loss of the helical structure of bovine serum albumin (in the case of Al particles and hydroxyapatite size 100 - 300 nm), small conformational changes in the secondary structure of the same protein (in the case of Zn and Au nanoparticles 5 - 100 nm), polymerization of tubulin (for TiO2 particles with a size of 20 nm), etc [29].

It should be emphasized that the proteins of the "crown" provide the interaction of nanoparticles with cells, facilitating their transmembrane transfer in phagocytosis, pinocytosis and receptor-mediated endocytosis, which contributes to the accumulation of nanoparticles in cellular structures. Also, nanoparticles with a diameter of less than 100 nm are able to enter cells, less than 40 nm - in the cell nucleus, and less than 35 nm - to overcome the blood-brain barrier, selectively regulates metabolism between blood, cerebrospinal fluid and central nervous system.

Undoubtedly, an important role in the reactions of cells and whole organisms to the influence of nanoparticles and nanomaterials is played by the systematic (taxonomic) position of the object of influence. There is also an assessment of the toxicity of nanomaterials using microorganisms, namely the response of bacteria (Escherichia coli), micromycetes (baker's yeast) and unicellular algae (chlorella) to the effects of silver and magnetic nanoparticles. It was found that the magnetic nanoparticles formed a dense layer, and the silver nanoparticles were located on the cell surface diffusely. Polymer films with nanoparticles delayed cell division, but had little effect on their enzymatic activity. It was also shown that silver nanoparticles penetrated together with the cells of host microorganisms into the body of the free-living nematode Caenorhabditis elegans and had an inhibitory effect on the growth and reproduction of nematodes. Thus, the movement of nanoparticles along the food chain and their indirect negative effects on multicellular organisms were demonstrated [31].

The results of biotesting of carbon nanomaterial "Town" on the example of culture of green protococcal algae, microscopic crustaceans - ceriodaphnic, testsystem "Ecolum" - on the example of culture of luminescent genetically engineered bacteria, spring wheat.

In plants, it was found that some species (eg, pumpkin, Lim beans) had the ability to filter nanoparticles, avoiding their influence, unlike other crops (cabbage, carrots, wheat, cucumber, soybeans), which accumulated them. Thus, in addition to studying the effect of nanoparticles of alumina and titanium on the morphophysiological parameters of agricultural plants, the importance of the biological model for this kind of experiments was confirmed.

It should be noted that depending on the effect on living organisms, nanomaterials can be divided into two groups: toxic, including those with antiseptic and bactericidal properties, and biologically compatible, of interest as a means of monitoring the body at the cellular and subcellular level. new biological sensors and as new drugs [31].

Evaluation of the biological action of both toxic and biocompatible materials should include not only biochemical, cytometric, immunological, electron microscopic research methods, but also methods of biotesting taking into account biotic connections in ecosystems that take into account the ability of nanoparticles to inhalation, transdermal, transdermal and enteral penetration into any human organs and tissues, including the central nervous system.

It is possible to allocate theoretical and practical aspects of research of biological action of nanomaterials. At the theoretical level, this study:

- ways of entering the components of nanomaterials of different chemical composition and structure in living organisms;
- mechanisms of their movements and transformations in metabolic reactions;
- participation of nanomaterials in regulatory processes in biological systems;
- inclusion in biological systems and transformation of nanocomposites and their components at different levels of organization of biological systems;
- species-specific effects of nanomaterials depending on the taxonomic affiliation of the organism.

At the practical level it is:

- study of areas and areas of application of nanomaterials, taking into account their toxic or biologically compatible nature;
- expanding the range and improving methods for studying nanomaterials and their components;
- creation of nanomaterials with the help of living organisms [32].

1.3 Perspectives on nanotechnology development strategies

The development of nanotechnology and new materials is a priority area for innovation in almost all technologically advanced countries. The global nano market is highly competitive, and with the development of the division of labor in the world, the status of each country depends on the result of competition. Therefore, according to experts, the position of the new world division of labor will be determined in 2022, and since Ukraine today is not an advanced country in the development of nanotechnology, that is acquired in other countries will not belong to this area. We hope to use the successful experience of developing technologies that will become the foundation for the development of the domestic nanotechnology industry.

The development of the scientific and technical potential of the EU member states in the field of nanotechnology will be carried out jointly by all member states. Thus, the main feature of the EU nanoindustry supervision is the coexistence of transnational regulations and national legislation of the member states [33].

May 2004 The EU adopted a 2015 nanotechnology development strategy. This strategy takes an integrated approach to the development of the nanoindustry, with an emphasis on research and industrial innovation, as well as other important aspects such as education, professional development and networking with masses.

The EU also has a foundation for scientific and technological research, technology development and demonstration. In this plan, funding for the development of nanotechnology was provided after FP4 (1994-1998) and financial support was provided for 80 nanotechnology projects totaling 120 million euros. Under the FP5 program (1998-2002), 157 nanotechnology projects received a funding of 220 million euros. FP7 (2007-2013) is a "cooperation" program with a budget of 3,418 million euros in the field of "Nanoscience, Nanotechnology, Materials, New Production Technology" (FP7-NMP) research subjects for nanotechnology development. Allocate within. This is about 7% of the total planned budget [34].

However, EU member states are implementing their own plans to develop nanotechnology. For example, in Germany nanotechnology research has received independent federal programs for independent infrastructure and its own budget. German political leaders said that in the long run, preferential state support in this area will first increase the competitiveness of the most developed sectors of the German economy (automobiles, chemicals, equipment, optics and information technology). He argued for the importance of nanotechnology. In June 2006, the inter-departmental integration plan "Nano Technology Plan 2010" was adopted, the main mechanism of which is the so-called "Leitinnovationen", and Germany has become a global technology. The goals of nanotechnology that we have set as leaders can be applied to key areas of mid-term project allocation and priority economics for direct real benefit. Each “major innovation” has its own “roadmap”. This includes specific tasks and employees, as well as terms of funding. Today, Germany is the "major focus" of nanotechnology such as electronics (NanoFab scheme), automotive industry (Nanomobil scheme), optical industry (Nanolux scheme) and pharmaceutical and biotechnology (NanoForlife scheme). Introducing "Technology Innovation", "Chemistry" (initiative "Nanom").

An important factor in ensuring the functional stability of the mechanisms that support the formation of the nanoindustry is the creation of spherical (management) regulators. This function is performed by:

- The main unit of the European Commission is DG Studies.

- US National Nanotechnology Commission and subcommittee of the National Nanotechnology Commission on Science, Technology and Nanoparticle Technology (NSET).
- The Japanese Economic Association (Keidanren) has formed a special committee on nanotechnology industry and technology.
- The main scientific organization "Russia-Nanotechnology" Committee-Research Center "Kurchatov Institute" [35].

It should be noted that the government actively supports corporate interests in the field of nanotechnology. Therefore, in 2002, the European Nanobusiness Association (ENA), a non-profit organization in the European Union, was established to coordinate the formation and development of nanotechnology. Japan has adopted NBCI (Japan Nanotechnology Business Plan). In Germany, as part of the development of nanotechnology, a series of specialized information tools have been developed to analyze the potential needs of various industries and to create a list of scientific and technological studies that meet these needs [36].

However, the availability of funds and appropriate efforts and strategies used for nanotechnology research is not sufficient to become a detrimental tool for the nanotechnology industry or to create the necessary prerequisites for nanotechnology development. The results of these studies require the development of the entire infrastructure, especially the network structure, to have a direct impact on economic growth and national competitiveness. National, regional and regional network systems are the most effective mechanisms for interacting with stakeholders. This is especially the case when new technologies can be used simultaneously in multiple disciplines (interdisciplinary research and development). These networks bring together various industries, NGOs, financial institutions, research institutions, universities and state-owned enterprises. The countries studied have extensive experience in clustering, so it is clear that these tools will be used in the national field development of nanotechnology [37].

The United States is a leader in cluster nanotechnology networks (more than 1,200 members) and affiliates (operating in all states). The country also formed two large clusters in the field of nanotechnology.

- Huge clusters of western California (center of Silicon Valley (San Jose), adjacent areas-San Francisco, Oakland, San Diego, Los Angeles, Santa Ana). The surrounding clusters are included in the production chain "Huge Cluster".
- Huge eastern clusters-New England (mainly Massachusetts, New York and Oregon)-the center is in Boston and the surrounding areas (Albani, Portland, Worcester, Rochester) have the traditional features of Urga.

However, although the private sector has begun financing nanotechnology research and development, the formation of large-scale nanocluster networks in the United States is primarily a government activity to improve the business environment (1990-1998). Systematic reduction of tax burden, revision of labor laws, introduction of new tax cuts and exemptions system (investment to create new enterprises, purchase and leasing of equipment in areas important to the national economy) and organizational reforms between economic institutions and the state to achieve synergy Do it. The main goal is to maximize public sector orientation in industrial and market demand systems [37].

The structure of the nanotechnology network in Korea is the National Center for Nanotechnology Production (2005), the National Center for Nanotechnology Production (2006), the National Center for Nanomaterials Technology (2007), the National Center for Nano-Druku Electronics (2008), and the Center for Nanotechnology Integration . (2007) serves as a material foundation for the function of the Korean nanotechnology industry.

The implementation of the cluster model for the development of nanotechnology in the Russian Federation is related to the activities of OJSC Rusnano. Since 2009, the RUSNANO cluster project program has begun. There are

50 projects, the budget is on average from 500 to 5,000,000,000 rubles, and the proportion of RUSNANO funds in the project is from 20 to 40%. Most clusters are currently in the early (real production) stage of their life cycle. In the near future, actual commercialization is only possible in the "Medicine and Biotechnology", "Nanostructured Materials" groups [38].

Therefore, as a result of studying the experiences of world leaders in the field of nanoindustrialization, it can be argued that the creation of nanotechnology clusters is always implemented with the participation of the state. However, this level of participation varies by country. In some countries, the role of government regulation in this area is very important and often decisive. An example of this approach is a complex multi-dimensional three-tier system for developing and supporting innovative projects in the EU. Here, the development of the nano-industry takes place primarily "from above" based on a large number of pan-European and national target development programs, dozens of universities, research institutions, and large technology platforms integrating several EU countries.

2. DEVELOPMENT OF COOPERATION IN THE SPHERE OF NANOTECHNOLOGIES AND NANOMATERIALS

2.1 Analysis-in the global nanotechnology market

Modern society is at that stage of its functioning, the invariable components of which are the widespread use of information technologies, the strengthening of the innovative component in the economy, the development of high-tech industries, globalization and internationalization of research, the growth of global competition in precisely those markets whose main products are innovative and high-tech goods and services. In such conditions, the key concept becomes the term "nanotechnology", which means a new branch of science that operates on matter at the nanoscale, thus providing it with new, revolutionary properties. Nanotechnology is an interdisciplinary field of fundamental and applied science and technology, it deals with a set of theoretical justification, practical methods of research, analysis and synthesis, as well as methods for the production and use of products with an atomic structure using controlled manipulations of individual atoms and molecules. All this makes nanotechnology one of the most promising areas of innovation in the world, and therefore, the main source of global competitiveness in the future world [39].

At the same time, many aspects associated with nanotechnology still remain undisclosed or insufficiently studied. Mainly, such a low level of development of the topic is a consequence of the "youth" of the field of nanotechnology. The applied foundations of nanotechnological developments, ethical and environmental aspects of their application require further research. The most important area of modern research is the study of the methodological foundations of the formation of the global nanotechnology market and international cooperation, as well as the principles and patterns of its functioning [40].

With the launch of nanomaterials, the first commercial product in 1994, it was only a matter of time before the formation of a global market. It is worth noting that the market for products for nanotechnology components was already developing at that time, and computer giants such as IBM and Intel were constantly developing chip-based integrated circuits.

Analyzing the prerequisites for the formation of the global nanotechnology market, along with the characteristics of the global market, one can single out specific factors inherent only in the nanotechnology market. Thus, specific preliminary categories for the formation of a global nanotechnology market are:

- Transition to the sixth technological order of modern society;
- Active development of applied nanotechnology;
- The desire of world production to use nanotechnological innovations, know-how, etc.;

Research into various aspects of nanotechnology in developed countries has stimulated the implementation of existing developments in practice [40].

Under the influence of general and specific factors, the formation of the global nanotechnology market took place in three stages:

1. The first step (1994-2000) - the commercialization of the achievements of applied nanotechnology: the first nanopowders, nanocoatings, nanomaterials, etc appeared on the market; Creation of the first organizations and clubs for the development of nanotechnology.
2. The second stage (2000-2005) - Intensive development of research programs (since the early 90s) and the introduction of nanotechnological initiatives in many countries of the world at the national level. That contributed to the rapid development of the nanotechnology naked market
3. The third stage (from 2005 to the present) is the expansion of the market, the emergence of new products, reinforced concrete products, a decrease in the share of nanotechnology in world production, an increase in the influence of nanotechnology on other sectors of the economy [41].

In the context of the rapid development of the nanotechnology industry, certain features of the current stage of development of the world nanotechnology market can be determined by the influence of nanotechnologies themselves on other sectors of the economy (Table 2.1).

Table 2.1 – The impact of nanotechnology on other sectors of the economy

Influence	Industries
Strong	Aerospace and defense, chemical, electronics, semiconductors, medical products and equipment, metallurgy, pharmaceuticals
Average	Sewing, food, building materials, food products, equipment for agriculture, automotive industry
Weak	Air transportation, car sales, construction, forestry, raw materials extraction, waste recycling, insurance, furniture industry
Missing	Advertising, marketing, banking, software, real estate

*Source: https://www.nap.edu/read/11752/chapter/5#63

Over the past two years, nanotechnology has revolutionized the technology market. Today they have successfully moved from revolutionary issues to the most demanding scientific and technological developments in the world. Several states are already implementing national nanotechnology development programs [42].

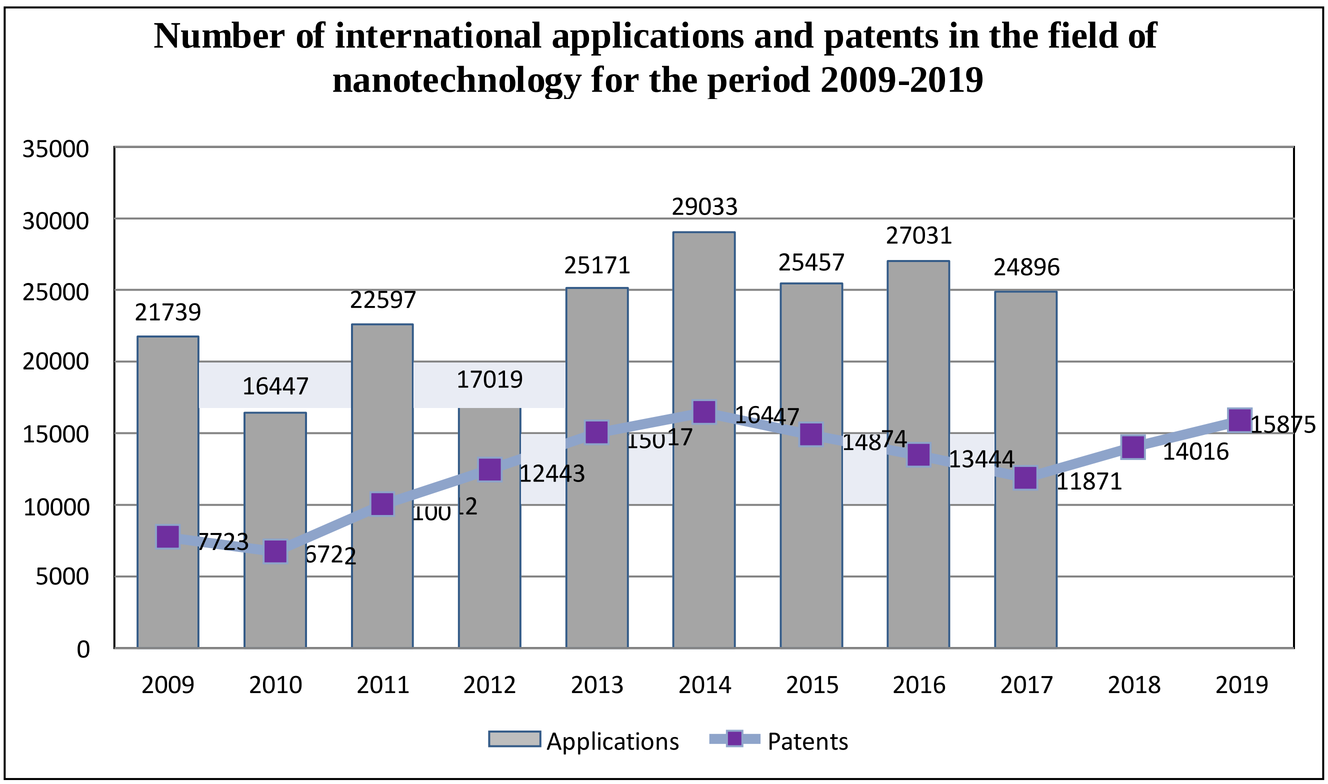
Every year there is a demand for nanotechnology in a wide variety of industries, such as new (for example, new materials) and traditional (medicine), energy.

Investments of world leaders in nanotechnology:

- The US remains at the forefront of government investment in the nanotechnology industry (over $ 1.4 billion in 2019, with a combined total of around $ 29 billion).

- ➢ Taiwan completed the second phase of its national nanotechnology program in 2015 with a budget of US $ 700 million.
- ➢ Since 2001, Japan has supported a nanotechnology development budget of about $ 900 million per year.
- ➢ Germany annually allocates more than 500 million euros from the federal budget for national programs in the field of nanotechnology [43].

Table 2.2 – Number of international applications and patents in the field of nanotechnology



*Sourse: https://fiop.site/o-fonde/godovye-otchety/2018/?/ru/30-overview-of-the-global-and-russian-nanotechnology-market

South Korea, which has invested US $ 3.1 billion since 2011 in nanotechnology development plans. The applied nature of research is causing an active increase in the number of patents. Thus, in 2019, the number of international patent families dedicated to nano-objects, nanotechnologies and nanoproducts exceeded 200,000, and the number of patent applications reached about 400,000 [44].

China is a key player in this market with over 65,000 nanotechnology patents. America (28,000), Korea (17,000), Japan (10,000). Among enterprises, China also strengthened its leadership in 2019. In the field of nanotechnology, Chinese universities are among the ten most protected in terms of intellectual property.

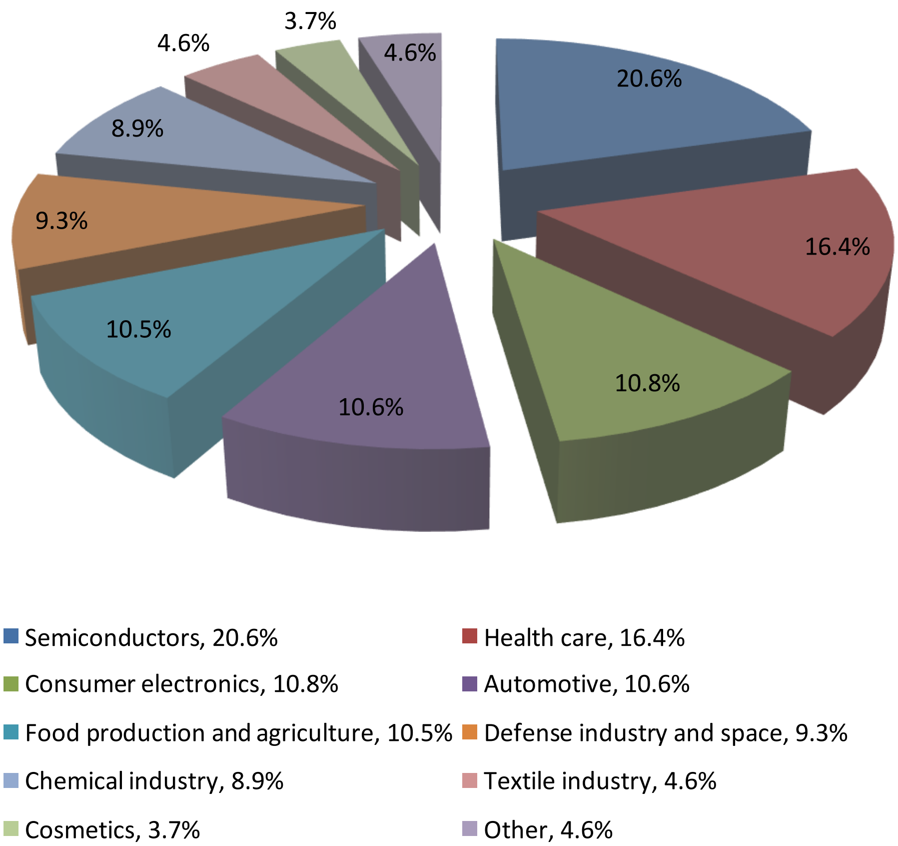


Figure 2.1 The main areas of application of nanotechnology

*Source: https://fiop.site/o-fonde/godovye-otchety/2018/?/ru/30-overview-of-the-global-and-russian-nanotechnology-market

The main areas of application of nanotechnology - the semiconductor industry (20.6% of the world market) and healthcare (16.4%) - together occupy more than a third of the world market.

The largest market for nanotechnology is the United States, where nanotechnology research is carried out in medicine, the semiconductor industry and electronics. In Europe, nanotechnology is also a key innovation [44].

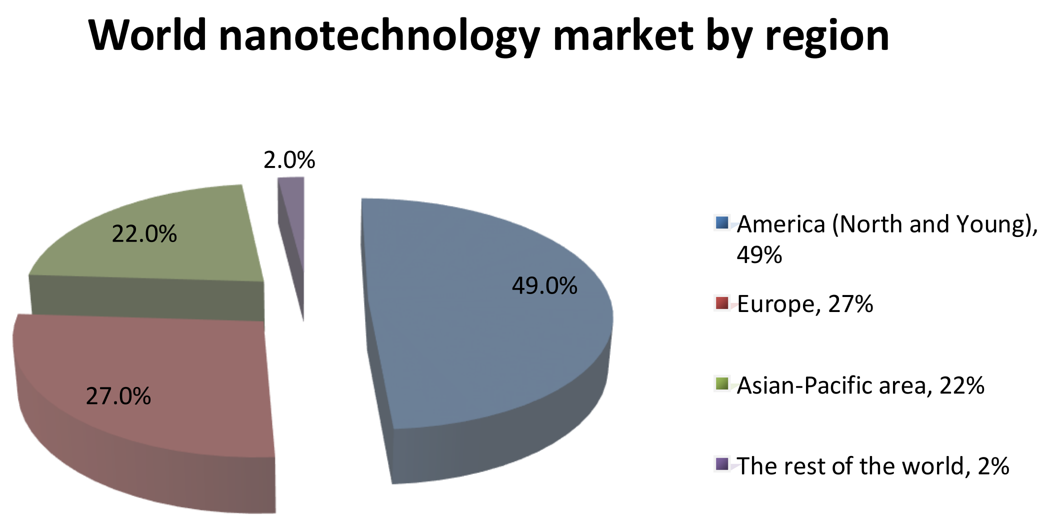


Figure 2.2 World nanotechnology market by region

*Source: https://fiop.site/o-fonde/godovye-otchety/2018/?/ru/30-overview-of-the-global-and-russian-nanotechnology-market

The EU Horizon program includes lightweight nano-modified multifunctional materials and components, nano-coatings, surface-modified materials and membranes, biological nanomaterials, functional nanomaterials for construction, and nanopharmaceuticals. The Asia-Pacific market, especially Japan, Korea, China and Taiwan, is the fastest growing, with semiconductor and consumer electronics being key segments [44].

Large European news 2000s to 2010s agencies CMP Cientifica and Lux Research gave high estimates of the size of the nanotechnology market. However, the overall estimate was based on revenue from "product sales, including nanotechnology". Modern approaches to valuation make it possible to "split" the cost of nanocomponents.

One of the key components of technology development is new materials that play a decisive role in updating the functionality of any device. At the same time, nanomaterials, along with biomaterials, are driving the overall growth of the market for new materials. The nanomaterials market in 2019 was $ 49 billion. Analytical institutions predict a growth rate range of 8.89% (Nester Research) to 18% (OG Analysis) by 2027 [45].

The scope of application of nanotechnology continues to expand, including in the medical, biotechnological, agricultural and food industries. The global nanomedicine market in 2019 was estimated at $ 176 billion. Growth forecast for 2024 is estimated at US $ 27.7 billion (CAGR 9.5%). Almost half of the market is occupied by US companies. At least 100 nanomedical products, devices and systems have been approved by the US FDA over the past decades.

Renewable energy sources are an important area for the introduction of nanotechnology. In recent years, solar energy has become a leader in this field. Since 2017, the installed capacity of solar power plants has exceeded the installed capacity of power plants powered by wind, water and biofuels.

According to Bloomberg New Energy Finance, installed solar capacity will account for 22% of the world's total installed capacity of 13,919 GW by 2040, or more than 3,000 GW of solar power. Another 10% of the world's electrical capacity, or about 1,400 GW, will come from low-power solar systems in homes and businesses. And by 2050, about 50% of the world's energy production will come from solar and wind energy [45].

This vigorous growth in this renewable energy sector is associated with a sharp decline in the cost of solar modules and continued efficiency gains. Over the past decade, the average efficiency of solar modules has increased from 14.7% to 18.4%. The average power per standard module has increased from 241.5 W to 302.5 W. At the same time, the cost of 1 watt fell from $ 1.7 per watt to $ 0.24 [46].

The significant decline in solar cell cost is driven by economies of scale and learning curve (learning curve, 40% slope over the last decade) of the silicon solar industry, the dominant solar power technology.

Every year the world nanotechnology market is growing by 15-17% and this trend will continue for quite a long time. According to the segmental analysis of the species structure, now in the nanotechnology market the largest shares belong to nanodevices and nanobiotechnology - 420 and 415 million US dollars, respectively; nanomaterials and nanoinstruments account for USD 145 and 50 million, respectively. It is assumed that the market segments that will have the highest growth rates will be nanocomposite materials and solid nanoparticles with growth rates of 28.8% and 17.5%, respectively. The growth rates of segmented and nanofilms and nanostructured monolithic materials will be 7.5% and 9.4% [47].

2.2 International scientific and technical cooperation in the field of nanotechnology and nanomaterials.

Specialization of science and technology thinking in a specific field in the context of modern global economic development, characterized by globalization of international economic relations, increasing the role of information and communication technology, accelerating technological innovation, and increasing the impact of scientific and technological knowledge on national welfare, etc. You need to do this. Join the efforts of stakeholders in the global community to solve scientific and technical problems, share experiences, and find new knowledge (e.g. nanotechnology and nanometer materials). Basic and applied research and development requires significant investments in financial, labor, materials and technical resources, thus limiting the ability of individual countries to enhance their competitive advantage in science and technology. The growing demand for interdisciplinary research, the high level of uncertainty and risk of consequences, the need to minimize "expensive research redundancy" and the need to increase the speed of technology transfer contribute to deepening collaboration among the global community in the field of science and technology [48].

In addition to the above, many scientific and technological problems, mainly socio-economic problems, are of great importance worldwide and require national efforts to address them.

Nanotechnology offers a variety of opportunities to use renewable energy sources and can make significant contributions to energy production and conservation. Here's how nanotechnology can improve the efficiency and conservation of Earth's resources.

• Use of renewable sources (solar panels, thermoelectric devices, fuel cells).

• Energy storage (battery and super capacitor, hydrogen tank).

• Reduced material consumption (eg, creating lighter or stronger building materials or increasing activity).

• Use of alternative (more common) materials (eg, replacement of rare earth elements with nanostructured metal oxides during catalysis).

The most developed nanotechnology projects in the energy sector are storage, transformation, improved production (reduced material consumption and processing duration), energy saving (for example, through the development of new insulation methods), and the use of renewable energy sources. Among the various approaches used to solve these problems, it is worth mentioning new materials, catalysts and strong lightweight structural elements used in batteries, fuel cells and solar panels (Table 2.3) [49].

The main areas of application of nanotechnology. Solar power generation and aerogels with nano coatings have already entered the commercialization stage, but in the next few years it is unlikely to make a significant contribution to the material market due to numerous technical issues, unresolved upscaling and high costs. Increasing energy costs, production of traditional energy sources, and legal regulations require that the product life cycle and production process do not have a significant impact on the environment. Therefore, we can talk about the basic work of using more environmentally friendly nanostructures and "smart" materials.

Table 2.3 – Nanomaterials used in batteries, fuel cells and solar cells

Market area	**Market area segment**	**Nanoproducts**
Energy conversion	Solar thermal energy	Nanoporous aerogels as a coating for solar collectors
	Solar panels	- Solar cells based on organic dyes - Photovoltaic cells based on quantum dots interconnected by carbon nanotubes - Flexible solar cells based on nanocomposite materials consisting of inorganic nanorods embedded in an organic semiconductor film
	Fuel cells	Catalysts consisting of 1-5 nm metal particles in a carbon matrix
	Thermoelectricity	Thermoelectric materials organized in super lattices that convert heat
Energy storage	Rechargeable batteries	Nanocrystalline materials and nanotubes that significantly increase the energy density, lifetime and rate of charge - recharge. Nanotubes also replace conventional graphite and lithium-graphite electrodes
	Hydrogen storage	Repeatable adsorption - desorption of hydrogen by nanostructured materials based on graphite
	Supercapacitors	Porous carbon electrodes as capacitor "plates". Ultra-small nanopores provide a high specific surface area of about 1000 m2 / g
Energy saving	Thermal insulation	- Nanoporous aerogels - Electrochromic coatings consisting of a thin layer of indium oxide and tin as electrodes used to reduce heat loss
	More efficient lighting	Nanophosphorus emitting bright "daylight" light after exposure to ultraviolet radiation
	Internal combustion engines	Increasing engine efficiency with nanoporous catalysts or nanoparticles that improve conversion

*Source:https://www.researchgate.net/publication/224584720_Modeling_Nano_Enabled_Elements_of_Solar_and_Fuel_Cell

Today, the issue of international science and technology cooperation is being studied by domestic and foreign scientists. They focus on the regional aspects of international scientific and technological cooperation (examples of the North-Western Federal District of the Russian Federation and the Republic of Belarus). In general, the issue of international scientific and technological cooperation, especially with Ukraine. Changes in international scientific and technological cooperation in the context of globalization and Ukrainian integration [50].

The first point of organizational cooperation in the international community in the field of science and technology can be considered as the first scientific conference on the conservation and use of UN resources in 1949 (UN Scientific Conference on the Conservation and Use of UN resources), but directly with science and politics. Is related.

Technology has not advanced, but views and experiences have been exchanged within the scientific competence of scientists. It was first included on the agenda in 1963 at the United Nations Conference on Science and Technology for Least-developed Countries as the main agenda of science and technology policy for development [51].

At that time, the active interest in international cooperation in nanotechnology, science, technology and technology was largely attributed to scientific and technological advances in general, especially the current scientific and technological revolution, which brought science to the forefront and transformed it into a single whole. Scientific and technological activities, the driving force of global economic development, are the key drivers of economic growth and socio-economic development for all groups of countries.

It is noteworthy that despite over 60 years of development experience, the term base of international scientific and technological cooperation has not been properly considered. Due to the complexity and complexity of measurement, international scientific and technological cooperation in terms of definition is one of the unresolved methodological problems. Interpretations are prioritized taking into account the list of basic forms and types of international scientific and technological cooperation or statistical needs. Definition is something that can be considered (indicators of entry and exit of scientific and technological relations). At the same time, as an integrated economic category, the lack of independence of international scientific and technological cooperation determines the relevance of research issues.

2.3 The main situation and trends in the development of nanotechnology in Ukraine

Compared to foreign countries, Ukraine's spending on research in this field seems to be not small. The program "Nanosystems, Nanomaterials and Nanotechnology" of the National Academy of Sciences of Ukraine accounted for about 3% of the total budget of the National Academy of Sciences of Ukraine. Almost identical Ukrainian scientists receive it from international donors. But often this money is enough for capital investments, namely the purchase of new scientific and technological equipment, the establishment of a "clean laboratory". Funds are mainly used to maintain some decent salary for scientists. Domestic developers of nanotechnology believe that investment in this field of science and technology puts off state and business, which could make Ukraine an outsider in all areas where nanotechnology is expected to make a speech in the near future. This also applies to the defense and security spheres of the country [52].

However, A. Naumovets, Vice-President of the National Academy of Sciences of Ukraine, said, "Domestic science has entered the nanoindustry quite naturally. The first research on the nanoscale was carried out by Ukrainian scientists before the war. They worked with colloidal solutions and studied the properties of nanofilms and nanoparticles. And now there are some creative advances in some areas of nanoscience. For example, at the Donetsk Institute of Physics and Technology. A.A. Ukraine's Galkin NAS proposed a spiral hydraulic extrusion method-a new material with nano-grains and improved fur properties are formed due to the screw deformation of the metal under pressure. In particular, the strength of these materials is doubled.

We would single out the two most promising areas of application of Ukrainian nanotechnologies - electronics and materials science. However, successful work at the nanoscale requires modern expensive equipment, for the purchase of which Ukraine often lacks the money. The development of Ukrainian nanotechnologies is facilitated by international cooperation - a program in the field of nanophysics and nanoelectronics and a similar Ukrainian-German program. There are also agreements with other states. This cooperation provides Ukrainian scientists with access to state-of-the-art equipment, without which full-fledged research is impossible. Of course, we need a national program that would allow us to develop those areas of Ukrainian nanotechnology that are currently competitive in world markets. It is very important for us not to lose the pace of development of nanoscience. If Ukraine loses its potential in the field of nanotechnology, it will be doomed to a role as a supplier of raw materials to the world economy. After all, even the successful development of medicine and agriculture is unlikely to be possible without the introduction of nanodevelopment [53].

Shortage of qualified scientific personnel and world-class scientific developments are already being felt, as the decline in the interest of the state and business in science coincides with the change of generations in the fields of education and science. The problem is that no one can implement the results of scientists' work - there are few enterprises in the country, both large and small and medium, that are technically capable of accepting nanotechnology and nanoproducts. "One of the key problems for Ukraine is the lack of trained specialists in the field of nano, who are able to take risks, organize their business, and who understand that their vocation is this rapidly developing market segment."

In Ukraine, fundamental and applied is research aimed at obtaining, studying the properties and application of nanostructured materials has been carried out for the last 15 years within the topics of departmental orders of the NAS of Ukraine, grants from the Ministry of Education and Science, grants from international scientific foundations, direct contracts with industry. The combined experience of Ukrainian academic laboratories by weight, in the world most of their developments are recognized as advanced. However, most efforts are fragmented, while the global nanotechnology direction is evolving through multidisciplinary programs and consortia [54].

Until 2003, Ukrainian science did not have its own full-scale program for the development of this high-tech industry, so the main goal of this program was to achieve.

Table 2.4 – Structure of the institutes researching

№	Main tasks	Head organization
1.	Nanophysics and Nanoelectronics	**Institute of Physics NASU**
2.	Multifunctional nanomaterial technology	**Institute for Problems of Materials Science I.M. Frantsevich NASU**
3.	Electronic, atomic structure and properties of nano-structural materials	**Institute of metalophysics named after G. V. Kurdyumova NASU**
4.	Bionanomaterials: synthesis and properties	**Institute of metalophysics named after G. V. Kurdyumova NASU**
5.	Diagnostics of nanosystems	**Technical Center of NASU**
6.	Atomic-molecular architecture of nanostructures	**Institute of Physical Chemistry. L.V. Pisarzhevsky NASU**
7.	Physics of semiconductor nanostructures	**Institute of Semiconductor Physics V. E. Lashkareva NASU**
8.	Physicochemistry of surface phenomena	**Institute of Surface Chemistry NASU**
9.	Synthesis and formation of nanostructures	**Institute of General and Inorganic Chemistry. V.I. Vernadsky NASU**
10.	Colloidal nanoscale systems	**Institute of Biocolloid Chemistry. F. D. Ovcharenko NASU**
11.	Thin-film nanotechnology for joining inorganic materials	**Institute of Electric Welding named after E.O. Paton NASU**
12.	Physics and technology of nanomaterials in extreme conditions	**Donetsk Institute of Physics and Technology A. A. Galkina**
13.	Information support of work on the problem	**Technical Center of NASU**

*Source: http://www.nas.gov.ua/EN/Structure/Pages/default.aspx

Ukrainian companies working in the field of nanotechnology are not worried about local market players, as they work mainly for export. Excessive electronic circuits, new types of materials and fuels, medicines, cosmetics - in all these areas is now working in Ukraine. The same areas will remain promising. As a rule, Ukrainian nanocompanies are enterprises at universities and research institutes, the founders of which are mostly scientists who master the latest technologies on a commercial basis. For example, Donetsk Physical and Technical Institute. Galkina promotes nanopowders on the market - the use of these materials in the production of ceramics, according to the developers, increases the service life of products tenfold. Domestic

STC "Nanotechnology" develops coatings and materials with unique physical and chemical properties that provide high wear resistance [55].

The optimistic scenario for the development of nanotechnology in Ukraine is to create an effective program and the participation of all innovative companies in it. Ukraine has not yet lost its chances - in the future, any sectoral program in one way or another will need the introduction of nanotechnology, because most developments of this kind already today have two- and three-tier applications in the economy. Soon the nanotechnology market will be divided according to the principle "who did not have time, is late." Ukraine still has certain competitive advantages in the field of nanomechanotronics - the creation of devices for working in microspace.

The pessimistic option - the awkward implementation of the nanotechnology program will result in a process of leakage of developments and scientific personnel abroad. Nanoindustry will not appear in Ukraine, and the introduction of the latest products will take place through the mediation of foreign companies. Several export-oriented Ukrainian nano-companies will remain on the market.

Proposals and prospects in Ukraine

Experts believe that solving two main problems can help Ukraine realize its potential in the field of "nano-". The first problem that has already been mentioned is the lack of university programs to train the necessary specialists. As a result, there are simply not enough people in Ukraine willing to work in the nanotechnology market. "Our main problem is the lack, sometimes the lack of necessary equipment," - formulates the second problem, Academician A. Naumovets, Vice President of the NAS of Ukraine. The cost of such equipment, according to the expert, is measured in millions of dollars. In the very scientific environment, the development of nanotechnology is hampered by the excessive inertia of some scientists and their commitment to old traditions. Many believe that interest in different "Nano-" is an instant delight. In Ukraine, it is necessary to create a state multidisciplinary program "Nanosciences and Nanotechnologies". To fund research under it, Ukraine needs to spend at least $ 100 million annually over the next 5 years. In addition, for the full implementation of the results of nanotechnology developments under this program "Nanosciences and Nanotechnologies" should be identified as a strategic priority for the development of science and technology of the country and closely linked with other priorities of society in Ukraine - health, environmental protection, development of energy-saving technologies, state security issues, etc. It is also important to agree with the European Union and participate in the 7th Framework Program, which has a large section on nanoscience and nanotechnology [56].

Intensive development of domestic research in the field of nanotechnology and the study of foreign experience should allow Ukraine to implement such advanced areas of science and technology as computer science, microelectronics, microbiology, nuclear energy research, laser technology and others. At the same time, the country has not yet formed a holistic systemic approach to solving problems of nanotechnology.

This leads to the need to organize the development and implementation of a national comprehensive scientific and technical program on this issue, combining the efforts of academic institutions, interested industrial corporations and relevant government agencies.

3. PROSPECTS AND SCENARIOS OF NANOTECHNOLOGICAL SPHERE DEVELOPMENT

3.1 The main directions of state regulation of nanotechnology activities and scenarios for the development of nanotechnology in Ukraine

Calls for the formation of a balanced innovation strategy that the anticrisis model of economic development, which is to be implemented in Ukraine in the coming years. And ignoring the latest global trends in scientific and technological development and separating them from the innovative processes that are actively developing in the global economy will only slow the modernization of our country's technology further and consequently slow the competitiveness of domestic companies in an unstable economic environment. This trend contributes to Ukraine actively seeking its place in the nanotechnology market and shaping appropriate policies to meet urgent national needs.

It should be noted that due to the nature of nanotechnology activities, national policy for nanotechnology development cannot be a service in the IT industry, for example. State participation in the formation of domestic nanoindustries should be distinguished by more participation in key stages of the innovation cycle. Therefore, there is no doubt that only the comprehensive use of state regulatory methods for the field of nanotechnology in Ukraine can ensure the stable growth of nanotechnology production and the formation of the nanoindustry as a whole [57].

The convenience of using the administrative methods of national regulations on nanotechnology activities is due to the need to develop basic standards for nanotechnology products (terminology, classification, safety, ecology) and applied industry standards in the field of nanotechnology development and to current international standards. It is described as an adaptation to. Standard developed by ISO. Today, this process is hampered by the usual old-fashioned practices (mandatory nature of national standards, the complexity of registration) that regulate the standardization process in the country. Taking into account Ukraine's obligations in connection with the conclusion of association agreements with EU member states, work is currently ongoing on the harmonization and convergence of the European system and domestic standardization mechanisms, in which all interested parties are essentially voluntary in the development of standards. The state is determined by binding only basic safety parameters. Since there are no standards for nanotech products in Ukraine, the development must be carried out taking into account the specified requirements [58].

In addition, administration is required due to issues related to research and patent grants in the field of nanotechnology, such as:

1) Methodological (development of novelty doctrines, advancement (non-clarity), validity, disclosure of usefulness for the development of nanotechnology fields), technical and organizational support of work related to patents, and improving licensing activities in the field of nanotechnology. Harmonization of application processing procedures with global patent offices;
2) Reinforcing the organizational resources of the intellectual property management process, shortening the application processing time in the nanotechnology field, and cultivating experts in the field of nanotechnology that can have a significant impact on the process of granting a patent... Disagreement in competency is false or weak It can lead to the issuance of patents, and patents with too broad claims can prevent the development of the industry or the introduction of innovation and limit the flow of investment into the industry.
3) Provide consulting support to companies conducting research in the nanotechnology field by organizing a round table to clarify the characteristics of patent inventions in the nanotechnology field. Thus, during the formation of the nanoindustry in the United States, the Office of Patent and Trademark Registration organized partnership meetings with applicants. Its purpose was to

inform registered applications of the need for a more detailed description of the old technology and the use of commonly accepted terminology.

4) Creation of an integrated and effective legal framework for the protection of intellectual property rights and extension of the intellectual property rights of developers
5) Providing national support (both information and finance) to research institutions submitting applications to the World Patent Office [59].

Economic regulation of nanotechnology activities is governed by budgetary means, taxes (exemption of tariffs on export operations with materials necessary for the implementation of nanotechnology activities- already in use, providing preferential taxation for joint ventures). Nanotechnology activities, introduction of tax deductions for research expenses, etc.) and monetary state policy (providing concession loans to enterprises whose nanotechnology activities aim to achieve the strategic goals of socio-economic development in Ukraine) [60].

In order to optimize the adoption of management decisions and the adoption of appropriate measures aimed at the development of nanotechnology activities in Ukraine, it is advisable to develop possible scenarios for the development of domestic nanoindustry in the short term. To this end, information on the conditions of development in the Ukrainian nanotechnology sector has been systematized using strategic planning tools such as SWOT analysis, which can be used when developing scenarios for the development of the economy as a whole or individual factors at the macro level as well as at the micro level [61].

SWOT analysis of domestic nano industry development

Strengths:

- Significant scientific and technological potential and high-level basic development in certain areas of nanotechnology activity;
- Availability of qualified personnel in specific fields (education, science)

- Availability of reserves of high-quality raw materials (deposits of graphite and manganese and silicon oxide with properties necessary for nanotechnology activities).

Weakness :

- Significant delay in the beginning of implementation of national programs for nanoindustrial development in the United States and Western Europe.
- Lack of specialized structures and tools to support the development of nanotechnology;
- weak government support for nanotechnology financing and private sector investment interests;
- Low level commercialization of existing nanotechnology development;
- Creating an internal market for nanotechnology products;
- Lack of awareness of players in the global and domestic markets with respect to Ukrainian nanotechnology companies and the products they manufacture.

Opportunities :

- Focus limited resources on priority areas that prevent capital diversification with the gradual expansion of research scope.
- development of new (split) companies based on existing developments;
- In the process of developing national policies for nanotechnology development, it takes into account the successful experiences of major countries in this field.
- Significantly important potential market for nanotechnology end-use products;
- Overflow of resources from stagnant industries to nanotechnology sectors;
- Increased export opportunities due to devaluation of national currencies.

Threats :

- growing economic gap between Ukraine and developed countries;
- Threat of occupation of the domestic market of nano products by foreign companies;
- Decreased public funding in connection with sequestering state budgets in the face of persistent economic downturns and political instability [61].

Ukraine's Nanotechnology Area Development Scenario. Events that took place in Ukraine last year can serve as a catalyst for Ukrainian economic restructuring and contribute to the revision of national innovation and science and technology policies, which in turn will have a positive effect on the level of development in the domestic nanotechnology sector.

Basic starting point - there is intensive economic growth of the national economy and the reinforcement of innovation is urgent due to the economic growth rate, structural changes in the national economy, and the need to ensure national security (including military security).

National policy measures:

- ✓ The policy of shaping the national nanoindustry takes full form, is clearly structured and aims not to follow the latest global trends in the development of the area of innovation, but is effective to achieve the main goals of the development of Ukrainian nanotechnology activities approved in that strategy. Provides the creation of mechanisms.
- ✓ The amount of national aid has increased significantly, allowing large-scale adoption of nanotechnology in most national economic sectors. Significant expansion of the toolkit to support nanotechnology activities (use of taxes, budgets and monetary incentives). At the same time, the already traditional program approach to policy shaping the domestic nano-industry with new mechanisms is used. New effective programs are being created that provide

active participation of the private sector in financing domestic nanotechnology activities and forming a list of nanotechnology developments important to domestic industry. Their successful commercialization. However, we should not expect a major change in the domestic fund structure for research and development in the nanotechnology field. The most likely option is to play a dominant role over the country. These models for the development of nanotechnology activities are inherent in EU countries, where most of them are financed from state budgets. Formation of a significant amount of state orders for nanotechnology products (including military products).

- ✓ Changing approach to establishing interactions between scientific disciplines, industries and countries. Development and implementation
- ✓ Large-scale programs to popularize nanotechnology activities and nanotechnology products among representatives of the manufacturing sector and the public;
- ✓ Further stimulation of the process of international scientific and technological cooperation in the field of nanotechnology;
- ✓ In addition to higher education, graduate and doctoral programs, a list of areas for nurturing nano-industry experts, including retraining courses for existing scientific and engineering personnel, by introducing a closed staff cycle to cover school education (Taking into account the requirements of the actual economic sector) [62].

Ukraine's further adherence to this policy process in the field of nanotechnology, as a result of which it has become part of nanotechnology enterprises, budget sequestration and conflict freeze in the eastern region; Scientific institutions conducting research on nanotechnology; In the case of higher education institutions in which the nano-industrial manpower was trained, it is temporarily excluded from the economic process, and the process of developing nanotechnology and the outflow of scientific manpower abroad is inevitably deepened. It is rather insignificant. The number of export-oriented nanotechnology companies.

3.2 Multifaceted system for assessing the level of development and prospects of domestic nanotechnology

Aggregated quantitative indicators are needed to make management decisions about the development of the country's nanotechnology potential. For this, it is necessary to clarify the causal relationship between conjunctival formation factors and indicators in the development of nanotechnology, and reflect this. However, since the country's official statistical service does not monitor nanotechnology activity at all or only tracks certain aspects, the formation of such lists of indicators is hampered by the nature inherent in the development of nanotechnology activity, i.e. the lack of systematically collected statistical data. Also, the relatively small size of the nanotechnology market makes it difficult to obtain information. Therefore, the reliability and consistency of these data is very questionable. All of this makes a significant difference in the choice of indicators to monitor and evaluate the level of development of nanotechnology activities [63].

A critical analysis of existing methodological advances to assess the level of advancement in the nanotechnology sector (Lux Research, OECD, CMP Científica, Forfás, European Commission) has a fairly broad approach to identifying indicators that can determine the level of advancement in the nanotechnology sector. Showed the way. All indicators proposed to assess the scale and outcome of nanotechnology activities can be classified into categories such as publication activity indicators, patent activity indicators, organizational and institutional support indicators, staffing indicators, and nanotechnology diffusion indicators in the production and consumption sectors. There is. However, in today's world practice, an integrated approach to assess the level of development of nanotechnology activities still does not exist, and the most widely used are indicators to evaluate the effectiveness of scientific and technological activities, and the assessment of the development of the nanotechnology market is practical. Does not happen.

A methodological approach to assess the level of development of the national nanoindustry, enabling a multi-faceted analysis of the level of development in the Ukrainian nanotechnology sector.

In the multi-criteria system proposed for the evaluation of the national nanoindustry development level, the evaluation is performed according to the following algorithm.

1) Calculate the indicator values within each indicator and allocate the appropriate number of points.

2) Calculate the value of each indicator $Indi = \sum_{i=1}^{n} Ki * \alpha i,$ provided

that $\sum \alpha i = 1, \sum \alpha_i = 1,$

where $Indi$ - is the value of the ith indicator included in the indicator of supply and demand, points;

Ki - the value of the i-th indicator within each indicator (in points).

αi - weight factor of the i-th indicator in the indicator.

3) Calculate the value of the proposition indicator $Ind\ S * \sum_{i=1}^{3} \beta_l\ Ind_i$ provided that $\sum_{i=1}^{3} \beta_l = 1,$

Where $Ind\ S$ is the value of the supply indicator;

β_l is the weighting factor of the ith middle metric in the supply metric.

Indi - is the value (point) of the *i* th indicator contained in the supply indicator.

Supply indicators (Table 3.1):

- Indicators of organizational and institutional support for the proposal make it possible to determine nanotechnology in the national priority system of the country, and also characterize the level of use of the national lever to create favorable conditions for scientific research and development in the field of nanotechnology.

- The indicator of science and technology activity is characterized by the ability of domestic science parks to produce and use new knowledge in the field of nanotechnology and act as a source of economic growth.
- The workforce indicator makes it possible to assess the ability of the training system to meet the needs of the nanotechnology industry for highly qualified workforces.

Tables 3.1 – Multifaceted system for assessing the level of development of the national nanoindustry - definition of the supply indicator (Ind S)

Groups of indicators	Points	Indicator weights within the indicator	Indicator weights within the supply / demand indicator
Indicator of organizational and institutional support of the proposal (Ind1)			
1.1 The ratio of budget expenditures for the development of nanotechnology in terms of GDP		0,4	0,4
Up to 0.001%	1		
Up to 0,01%	2		
More than 0,01%	3		
1.2 State stimulation of basic and applied research in the field of nanotechnology		0,6	
There is no state stimulation of scientific research in the field of nanotechnologies	1		
Moderate support for research in the field of nanotechnology by the state (use of exclusively software form of stimulation of research in the field of nanotechnology)	2		
Significant support for research in the field of nanotechnology by the state (availability of targeted research programs in the field of nanotechnology, the provision of tax credits for research in this area, the use of accelerated depreciation of special equipment for nanotechnology, etc.)	3		
Indicator of scientific and technical activity (Ind2)			
2.1 The ratio of the share of research institutes that carry out nanotechnological research in the total number of research		0,1	0,4

institutes			
To 20%	1		
To 30%	2		
More then 30%	3		
2.2 The ratio of the share of research institutes for which activities in the field of nanotechnology are the main, in the total number of research institutes		0,2	
To 5%	1		
To 10%	2		
More then 10%	3		
2.3 The ratio of the share of articles on nanotechnology in the total number of articles in Ukraine (according to the service of indexing citations of scientific articles ISI Web of Knowledge)		0,1	
To 5%	1		
To 15%	2		
More then 15%	3		
2.4 Coefficient of specific weight of created nanotechnologies in the total number of created advanced technologies		0,2	
To 5%	1		
To 15%	2		
More then 15%	3		
2.5 The ratio of the share of patents obtained in the field of nanotechnology in the total number of patents issued in the country		0,2	
To 1%	1		
To 5%	2		
More then 5%	3		
2.6 Ratio of the number of patents obtained in the field of nanotechnology by residents in the total number of issued patents in the field of nanotechnology in the world (according to the World Intellectual Property Organization)		0,2	
To 1%	1		
To 5%	2		
More then 5%	3		
Staffing indicator (Ind3)			
3.1 The ratio of the share of universities that provide training for nanotechnology, in the total number of universities		0,3	0,2
To 5%	1		
To 10%	2		
More then 10%	3		
3.2 The ratio of the share of university graduates who received nanotechnology education in the total number of university graduates		0,7	

To 1%	1		
To 3%	2		
More then 3%	3		

*Source: http://www.economy.nayka.com.ua/?op=1&z=4554

As the statistical monitoring of nanotechnology activities improves, the following indicators must be supplemented with the indicators of a multilateral system for assessing the level of development of the national nanoindustry in the future.

1. The percentage of people employed in nanotechnology in the total number of employees;
2. The share factor of the cost of manufactured nanotechnology products from the total cost of products manufactured in Ukraine;
3. The quotient coefficient of the value of exported nanotechnology products from the total Ukrainian exports.

Demand indicators (Table 3.2):

- Indicators of organizational and institutional supply to demand characterize the state's interest in the formation of the developed nanotechnology market, allowing you to evaluate the effectiveness of measures to promote nanotechnology production.
- The indicators of a company's nanotechnology activity reflect the ability and readiness of domestic companies to absorb nanotechnology innovations and modernize their own production.
- Social readiness indicator reflects the ability and readiness of the general public to consume nanotech products.

Table 3.2 – Multifaceted system for assessing the level of development of the national nanoindustry - determination of the demand indicator (Ind D)

Groups of indicators	Points	The weight of the indicator within the indicator	The weight of the indicator in within the demand indicator
Indicator of organizational and institutional support of demand (Ind4)			
4.1 Strategy as a defining element of the state policy of development of the domestic nanoindustry		0,3	0,3
- there is no strategy for the development of the domestic nanoindustry	1		
- the strategy of development of the domestic nanoindustry is in process formation	2		
- the strategy of development of the domestic nanoindustry is formed	3		
4.2 State stimulation of production of nanotechnological products (availability of targeted state support, subsidies, exemption from customs duties and VAT of goods intended for export, preferential crediting, budgetary reimbursement of expenses at various stages of nanotechnological activity, etc.)		0,2	
- there is no state stimulation of nanotechnology production	1		
- moderate support for the production of nanotechnology products by the state (single use of these tools)	2		
- significant support for the production of nanotechnology products by the state (large-scale use of these tools)	3		
4.3 Level of development of innovation infrastructure (in particular for the formation of nanoindustry)		0,3	
- low (single creation of subjects of innovation infrastructure, imperfect legislative regulation of their activity)	1		
- average (small number of subjects of innovation infrastructure, often in combination with non-fulfillment of tasks set for them, or permanent performance of functions not peculiar to them)	2		
- high (availability of an extensive network of venture funds, technology parks and technopolises, business incubators, etc.)	3		
4.4 State regulation of certification, standardization and metrology in the nanotechnology field		0,1	
- the relevant component of nanotechnology development policy is missing	1		
- the relevant component of nanotechnology development policy is at the stage of formation	2		
- the relevant component of nanotechnology development policy is formed and effectively implemented	3		
4.5 State order for nanotechnology products			

- there is no state order for nanotechnology products	1	0,1	
- the state order for nanotechnological products takes place in insignificant quantities (up to 10% of the total cost of the state order)	2		
- the state order for nanotechnological products is significant (over 10% of the total cost of the state order)	3		
Indicator of nanotechnological activity of enterprises (Ind5)			
5.1 The level of innovation of the economy, in which the products of nanoindustry can be comprehensively demanded (according to the indices of innovative development)		0,4	0,4
- low level of innovation of the economy	1		
- average level of innovation of the economy	2		
- high level of innovation of the economy	3		
5.2 Number of enterprises that create and use nanotechnologies in the total number of business entities		0,3	
- to 0,1%	1		
- to 0,5%	2		
- more than 0,5%	3		
5.3 Coefficient of specific weight of used nanotechnologies in the total number of used advanced technologies		0,3	
- to 1%	1		
- to 5%	2		
- more then 5%	3		
Social readiness indicator (Ind6)			
6.1 Level of popularization of nanotechnologies in society (holding various conferences and symposia on the development of nanotechnologies, conducting informational and educational events among the general public on the possibilities of using nanotechnologies, implementation of a set of measures aimed at attracting young people to the industry, etc.)		0,6	0,3
- information and communication environment is not developed	1		
- information and communication environment is in the process of formation	2		
- information and communication environment is developed	3		
6.2 Level of guaranteeing the safety of manufacturers and users of nanotechnology products		0,4	
- the corresponding system is absent	1		
- the system is in the process of formation	2		
- the system is formed and fully functioning	3		

*Source: http://www.economy.nayka.com.ua/?op=1&z=4554

4) Calculating the value of the demand indicator = $Ind\ D^{*} \sum_{l=1}^{3} \omega_l \ Indi,$

provide that $\sum_{l=1}^{3} \omega_l = 1,$

where Ind D – meaning indicators demand in points;

ω_I – weight coefficient i - an intermediate indicator within the demand indicator;

Ind_i - the value of the i-th indicator, which is part of the demand indicator, in points.

In order to determine the weighting factors of indicators for assessing the level of development in the national nanotechnology sector, this professional approach to weighting is based on pairwise comparison, ranking method, direct evaluation method and adaptive evaluation method. I investigated.

Taking into account the values of the acquired supply and demand indicators, the country is determined by the level and prospects of nanotechnology development.

During this period, our country's indicators are in the "dead zone" (low grade), but it can be said that they are heading towards the "embryonic zone" (high grade).

In Ukraine, a multilateral assessment method developed to assess the level of development in the field of nanotechnology was used. The value of the indicators within each indicator was calculated as a priority (Table 3.3).

Using the weighting factor, it was possible to calculate the value of the intermediate indicators included in the supply and demand indicators:

$$Ind_1 = \sum K_1 \cdot \alpha_1 = 1 \cdot 0{,}4 + 2 \cdot 0{,}6 = 1{,}6$$

$$Ind_2 = \sum K_2 \cdot \alpha_2 = 3 \cdot 0{,}1 + 2 \cdot 0{,}2 + 2 \cdot 0{,}1 + 2 \cdot 0{,}2 + 1 \cdot 0{,}2 + 1 \cdot 0{,}2 = 1{,}7$$

$$Ind_3 = \sum K_3 \cdot \alpha_3 = 1 \cdot 0{,}3 + 1 \cdot 0{,}7 = 1{,}0$$

$$Ind_4 = \sum K_4 \cdot \alpha_4 = 1 \cdot 0{,}3 + 2 \cdot 0{,}2 + 1 \cdot 0{,}3 + 2 \cdot 0{,}1 + 1 \cdot 0{,}1 = 1{,}3$$

$$Ind5 = \sum K_5 \cdot \alpha_5 = 1 \cdot 0{,}4 + 1 \cdot 0{,}4 + 1 \cdot 0{,}3 = 1{,}1$$

$$Ind_6 = \sum K_6 \cdot \alpha_6 = 1 \cdot 0{,}6 + 2 \cdot 0{,}4 = 1{,}4$$

Table 3.3 – Multifaceted assessment of the level of development of the domestic nanotechnology sphere

№	Points		Rationale
Supply indicator (Ind S)			
Indicator of organizational and institutional support of the proposal (Ind1)			
1.1	The ratio of budget expenditures for the development of nanotechnology in terms of GDP		
	- to 0,001%	1	In 2012, the amount of funding for the State Targeted Scientific and Technical Program "Nanotechnologies and Nanomaterials" for 2010-2014, which is the main source of funding for nanotechnology activities in Ukraine, amounted to UAH 39.01 million, while GDP amounted to 1411238 mln. Thus, the desired ratio corresponds to a range of up to 0.001%
1.2	State stimulation of basic and applied research in the field of nanotechnology		
	- moderate support for research in the field of nanotechnology by the state (use of exclusively software form of stimulation of research in the field of nanotechnology)	2	Support for nanotechnology research in Ukraine is carried out exclusively in the framework of nanotechnology support programs: today the implementation of the target comprehensive program of basic research of the NAS of Ukraine "Fundamental problems of creating new nanomaterials and nanotechnologies" for 2015-2019. nanomaterials "has already been completed. Other government levers are not used.
Indicator of scientific and technical activity (Ind2)			
2.1	The ratio of the share of research institutes that carry out nanotechnological research in the total number of research institutes		
	- over 30%	3	In 2012, the NAS of Ukraine hosted 199 scientific institutions, of which 75 institutions to some extent carried out research in the field of nanotechnology, which is about 37.6% of the total.
2.2	The ratio of the share of research institutes, one of the main areas of activity of which is the conduct of research in the field of nanotechnology, in the total number of research institutes		
	- to10%	2	In 2012, 199 scientific institutions were subordinated to the National Academy of Sciences of Ukraine, of which for 17 institutions the implementation of research in the field of nanotechnology was the main field of activity, accounting for about 8.5%загальної кількості.
2.3	Coefficient of specific weight of articles devoted to nanotechnologies in the total number of articles in Ukraine (according to the citation indexing service of scientific articles ISI Web of Knowledge)		
	- to15%	2	In 2013, 4853 articles by Ukrainian authors were registered in the ISI Web of Knowledge database, of which 706 units. was devoted to nanotechnology, which is 14.5% of the total.

Countinue table 3.3

№	Points		Rationale
4.2	State incentives for the production of nanotechnology products (availability of targeted state support, subsidies, exemption from customs duties and VAT on goods intended for export, preferential lending, budget reimbursement of costs at various stages of nanotechnology activities, etc.)		
	- moderate support for the production of nanotechnology products by the state (single use of these tools)	2	The only preference provided for the development of the domestic nanoindustry in the legislation, namely in the Customs Code, is the exemption from customs duties on materials, raw materials and equipment that will be used in nanotechnology production or work with the use of nanotechnology.
4.3	Level of development of innovation infrastructure (in particular for the development of nanotechnologies)		
	- low (single creation of subjects of innovation infrastructure, imperfect legislative regulation of their activity)	1	Today, the legislative regulation of innovation infrastructure is characterized by fragmentation and inconsistency. In addition, a small number of forms of innovation infrastructure are represented and successfully operate in Ukraine.
4.4	State regulation of certification, standardization and metrology in the nanotechnology field		
	- the relevant component of nanotechnology development policy is at the stage of formation	2	One of the expected results of the State Targeted Scientific and Technical Program "Nanotechnologies and Nanomaterials" for 2010-2014 is the preparation of standards and certificates that will regulate the development and implementation of nanotechnologies and the manufacture of nanomaterials. The establishment of a certification center for nanomaterials, nanostructures and devices is envisaged.
4.5	State order for nanotechnology products		
	- there is no state order for nanotechnology products	1	There is no state order for nanotechnology products in Ukraine.
	Indicator of nanotechnological activity of enterprises (Ind5)		
5.1	The level of innovation of the economy, in which the products of the nanoindustry can be in demand (according to the indices of innovative development)		
	- low level of innovation of the economy	1	According to the indices of innovative development, Ukraine's position in 2012 deteriorated and characterizes the innovative development of its economy as low.
5.2	The number of enterprises that create and use nanotechnology in the total number of business entities		
	- to 0,1%	1	In 2013, there were 1,722.1 thousand business entities in Ukraine, of which 0.05 thousand enterprises are engaged in nanotechnology activities, which is 0.003% of the total.

Countinue table 3.3

№	Points		Rationale
5.3	Coefficient of specific weight of used nanotechnologies in the total number of used advanced technologies		
	- to 1%	1	In 2013, 14038 advanced technologies were used by economic entities in Ukraine, of which 64 technologies belonged to nanotechnologies, which is 0.5% of the total number of advanced technologies used.
	Social readiness indicator (Ind6)		
6.1	The level of popularization of nanotechnologies in society (holding various conferences and 162 symposia dedicated to the development of nanotechnologies, conducting informational and educational events among the general public on the possibilities of using nanotechnologies, implementation of a set of measures aimed at attracting young people, etc.)		
	- information and communication environment is not developed	1	In Ukraine, due importance is not given to the formation of a positive image of nanotechnology activities and the promotion of increasing public interest in nanotechnology.
6.2	Level of guaranteeing the safety of manufacturers and users of nanotechnology products		
	- the system is in the process of formation	2	One of the tasks of the State Targeted Scientific and Technical Program "Nanotechnologies and Nanomaterials" for 2010-2014 is to develop a procedure for assessing the impact of nanotechnologies and nanomaterials on humans and the environment.

*Source: http://www.economy.nayka.com.ua/?op=1&z=4554

The final stage of multi-aspect assessment of the level of development of nanotechnology in Ukraine is the calculation of the values of indicators of demand (Ind D) and supply (Ind S):

$$Ind\ S = \sum_{i=1}^{3} \beta i * Indi = 1.6 * 0.4 + 1.7 * 0.4 + 1.0 * 0.2 = 1.52$$

$$Ind\ D = \sum_{i=1}^{3} \omega i * Indi = 1.3 * 0.3 + 1.1 * 0.4 + 1.4 * 0.3 = 1.25$$

Using the obtained values of the demand indicator (Ind D) and the supply indicator (Ind S) as the coordinates of Ukraine's place on the matrix of prospects for the development of nanotechnology, we obtain the taking into account the values of the acquired supply and demand indicators, the country is determined by the level and prospects of nanotechnology development [64].

During this period, our country's indicators are in the "dead zone" (low grade), but it can be said that they are heading towards the "embryonic zone" (high grade).

Therefore, using a multilateral system developed to assess the development level and prospects of the national nanotechnology sector, it is found that Ukraine is currently in a so-called "dead" zone with a low level of nanotechnology production and a low level of absorption by industry and population I did. Interpretation of the obtained results can identify additional impulses and constraints for the development of the domestic nanotechnology field.

3.3 Investment attractiveness in the ratio of cooperation between several different fields of activity of nano-technologies and materials

The issue of attracting foreign investment is always attracting attention.

This problem is particularly related to the unstable economic growth in the national region. All of this presupposes the identification of a region that can at least partially satisfy the needs of foreign investors. The relevance of the research topic is due to the need to develop a regional system that is formed in complex geopolitical situations under the influence of the negative impact of the process of the global financial crisis. The issue of attracting foreign investment is always related to expanding international relations and increasing the sustainability of the development of global regional systems.

For an example of calculating investment attraction, let's take nanomedicine. By miscalculating investments, it is possible to increase the prevailing chances in improving the efficiency of certain areas of medicine. Which will have a positive effect on the quantitative percentage increase in positive treatments.

We will take as a basis the study of investment attraction "LIMITED LIABILITY COMPANY RESEARCH INSTITUTE OF NANOTECHNOLOGY" and their cooperation with the investment fund.

Formula for calculating the payback period of investments (investment project)

$$PP = \min n, \sum_{i=1}^{n} CFi > IC; \qquad (3.1)$$

Where:

IC (Invest Capital) - investment capital, initial costs of the investor in the object of investment. In the formula in foreign practice sometimes use the concept not of investment capital, but the cost of capital (CC), which essentially has a similar meaning;

CF (Cash Flow) - cash flow generated by the object of investment. Cash flow is sometimes used in formulas to mean net profit (NP, Net Profit).

The formula for calculating the payback period / payback period can be described differently, this option is also often found in the domestic literature on finance:

$$PP = \frac{Investments\ cost}{Cash\ Flow} \qquad (3.2)$$

It should be noted that investment costs represent all the costs of the investor when investing in an investment project. Cash flow must be taken into account for certain periods (day, week, month, year). As a result, the payback period of the investment will have a similar measurement scale.

Example of calculating the payback period of an investment project in Excel The figure below shows an example of calculating the payback period of an investment project. We have initial data that the cost of initial costs amounted to UAH 23,000. The monthly cash flow from investments amounted to UAH 2,000. In the beginning it is necessary to calculate the cash flow cumulatively, for this purpose the following simple formula was used: Cash flow cumulatively is calculated in a column C,

$$C7 = C6 + \$\,C\,\$\,3 \qquad (3.3)$$

Table 3.4 – Payback period of the investment project (Payback Period)

Cash flow for each period, CF.		**UAH 5,000.00**
Period (month), T	Initial costs, IC	Cash flow cumulative total, CF
1	UAH 23,000.00	UAH 3,000.00
2	UAH 23,000.00	UAH 5,000.00
3	UAH 23,000.00	UAH 7,000.00
4	UAH 23,000.00	UAH 9,000.00
5	UAH 23,000.00	UAH 11,000.00
6	UAH 23,000.00	UAH 13,000.00
7	UAH 23,000.00	UAH 15,000.00
8	UAH 23,000.00	UAH 17,000.00

*Source: https://xplaind.com/849768/payback-period

If you calculate the payback period by the formula, you get the following:

Payback period [65] of investments = 23000/2000 = 11,5~12 months.

Since we have a discrete period, it is necessary to round this period to 12 months.

Net Present Value (Net Present Value) [66] (NPV, net present value, net present value, present value) is an indicator that reflects changes in cash flows and shows the difference between discounted cash income and expenses. discounted income is used to select the most investment-attractive project. The formula of net discounted income:

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} - CF_0\,; \qquad (3.4)$$

where:

NPV - net discounted income of the project;

CFt - cash flow in time t;

CF0 - cash flow initially. The initial cash flow is equal to investment capital (CF0 = IC);

r - discount rate (barrier rate).

Table 3.5 – Project evaluation based on NPV criterion

Project evaluation based on NPV criterion	
NPV evaluation criterion	Conclusion on the project
NPV<0	An investment project that has a negative NPV value should be excluded from consideration
NPV=0	An investment project that has a negative NPV value should be excluded from consideration
NPV>0	The investment project is attractive for investment
NPV_1>NPV_2*	Comparing the NPV of one project with the NPV * of another, shows the great investment attractiveness of the first

*Source:https://www.pmi.org/learning/library/net-present-value-project-scheduling-5743

Example of calculating net discounted income in Excel

Consider an example of calculating net discounted income in Excel. The program has a convenient NPV function (net present value), which allows you to use the discount rate in calculations. We calculate below in two versions of NPV [67].

So, let's analyze the algorithm for sequential calculation of all NPV indicators.

Cash flow calculation by years:

$$E7 = C7 - D7 \quad (3.5)$$

Discounting cash flow over time:

$$F7 = \frac{E7}{(1 + \$C\$3)^{A7}} \quad (3.6)$$

Summation of all discounted cash inflows for the investment project and deduction of initial capital expenditures (NPV (1)):

$$F16 = SUM\ (F7 : F15) - B6 \quad (3.7)$$

Table 3.6 – Calculation of net discounted income

Net Present Value					
Discount rate, r =		10%			
Period (year), T	Initial costs, IC	Cash income	Money expense	Cash flow, CF.	Discounted cash flow
0	UAH 23,000.00				
1	0	UAH 3,000.00	UAH 1,750.00	UAH 1,250.00	UAH 1,136.36
2	0	UAH 7,000.00	UAH 3,465.00	UAH 3,535.00	UAH 2,921.49
3	0	UAH 5,000.00	UAH 2,312.00	UAH 2,688.00	UAH 2,019.53
4	0	UAH 3,000.00	UAH 1,200.00	UAH 1,800.00	UAH 1,229.42
5	0	UAH 4,500.00	UAH 1,430.00	UAH 3,070.00	UAH 1,906.23
6	0	UAH 6,700.00	UAH 1,340.00	UAH 5,360.00	UAH 3,025.58
7	0	UAH 8,500.00	UAH 2,450.00	UAH 6,050.00	UAH 3,104.61
8	0	UAH 7,800.00	UAH 2,080.00	UAH 5,720.00	UAH 2,668.42
9	0	UAH 5,700.00	UAH 2,275.00	UAH 3,425.00	UAH 1,452.53
				NPV(1)=	UAH (3,535.82)
				NPV(2)=	UAH (3,535.82)

*Source:https://corporatefinanceinstitute.com/resources/knowledge/valuation/net-present-value-npv/

Calculation using the built-in NPV (2) formula [68]. It should be noted that it is necessary to deduct the initial capital costs (B6).

$$f = NPV\ (\$C\$3; E7; E8; E9; E10; E11; E12; E13; E14; E15) - B6 \quad (3.8)$$

The results in both NPV calculation methods, as we see, are the same.

So we see on the net discounted income in (3,535.82 UAH), that there is a high probability of selection of this project as the most attractive.

Using the Profitability index (PI), we can calculate the usefulness and correctness of investments and attracting certain investments in our industry.

The indicator illustrates the ratio of return on capital to the amount of invested capital, the rate of return on investment shows the relative profitability of the project or the discounted value of cash receipts from the project per unit of investment. The profitability index is calculated by the formula [69]:

$$PI = \frac{NPV}{I} \tag{3.9}$$

where I - attachments.

$$PI = \frac{3535.82}{23000} = 0.1537$$

Considering the indicator "index (rate of return)", it is necessary to take into account that this indicator is relative, which describes is not the absolute amount of net cash flow, but its level in relation to investment costs. This advantage of the index of return on investment allows you to use it in the process of comparative evaluation of the effectiveness of investment projects that differ in size (the amount of investment costs).

The decision criterion is the same as when deciding on the indicator NPV, that is PI > 0 [70]. There are three options:

- PI > 1.0 - the investment is profitable and acceptable in accordance with the chosen discount rate;
- PI < 1.0 - investments are not able to generate the required rate of return and are unacceptable;

- PI = 1.0 - this area of investment exactly satisfies the chosen rate of return, which is equal to IRR.

So, PI (0.1537) < 1.0 – investments are not able to generate the required of return. But for that’s only one point near either ways for check it clear.

Projects with high PI values are more stable. However, it should not be forgotten that very large values of the index (coefficient) of profitability do not always correspond to the high value of the net present value of the project and vice versa. The fact is that projects that have a high net present value are not necessarily effective, and therefore have a very low profitability index.

CONCLUSIONS

The development of the national economy and the search for new elements to increase the efficiency of domestic manufacturers should contribute to the introduction of nanotechnology and nanomaterials. It turns out that today, governments of the most technologically advanced countries are paying more and more attention to the formation of the national nanoindustry. This is because the introduction of nanotechnology can have significant economic benefits in most economic sectors. Ensure economic, technical and military security, solve mankind's most global problems, improve quality of life, and create new jobs. In addition, the high speed of development of nanotechnology and its merger with other scientific industries (NBIC technology) can greatly accelerate this process.

The advancement of nanotechnology in the modern world is largely driven by government support. As a result of research, the main challenges addressed by national and transnational regulatory methods are to support scientific research in the field of nanotechnology, create conditions for converting new technologies into products for commercial use, and develop workforce components in the field of nanotechnology. Is to do. It turns out that this is about building an innovation infrastructure and ensuring accountability. Development of nanotechnology and its products.

We use the information above to improve our investment situation and support these areas of activity. Some conclusions have been drawn depending on the decision to get out of the situation.

1. Creation of a professional body in the field of nanotechnology that can prioritize, coordinate projects, and develop tools for program coordination.
2. Formation of human resources in the field of nanotechnology by introducing a sustainable functional system of interdisciplinary education.

3. The formation of conceptual devices to define the concept and classification of nanotechnology activity areas.
4. Ensure adequate level of funding for nanotechnology projects.
5. Building infrastructure for nanotechnology development that will ensure the unification of the potential of basic science and applied science.

In Ukraine, in order to search for new factors to enhance the development of the national economy and increase the efficiency of domestic producers, there is a need to stimulate the introduction of technologies of the sixth technological order, including nanotechnology. In recent years, Ukraine has taken a number of important steps towards stimulating the development of the nanotechnology industry, namely: the official fact of recognition of the need for the development of nanotechnology by the state, the definition of the development of the nanotechnology sector as one of the strategic priority areas of innovation in Ukraine for 2011-2021; implementation of state programs and programs of the National Academy of Sciences of Ukraine for the development of nanotechnological activities; introduction of training of specialists for the nanotechnology sphere in higher educational institutions and the like.

However, having carried out a critical analysis of the organizational and institutional support of nanotechnological activities in Ukraine, it was concluded that the fragmentation of state support, the real level of funding, the existing structure of institutional support for the development of nanotechnology and the lack of an effective mechanism for monitoring the implementation of actions aimed at the development of this area cannot guarantee Ukraine not only world leadership, but also a place in the market for nanotechnological goods and services. That is, the Ukrainian policy on the development of nanotechnological activities is aimed at formal adherence to world trends in the development of the innovation sphere and cannot significantly influence the process of formation of the domestic nanotechnology industry, despite the fact that it is the state at the first stage of nanotechnology development (which is confirmed by the experience of the formation of the nanotechnological sphere in leading countries) should take over the bulk of the work on creating a scientific and investment base, creating an innovative infrastructure, creating a platform for cooperation between scientific institutions and private enterprises, establishing public-private partnerships.

However, it should be noted that today Ukraine still has a fairly high scientific and technological potential in the field of nanotechnology. Fundamental and applied research aimed at the development of nanotechnological activity was carried out long before the start of state programs for the development of nanotechnology.

Given the weakness of state support for the nanotechnology sector in Ukraine and the lack of awareness of the business environment about this type of activity, one can state the underdevelopment of its industrial segment. So, today the Ukrainian market of nanotechnologies and goods manufactured with their use is at the initial stage of its development, is fragmented, unstable and geographically heterogeneous.

Thus, a balanced state policy for the development of the sphere of nanotechnology is urgently needed, which will cover the use of all possible tools to stimulate the development of the studied type of activity, since the passive form of state participation in these processes will not contribute to the development of the domestic nanoindustry.

Based on the data described above, it can be concluded that international cooperation of Ukraine can be implemented in different ways, as well as carried out as a research exchange of data, as well as attracting investments based on investment projects can provide additional branches for the development of this area in a developing country. However, this is far from sufficient for the implementation and creation of new segments of the nano market. For the full use of the given options and solutions, it is necessary to implement public investments and focus on this. At the level of state dynamics of budgeting in the sphere of nanotechnology and nanometrial, there should be implementation not only of institutional research, but also of the country's businesses.

International cooperation in the field of nanotechnology begins from the country, and the next conclusion is on the development of this field and industry.

1. The advancement of nanotechnology in the world is largely due to government support. The most important tool to watch out for when developing national regulatory policy in the nanotechnology sector, taking into account positive foreign experiences, is to secure adequate funding for nanotechnology projects and programs implemented within the framework of national strategic priorities. Creation of approved institutions for nanotechnology development; Human resource formation in the nanotechnology sector; Ensuring partnerships with the private sector in various fields of public policy (including industry, budget, currency, foreign economy), building infrastructure for nanotechnology development, building technological forecasts in research fields. At the same time, the growing role of the private sector in the development of the nano-industry is only the result of an effective regulatory policy for the development of the nanotechnology market, and it becomes possible only by overcoming the early stages of development.

2. The low level of efficiency of organizational and institutional support for nanotechnology activities in Ukraine is due to the fragmentation of state support, the absence of a single body specifically approved for the development of nanotechnology, incomplete qualitative filling of the arrangement of existing legal norms, in fact nanotechnology It makes it impossible to exercise significant positive influences, such as regulating activities. Despite the fact that Ukraine still has a fairly high scientific and technological potential in the field of nanotechnology in the process of formation of the domestic nanotechnology, the problems inherent in domestic nanoscience become a potential threat to the successful implementation of scientific research in nanotechnology. There is. The incompleteness of the national personnel policy and the weakness of marketing support for the development of nanotechnology in Ukraine also negatively affect the development of the domestic nanoindustry. Therefore, Ukrainian policy for the development of nanoscience and

nanotechnology aims to formally follow the global trends in the development of the sphere of innovation.

3. In the context of existing political risks, EU member states remain practically Ukraine's only strategic partner in the field of nanotechnology. Participation in EU programs and projects is the main form of international cooperation, and the most active participants are Ukrainian National Academy of Sciences and universities. On the one hand, the global community's demand for the scientific advancement of domestic organizations in the field of nanotechnology, identified by several indicators, can contribute to integrating the Ukrainian complex into the international high-tech market and ensuring the competitiveness of domestic products. Without adequate state stimulus to the development of this area of activity, Ukraine is threatened by the loss of intellectual property rights and qualified experts in important nanotechnology.

4. The complex use of state regulatory methods in the Ukrainian nanotechnology field can ensure the stable growth of nanotechnology production and the formation of the entire nanotechnology industry. The first step towards the development of the domestic nanotechnology industry is the approval of the development strategy for this field, the definition of its goals and objectives, integration with the national development plan, and setting the priority direction for nanotechnology development.

5. The formation of national information resources for the development of nanotechnology and making informed management decisions requires adequate tools to assess the level of nanotechnology development. When evaluating the level of development in the field of nanotechnology, critical analysis of existing methodological developments allowed us to pick and group indicators that could characterize certain aspects of nanotechnology activity. The most widely used indicators are those that evaluate the effectiveness of scientific and technological activities, but it is almost impossible to evaluate the development of the

nanotechnology market. In today's world practice, it has been proven that there is no integrated approach to such assessment.

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Appendix A

SUMMARY

I. V. Kursenko INTERNATIONAL COLLABORATION DEVELOPMENT IN NANOTECHNOLOGY AND NANOMATERIALS. Qualification of the master's robot. Sumy State University, Sumi, 2020 p.

The work investigated the development of international cooperation in the field of nanotechnology and nanometrial. The analysis of this sphere of activity in Ukraine, its dependence on international investors and partners is carried out. The purpose of qualification paper is to examine the theoretical approaches to development of international collaboration in nanotechnology and nanomaterials. Revealing the prospects and relevance of the field of nanotechnology and nanomaterials, definition of international nanotechnological cooperation of individual programs, revealing the negligence of the domestic authorities towards promising areas of scientific and technological spheres of nanotechnology, availability of prospects in case of improvement of cooperation of Ukraine on the European Framework Program.

Keywords: NANOTECHNOLOGY, NANOMATERIALS, DEVELOPMENT, INTERNATIONAL COLLABORATION, INNOVATIONS, INVESTMENTS, UKRAINE.

АНОТАЦІЯ

І. В. Курсенко. Розвиток міжнародного співробітництва в сфері нанотехнологій і наноматеріалів. Кваліфікаційна робота магістра. Сумський державний університет, Суми, 2020 р.

Робота досліджувала розвиток міжнародного співробітництва у галузі

нанотехнологій та нанометрії. Проведено аналіз цієї сфери діяльності в Україні, її залежності від міжнародних інвесторів та партнерів. Метою кваліфікаційної роботи є вивчення теоретичних підходів до розвитку міжнародного співробітництва в галузі нанотехнологій та наноматеріалів. Розкриття перспектив та актуальності галузі нанотехнологій та наноматеріалів, визначення міжнародного нанотехнологічного співробітництва окремих програм, виявлення недбалості вітчизняної влади щодо перспективних напрямків науково-технічної сфери нанотехнологій, наявність перспектив у разі вдосконалення співпраці Україна щодо Європейської рамкової програми.

Ключові слова: НАНОТЕХНОЛОГІЯ, НАНОМАТЕРІАЛИ, РОЗРОБКА, МІЖНАРОДНА СПІВПРАЦЯ, ІННОВАЦІЇ, ІНВЕСТИЦІЇ, УКРАЇНА.