CHAPTER 4
SECTORAL ANALYSIS OF THE HIGH-TECH PRODUCTS MARKET

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4.1. The market of nano- and biotechnologies

The development of a modern strategy for the commercialization of high-tech products should take into account not only the regional, but also the sectoral aspect. The sectoral aspect of the development of the high-tech products market is primarily characterized by the fact that the technologies shown in Figure 4.1.

In our opinion, it is necessary to emphasize the most important feature of the development of high-tech industries of the sixth order. In contrast to the system-forming branches of previous technological structures, outlined in Figure 4.1 industries do not exist separately. The directions of R&D in these fields are closely related and sometimes appear as a whole. Its classification was called NBIC-convergence (abbreviation for the first letters of high-tech directions: N – nano; B – bio; I – info; C – cogno). The term was introduced in 2002 by M. Rocko and V. Bainbridge [133].

The four defined areas of basic research are closely related, interact, and the most interesting results can be obtained as a result of their collision.

Convergence means not only mutual influence, but also the interpenetration of technologies, when the edges between them disappear, and interesting results arise precisely within the limits of interdisciplinary work at the border of technologicalfields.

The NBIC-technology cluster forms the sixth technological order of the world economy. Distinctive features of NBIC-convergence are:

1) intensive interaction between the specified scientific and technological branches;

2) significant synergistic effect of interaction;

3) wide range of coverage and influence – from the atomic level of matter to intelligent systems;

4) qualitative growth of technological capabilities of individual and social development of a human.

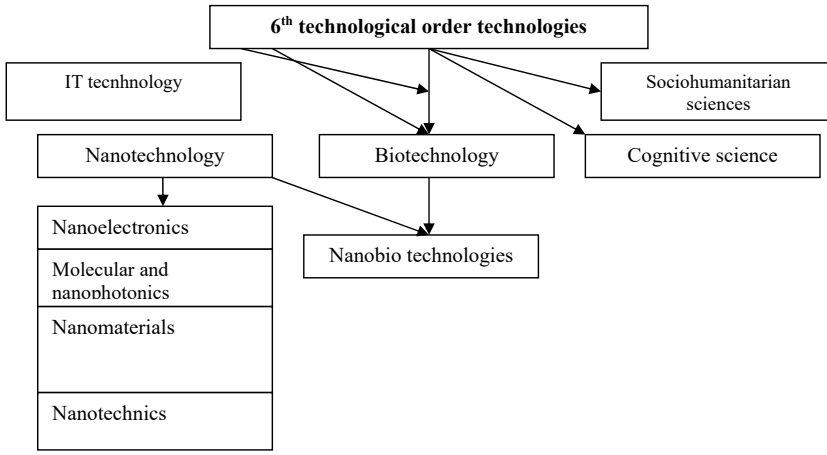

Figure 4.1. Basic technologies of the sixth technological system

Source: formed after [60]

The European Union recognized the importance of the international classification of NBIC technologies and the need to allocate significant resources for research initiatives in these areas. However, unlike American colleagues, the EU has developed its own in-depth approach to solving this task, which was reflected in the project "Converging technologies for the European knowledge society". In 2004, in the study "Converging technologies – shaping the future of European society", it was recognized that the approach to converging technologies should be based on the awareness of their opportunities and limitations, which include:

– inclusion of social and humanitarian sciences and other technologies and knowledge systems;

– full awareness and study of limitations;

– orientation towards achievement of the general goals of the European policy formulated within the framework of the European policy regarding the social process and general values [60].

M. Roko continued the development of the concept, transforming the concept of NBIC-convergence into a more global "Convergence of knowledge and technologies in the interests of society". CKTS is defined as the escalation and interaction between technologies, communities and

spheres of human activity to achieve mutual compatibility, synergy and integration.

Convergence has taken place step by step over the last few decades, starting with nanotechnology and the subsequent convergence of biotechnology, information and cognitive sciences to form new technologies. CKTS is the third level of convergence. It involves a general process of supporting creativity, innovation and social progress [169].

M. Roko also emphasized that convergence is a process of a huge scale of various dimensions and time periods and, having achieved the goal, will continue further development. He singled out three successive phases of convergence of science, technology and society (Table 4.1).

Table 4.1

Phases of CKTS-convergence

Period	Phase	Description
2001-2010	Reactive convergence	Random, based on the temporary activity of special missions, organizations, working groups created to perform a given, specific task
2011-2020	Proactive convergence	Principled, comprehensive and comprehensive. Realization of convergence based on principled, thought-out decisions
After 2020	Integral convergence	In-depth, multi-purpose, large-scale

Source: formed after [133]

To date, the countries of the European Union have clearly set the task of transitioning from the reactive to the proactive phase of convergence. Since 2014, the implementation of the largest EU framework program for scientific research and innovation "Horizon 2020" with a budget of 80 billion euros in 2014-2020 began (Table 4.2).

Most of the funding from the Horizon 2020 budget is distributed on a competitive basis for the implementation of projects within the three main components of the program:

1) advanced science – generating knowledge to strengthen the EU's position among the world's leading scientific nations, which provides support for: the most talented young scientists in conducting fundamental scientific research on the lines of the European Research Council; joint research in promising areas and the development of radically new

technologies of the future; improvement of personnel potential within the program "Events of Maria Sklodowska-Curie"; development of world-class research infrastructures in the EU with an emphasis on strengthening their innovative potential and human capital, as well as assistance in the implementation of European policy in international cooperation.

2) industrial leadership – achieving industrial leadership and supporting business, including small and medium-sized innovative enterprises, which will contribute to investment in the research of key industrial interdisciplinary technologies: information and communication technologies, micro- and nanoelectronics, photonics, nanotechnologies, new materials, biotechnology, efficient processes production, space.

3) social challenges, which includes the solution of social problems in response to modern challenges, which is based on combining resources and knowledge in various fields, including social and humanitarian sciences, involves all stages of innovative activity, from obtaining research results to their commercialization . The program will ensure an increase in the effectiveness of research and an increase in innovation in the following areas:

– health care, demographic changes and well-being;
– food safety, agriculture, ecosystems and bioeconomy;
– safe, clean and efficient energy;
– ecologically clean intelligent transport;
– impact of climate, efficiency of use of resources and raw materials;
– a progressive social system in European countries that ensures freedom, security and equal opportunities for all.

Table 4.2

Funding of the Horizon 2020 Framework Program

Investment directions	Expenses, EUR mln.
IT technologies	7 939
Nanotechnology	3 797
Biotechnology	509
Aerospace technology	1 536
Communications	5 894
Risk hedging	3 538
MSP direction	619

Source: formed after [178]

In addition, the program budget includes funding for the activities of: the Joint Research Center, which is the single service of the European Commission responsible for the scientific and technical support of business, the European Institute of Innovation and Technology, as well as research conducted within the framework of the Euratom Agreement.

The central place among various technologies forming the sixth technological structure is occupied by nanotechnologies [68]. Nanotechnology is a branch of fundamental and applied science and technology that deals with a set of theoretical justifications, practical trials, and technologies for the production with a defined atomic structure through the controlled manipulation of individual atoms and molecules. The Japanese physicist N. Taniguti, who first used the term "nanotechnology" in 1974 in his work "Basic concept of nanotechnology", gives the following definition of this term: "Nanotechnology mainly consists of the processes of separation, combination and deformation of materials atom by atom or molecule by molecule" [72, p. 5].

According to M. Rocko, products that meet three key requirements can be considered nanotechnologies: one of the proper dimensions cannot be larger than 100 nanometers; technologies for controlling the properties of their atomic structures are used in the production process; are synthesized into larger structures [168].

Let's define the list of areas of application of nanotechnology in accordance with current data: pharmaceuticals, thin-film and heterostructural components of microelectronics and optotronics, non-flammable polymer-based nanocomposites, nanoporous materials, integrated microelectromechanical devices, soft-magnet and hard-magnet materials, fuel cells, electric batteries, biocompatible fabrics for transplantation, nanocrystalline and amorphous materials [118].

The international market of nanotechnology as one of the segments of the world market of high-tech products is currently developing at the fastest pace. The development of this direction is a priority of the economic policy of the leading countries of the world economy and is a natural result of the evolution of the global economic system, the basis and impetus of the technological revolution. The application of nanotechnology in various industries, inter-industry and territorial complexes, serving their functioning spheres (financial, information, etc.), segments of the relevant markets of

the economic system gives pronounced synergistic and cumulative effects, stimulating the processes of humanity's transition to a qualitatively higher level of development.

More than sixty countries developed their own nanotechnology programs between 2000 and 2020. This process was initiated by the creation of the US National Nanotechnology Initiative. At the same time, a program in the field of nanotechnology was founded in Sweden. The real explosion of national nanotechnology programs took place immediately behind these countries, with twelve countries establishing one or another national program over the next year. Since then, the dynamics of creating national programs in the field of nanotechnology has increased. The Ukrainian state targeted scientific and technical program "Nanotechnologies and nanomaterials" for 2010-2014, 2014-2018 was approved by the Cabinet of Ministers in 2009 [163].

The global market for nanotechnology products was valued at $22.9 billion in 2013 and grew to approximately $26 billion in 2014. The global nanotechnology market reached from $90.5 billion in 2021 to $39.2 billion in 2016. The cumulative average annual growth rate is observed at the level of 18.2% in 2016-2021 [8].

In 2016, the global nanotechnology market showed impressive growth due to factors such as increased public and private sector R&D funding, increased partnerships and strategic alliances, and increased demand for smaller and more powerful devices at affordable prices. Currently, the health care industry is one of those where nanotechnology has made a big breakthrough in the diagnosis and treatment of chronic diseases. Moreover, notable developments are also taking place in other fields such as electronics, agriculture and energy. Over the past 11 years, governments around the world have invested more than $67.5 billion in nanotechnology funding [209].

In general, the dynamic development of nanotechnologies is characteristic of many countries of the world today, and forecasts of their further development in the world economy are quite optimistic (Table 4.3).

In the modern economy, nanoindustrialization forms: global financial flows and markets for the corresponding goods and services; research centers for the creation of nanotechnologies and concentration of specialized industry; global networks and communications, information

and infrastructure; global institutions and organizations for effective transformations and transactions in the field of nano-industry.

Table 4.3

Key indicators of the development of nanotechnology in the world and in the USA

Years	Number of employees	Scientific publications	Patent applications	Goods market	Total R&D expenses	Venture capital
2000	60 000 (25 000)	18 085 (5 342)	1 197 (405)	30 bln.	1,2 bln.	0,21 bln.
2010	400 000	65 000	12 776	200 bln.	15 bln.	1,4 bln.
2000-2010 (growth per year, average)	25%	23%	35%	25%	35%	30%
2015-2020	2 000 000 (800 000)	34%	38%	400 bln.	18 bln.	27%

Source: formed after [168]

The primary achievements of the field of nanotechnological products should be considered the following: increase and transformation of the technological structure of production; the foundation of a technological interdisciplinary basis for a range of fields of application, including biomedicine, ecology, pharmacology and electronics; enabling operations to be carried out at the atomized level, with the possibility of clearly defining the parameters of the processed objects; opening the prospect of full interdisciplinary science and powerful convergence of the technostructure of production; initiating revolutionary changes in the technological way in general.

The product commercialization strategy is determined by the specificity of the multiplicity of goals of the high-tech segment of the world market. These strategic goals are the increase of production volumes, the expansion of technology transfer, quotas for targeted strategic exports, and the growth of incomes of narrow special factors of production.

Despite the systemic economic crisis of the national economy and the problems of staffing, the scientific and technical potential of the state has a certain stability. Existing gains in the NBIC sector. The information

technology sector, which is the basis of the modern technological base of civilization, is one of the most promising sub-segments of the high-tech sector of the state. However, the legislative provision of activities in the field of information technologies is incomplete and does not reflect the reality of today. Significant bureaucracy and significant pressure from the state imposes excessively high obligations on this subsector. Excessive bureaucracy does not contribute to the implementation of public-private partnership in the field of information technologies, which is a brake on the intensification of intensive growth and the formation of a national innovation system [167; 194].

The existence of these problems is evidenced by the dynamics of the network readiness index of Ukraine for 2010-2018 according to the data of the World Economic Forum (Table 4.5).

Table 4.4

Dynamics of the position and value of the network readiness index of Ukraine for 2010-2018

2014		2015		2016		2017		2018		2019		2020		2021		2022	
rating	index	rating	index	rating	index	rating	index	rating	index	rating	index	rating	index	rating	index	rating	index
82	3,53	90	3,53	75	3,85	73	3,87	81	3,87	71	4	85	3,67	81	3,72	83	3,78

Source: formed after [72]

The next type of high-tech products and technology is nanotechnology. Nanotechnology is at the intersection of scientific and engineering sciences. Nanotechnologies are technologies for the production of devices for the manipulation of microparticles.

A number of nanotechnology market development programs have been active since 2001: "Nanophysics and nanoelectronics" (2001); "Nanotechnologies and nanomaterials" 2010-2014; "Nanostructural systems, nanomaterials, nanotechnologies" in 2003-2009, "Fundamental problems of nanostructured systems, nanomaterials, nanotechnologies" in 2010-2014.

The state was distinguished by achievements in the field of physics and chemistry of surfaces and catalysis, welding of capillaries, electrochemistry.

NAS of Ukraine has 50 agreements in the field of nanotechnology. According to the program "Nanostructural systems, nanomaterials, nanotechnologies", experiments in the physics of metals and alloys, powder technologies, colloidal nanosolutions, sorbents, medicines, microelectronics, and surface chemistry continue. During the past medium-term development period, 75 organizations carried out development, and 150 grants were received in this area. Most of the projects were implemented with France (24 projects), Germany (10 projects), Poland (9 projects), Spain and the United Kingdom (6 projects). The USA is also a partner of Ukraine, 20 projects have been jointly prepared.

Ukraine has potential in the following areas: friction materials, supercapacitors, amorphous materials, synthesis of powders, bio-implants and biomarkers [110].

Among the leading Ukrainian companies in the field of nanotechnology, it is possible to mention the Nauka Scientific Research Park, the Kyiv Polytechnic Science Park, the Saturn PJSC, the NanoMedTech company, the Nanomaterials and Nanotechnologies company, the NanoSvit LLC, the Nanotechnology Research Center, the NanoUnion company, and the New Technologies Center PJSC. , NPP "Lileya", PE "Innovations of Ukraine", NPP "Karat-Electron" SE PJSC "Concern-Electron" and others.

Another basic field of the sixth technological order is biotechnology. Today, biotechnologies are used in medicine and pharmaceuticals, agriculture and industry. The size of the world biotechnology market in 2018 is estimated at 369.62 billion dollars. USA (Table 4.5).

Table 4.5

The main indicators of biotechnology centers in the world 2012-2019

Indicators	Years							
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2019**	**2021**
Revenue	89,7	99,0	123,1	130,3	139,4	141,2	141,9	143,5
R&D expenses	25,4	29,4	35,4	40,6	45,7	46,7	48,2	51,6
Net profit	5,1	4,5	14,9	16,3	7,9	8,6	7,9	9,1
Number of employees	165	168	184	179	203	205	207	210
Number of public companies	602	619	714	680	708	712	721	725

Source: formed after [187; 188]

According to Ernst&Young's annual review, although the collective market capitalization of the biotech industry fell in 2016, the revenues of biotech companies increased by 7% ($139.4 billion in 2016 compared to $130.3 billion in 2018). and spending on research and development – by 12% ($45.7 billion in 2016 compared to $40.6 billion in 2018). In the same report, it is stated that the USA and the EU have to reckon with the growing amount of financing of the biotechnological industry of Asian countries and, first of all, with China. During 2016, total biotech funding in China, Japan, Singapore, South Korea and Taiwan increased by $2.5 billion. USA. L. Zhu in the article "China Rides the Biotechnological Wave" defines biotechnology as a key industry that stimulates economic development [13].

Today, the leaders in the field of biotechnology are the companies of the United States of America, the European Union, and Japan [22; 74] (Appendix B) (Table 4.6).

Table 4.6

Ranking of the 10 largest pharmaceutical and biotechnology companies based on revenues in 2017-2019

Company	Total revenue		
	2019	2020	2021
Johnson & Johnson	72.5	81,6	82,1
Roche	53.5	58,76	63,54
Pfizer	52.4	53,64	51,75
Novartis	49.2	44,75	47,45
Merck&Co	40	42,29	46,84
GlaxoSmithKline	40	40,96	43,26
Sanofi	43.3	38,59	40,51
AbbVie	31,5	32,75	33,27
Takeda	15,8	16,44	29,88
Bayer	27,6	28,39	26,59

Source: formed after [102; 187]

However, it should be emphasized that in the biotech industry, small biotech firms are more the rule than the exception, with 72% of biotech firms in the US having fewer than 50 employees. This aspect must be

taken into account during the further analysis of intra-corporate factors of companies entering the world market.

The analysis of the current state of various countries in the world market of high-tech products, conducted by us in the study, showed that in the conditions of globalization, competition in the field of high-tech products is intensifying. In the geo-economic sense, the following trends can be observed: the European Union barely maintains its position on the world market, while Japan is rapidly losing its share in most segments. China's potential is growing at a high rate, the USA is still considered the leading producer, although some American experts note that the dynamism of high-tech production in this country is slowing down [69].

The next promising area of commercialization of high-tech products is biotechnology. Biotechnology is the science of methods of producing products by implementing environmentally friendly processes.

Design and transformation of biological macromolecules, construction of cell and tissue cultures, bioinformatics, nanobiotechnologies used in medicine, pharmaceutical and biotechnological industries, in bioenergy and agriculture are considered the main areas of biotechnology development. The state currently has significant assets in this market segment.

An important factor in the development of biotechnology is the targeted interdisciplinary research program of the National Academy of Sciences of Ukraine "Fundamentals of molecular and cellular biotechnologies". Within the framework of the program, the Institute of Cell Biology and Genetic Engineering of the National Academy of Sciences of Ukraine conducted a scientific study on the topic: "Obtaining and researching molecular and genetic features of herbicide-resistant agricultural crops". As a result of these studies, a number of promising results were obtained, namely: development of test systems for hereditary diseases; identification of antigens and isolation of monoclonal antibodies; designing therapeutic gene delivery systems for therapy; fundamental developments in the use of stem cells; development of new means: recombinant proteins, interfering RNA, bioactive molecules; creation of new strains of microorganisms – drug producers; creation of a number of biosensors for environmental protection.

Agricultural biotechnology optimizes breeding methods and initiates new technologies. Plant disinfection measures are being developed. Studies of nitrogen fixation, photosynthesis, amino acid composition of proteins are

deepening. Growth regulators, microbiological protection agents, fertilizers are being developed. Genetically engineered vaccines are used to prevent diseases in animal husbandry. Genetically engineered growth hormone and embryo transplantation techniques are used to improve genetic selection. Protein obtained by the method of microbiological synthesis is also used [182].

In the field of bioenergy, the production of liquid biofuel for world markets is organized. Domestic scientists occupy prominent positions in the extraction of ethanol.

In addition to the above-mentioned areas of the international NBIC product classification of the 6th technological order, the industries of the 5th order – aerospace and aircraft construction – require special attention.

The aviation industry is a strategic sector of the national economy. Ukraine is one of the 9 countries in the world that have established a full cycle of aircraft production. The national aviation industry includes thirty-nine enterprises. The main ones are: ANTK named after Antonova, Kharkiv State Aviation Production Enterprise, state enterprise "Kyiv Aviation Plant "Aviant", state enterprise "Zavod 410 civil aviation" [203].

Ukraine produces transport and passenger aircraft for medium routes. Domestic scientists have developed a number of highly competitive models that beat similar competitors and have strong positions on the world market. These are transport ships, passenger ships, agricultural ships, seaplanes, aircraft for aerial photography, weather protection, polar, patrol, etc.

Aircraft manufacturers have significant opportunities in establishing international cooperation. Among the promising areas of cooperation is the joint development and production of transport and military transport aircraft together with Canadian companies. In addition, DK "Antonov" can establish production of modernized "Ruslans" with companies from the USA.

The state has a closed cycle of production of space rockets. Achievements include: launch of the Sich-1 satellite; design of the "Zyklon-4" launch vehicle; active cooperation within the "Sea Start". 120 rockets and 230 satellites were launched to order, including partner countries [109].

The aerospace industry of Ukraine includes seven design bureaus, research and design institutes, twelve industrial enterprises and thirteen specialized enterprises and institutions, which employ about forty-

three thousand people. The National Space Agency of Ukraine performs industry management functions. Enterprises of the industry include: National Center for Control and Testing of Space Means, SE "Pivdenny Machine-Building Plant", SE "Dnipro Design Institute", State Design Bureau "South" named after M. K. Yangel, OJSC "Ukrainian Research Institute of Mechanical Engineering Technology", SE "Dniprokosmos", SE "Pavlograd Chemical Plant", SE "Nikopol Tube Plant", SE "Science Center of Precision Machine Building", SE "Arsenal Plant", SE "Ukrkosmos", OJSC "Kyivskyi" radio plant, State NRC "Pryroda", OJSC NRC "Kurs", JSC "Elmiz", SE "PO "Kyivprilad", KP "Central design bureau "Arsenal", JSC "RSV-Radiozavod", SE "Center for standardization of rocket and space technology", State joint-stock holding company "Kyivskyi" radio factory", Scientific Research Technological Institute of Instrumentation [4].

At the same time, the conducted survey of Ukrainian high-tech enterprises indicates an insufficient level of use of the experience of international entrepreneurship. The basic models, mechanisms and tools for the commercialization of high-tech products developed in this study will allow domestic manufacturers, relying on existing achievements, to increase the effectiveness of commercialization in this segment of the world market. The theoretical and practical developments formulated in the study can be used by domestic enterprises as typical layouts, which will allow to strengthen the possibilities of commercialization and increase its effectiveness in a geostrategic sense. Today, this possibility is clearly observed only in certain segments of Ukrainian high-tech production.

In the sectoral aspect, the main trend in the world market of high-tech products is the priority development of nanotechnologies, bio- and information technologies, the emergence and deepening of the international NBIC convergence, which, according to many experts, is developing into the convergence of knowledge and technologies in the interests of society, i.e., the importance is growing significantly with the factor of human capital and the social orientation of the use of the latest technologies. The investigated specifics of the current state of development of the world market of high-tech products can serve as a basis for the development of a modern strategy of commercialization of high-tech products by individual enterprises.

4.2. The Information Technologies Market and the Development of Cognitive Sciences

Observers of the World Economic Forum emphasize that the state lacks a plan for interaction with the information technology subsector within the framework of systemic strengthening of the competitiveness of the national economy. The lack of regulated property rights and corruption, the transitivity of the economic system contribute to lowering the state's investment ratings and do not contribute to the import of international experience in this area.

Despite the mentioned problems, the IT sector in Ukraine is developing dynamically. According to the State Statistics Committee, in 2019 the share of information and communication technologies in the GDP was 1.56%. The IT industry has promising prospects for personnel support. The state ranks fourth in terms of certification of IT specialists, and is among the 30 main sites for the implementation of hardware and software development. Actively using modern outsourcing and outstaffing tools, the IT sector is already highly competitive on the international market today and forms a significant part of foreign exchange earnings [140].

In 2019, 17.2 billion UAH were invested in the IT sector. Capital investments increased most actively in the following directions: "Data processing, work with web nodes and related activities. Web portals, "Provision of information services" and "Activities in the field of wireless telecommunications". Exported information and telecommunication services by enterprises of this subsector enriched the national economy by 1.5 billion dollars in 2013 alone [125].

The most influential domestic IT companies are: "EPAM", "SoftServe", "Luxoft" and "GlobalLogic", etc. [205]. According to experts, the growth of the IT sector could accelerate in 2018, but slowed down due to the situation in the East, legislative obstacles and government pressure. The mentioned factors affected the rating of investors and customers, which caused an increase in the outflow of specialists from Ukraine [127].

It should be emphasized that the state's economy needs growth acceleration measures, which include the introduction of IT in all spheres of the national economy. While these processes are successfully developing in the areas of e-business, e-commerce, IT, they lag somewhat behind in telecommunication services, e-government, and are far behind in non-

cash payments, provision of public services, etc. Outsourcing and system integration services are currently the most promising areas of development of the information technology subsector.

Table 4.7

IT sector expences

Service	2019		2020		2021	
	Expences, $ bln.	Growth ratio, %	Expences, $ bln.	Growth ratio, %	Expences, $ bln.	Growth ratio, %
Data processing systems	178	4,4	179	0,6	179	-0,2
Corporate software	355	8,9	389	9,5	421	8,4
Devices	667	5,7	704	5,6 5,5	710	0,9
IT services	933	4,3	985	5,5	1 030	4,6
Communication services	1693	1,3	1 427	2,4	1 443	1,1
IT overall	3526	3,8	3684	4,5	3 783	2,7

Source: formed after [114]

It sector development is derived from the digitalization process, that takes place in the modern world. The main aspect of digital transformation is the process of integrating digital technologies into all aspects of business activities of the socio-economic system, which requires fundamental changes in technology, culture, operations and principles of creating new products and services. For the most effective use of new technologies and their prompt implementation in all spheres of the socio-economic system, it is necessary to abandon the former foundations and completely transform technological processes and business models. Digital transformation requires shifting the focus to the periphery and increasing the flexibility of data centers that must support the periphery.

Scientific approaches to the study of digital transformation include:

1. A process approach, within which it is customary to consider the socio-economic system as a chain of value creation from the development of products / services to their implementation and service.

2. Sectoral approach, which eliminates the need to study the close relationship of socio-economic systems of different levels and branches of the economy.

3. A technological approach to the digital transformation of socio-economic systems, which involves the selection of a dynamic pool of technologies capable of accelerated digitization and digital transformation of a specific socio-economic system.

Concepts of digital transformation are presented:

1. Concept of platforms.
2. The concept of a cyber-physical system.
3. The concept of the fourth industrial revolution "Industry 4.0".
4. Concept of social transformation "Society 5.0".

The content of the digital transformation process involves a gradual, sequential transition consisting of 4 stages:

– Digital data – digitization process: all data are unified in digital format;

– Digital infrastructure – introduction of digital technologies: formation of a pool of digital technologies;

– Digital models – digitalization: adjustment and restructuring of communication channels of digital technologies (forming the digital space of interaction of users of digital technologies);

– Digital transformation: restructuring of the business format and concept (transfer of all possible components of the socio-economic system to the digital space and to digital interaction with maximum use of the potential of implemented digital technologies);

The main trends of digital transformation are:

1. Data becomes the main source of competitiveness, that is, an intangible asset.
2. Development of the Internet of Things – a network consisting of interconnected physical objects or devices that have built-in sensors and sensors, as well as software that enables the interaction of physical things with computer systems and networks.
3. Digitization of business and economic sectors.
4. The spread of business models belonging to the ideology of the sharing economy.
5. Changes in communication and interaction models. Reconfiguration of consumer behavior.
6. Efforts to form business models resistant to negative influences. The transition to network interaction and the formation of ecosystems of suppliers, partners, consumers and competitors around companies.

7. Virtualization of physical infrastructure IT systems and transition to service models.

8. Application of artificial intelligence in production and circulation.

9. Digital platforms as sources of value formation in the digital economy.

10. "Environmentally clean" marketing.

11. Activation of data collection by companies, fight against asymmetry of information.

12. Significant role of cryptocurrencies (digital electronic money).

The role of cognitive sciences lies in artificial intelligence and big data processing.

Big Data is a huge amount of heterogeneous, unstructured or poorly structured, significantly distributed and rapidly growing digital information that changes and cannot be processed by traditional means. Also methods, technologies and means of their collection, storage, processing and analysis in order to obtain results that are perceived by a person.

Principles of interaction with big data:

1. Distribution. Keeping information in one place is pointless and almost impossible. the technology of working with Big Data should use distributed storage, management, processing and analysis of data located in various data repositories.

2. Horizontal scalability. Since there can be as much data as you want, any system that involves processing big data must be scalable.

3. Fault resistance. The principle of horizontal scalability implies that there can be many machines in the cluster. This means that some of these machines will be guaranteed to fail. Methods of working with big data must take into account the possibility of failures and survive them without significant consequences.

4. Data locality. In large distributed systems, data is distributed over a large number of machines. If the data is physically located on one server and processed on another, the costs of transferring the data can exceed the costs of the processing itself. Therefore, one of the most important principles of designing BigData solutions is the principle of data locality – if possible, data processing is carried out on the machine on which it is stored.

5. Interpretation of data in the process of their processing. Data enters the repository without prior description, without specifying their structure

and semantics. And only in the process of their selection for processing, their "understanding" occurs [94].

Methods of big data analysis include [5]:

1. Crowdsourcing (Crowdsourcing) is a method of collecting, categorizing and enriching data by the forces of a wide range of persons involved on the basis of a public offer, without entering into labor relations, usually with the help of network media.

2. Mixing and integration of data (Data Fusion and Integration) – a set of methods that allow integrating and analyzing disparate data from various sources for in-depth analysis more accurately and efficiently than from a single data source.

3. Association Rule Learning (Association Rule Learning) is a set of methods for analyzing necessary relationships, i.e. "association rules" among variables in large databases.

4. Machine learning (Machine Learning) is a class of artificial intelligence methods, the characteristic feature of which is not a direct solution to a problem, but learning in the process of applying solutions to many similar problems. Includes supervised and unsupervised learning, as well as the use of models built on statistical analysis or machine learning to produce complex predictions based on underlying models.

5. Natural Language Processing (NLP) is a general field of artificial intelligence and mathematical linguistics that studies the problems of computer analysis and synthesis of natural languages. In relation to artificial intelligence, analysis means understanding language, and synthesis means generating competent text.

6. Artificial Neural Networks (Artificial Neural Networks) – a mathematical model built on the principle of organization and functioning of biological neural networks – nerve networks of a cellular organism.

7. Network analysis (Network Analysis) is a set of methods used to describe and analyze relationships between discrete nodes in the network. In a social network, connections between people in society or an organization are analyzed.

8. Pattern Recognition – a set of machine learning methods that develop methods of classification and identification of subjects, phenomena, processes, situations, objects characterized by a finite set of certain properties and features.

9. Predictive Analytics – a class of data analysis methods focused on predicting the future behavior of objects and subjects in order to make optimal decisions.1

10. Analysis of the tonality of the text (Sentiment Analysis). A class of content analysis methods in computer linguistics, intended for the automated detection of emotionally colored vocabulary in texts and emotional assessment in relation to the objects discussed in the text.

11. Simulation modeling (Simulation Modeling) is a research method in which the system being studied is replaced by a model that describes the real system with sufficient accuracy (the constructed model describes the processes as they would occur in reality), from which experiments are carried out with the aim getting information about this system.

12. Spatial Analysis (Spatial Analysis) – a set of methods that analyze topological, geometric or geographic properties presented in a data set. Often, data for spatial analysis comes from geographic information systems.

13. A/B Testing – a control group of items is compared to a set of test groups in which one or more indicators have been changed in order to find out which changes improve the target indicator.

14. Analysis of time series (Time Series Analysis) is a set of mathematical and statistical methods of analysis designed to reveal the structure of time series and to forecast them. This includes, in particular, methods of regression analysis. Identification of the structure of the time series, necessary to build a mathematical model of the phenomenon that is the source of the analyzed time series. Artificial intelligence is an artificial system that imitates the solution of complex tasks by a person in the course of his life activities. It is customary to refer to artificial intelligence a number of algorithms and software systems, the distinguishing feature of which is that they can solve some tasks in the same way as a person thinking about their solution would do [5].

The main characteristics of the artificial intelligence system:

– Big data – the ability to process huge data sets;

– Reasoning – the ability to think deductively or inductively and draw conclusions;

– Learning – the ability to learn based on historical patterns, causal relationships and assessments;

– Problem solving – the ability to analyze and solve problems of general and special purpose.

Areas of development of artificial intelligence:

– solving problems related to bringing specialized AI systems closer to human capabilities and their integration, which is realized by human nature;

– the creation of artificial intelligence, which represents the integration of already created artificial intelligence systems into a single system capable of solving humanity's problems.

Areas of application of Artificial Intelligence:

– automatic translation;
– recognition of texts;
– intelligent information security systems;
– obtaining business analytics;
– extracting information;
– speech recognition;
– recognition of visual images;
– understanding and analysis of texts in natural language;
– robotics;
– expert systems;
– image analysis.

The use of artificial intelligence makes it possible to make business processes flexible and adaptive, to abandon traditional conveyors and move to the idea of integrating advanced artificial intelligence systems and people. This approach radically changes the interaction between a machine and a person, forms integrated teams of robots and people. Such teams are able to quickly process large data sets, learn new information and adapt to continuous changes in the course of production operations. AI capabilities allow companies to reengineer their business processes in a new way, significantly increase their productivity and reduce costs. Thus, one of the main areas of development and implementation of AI in industry is the reengineering of business processes.

Electronic commerce (e-commerce) is trading of products or services using computer networks, in particular the Internet. Modern e-commerce typically uses the Internet for at least one part of the transaction lifecycle, although it may also use other technologies, such as email. Electronic commerce can also be defined as the exchange of business information,

the maintenance of business relationships, and the conduct of business transactions using computers connected to a telecommunications network.

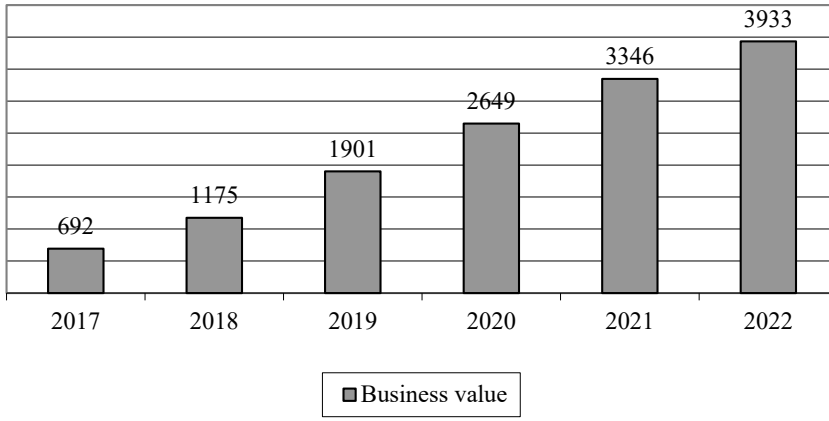

Figure 4.2. Artificial intelligence expense 2017-2022

Source: formed after [74]

E-commerce relies on the following digital technologies: mobile commerce, electronic funds transfer, supply chain management, online marketing, online transaction processing, electronic data interchange (EDI), inventory management systems, and automated data collection systems [87].

E-commerce includes the following categories:

1. Electronic markets. The range of offers available in the market segment is demonstrated so that the buyer can compare the prices of different offers and make a purchase decision.

2. Electronic data interchange (EDI):

– provides a standardized system of coding trade transactions;

– provides communication between one computer and another without the need for printed orders and invoices, delays and errors in working with paper;

– used by organizations that perform a large list of regular operations. EDI is used in large market chains to carry out transactions with suppliers.

3. Internet trade:

− used for advertising and selling a wide range of goods and services;

− intended for business and consumers. For example, buying goods that are then delivered by post or booking tickets.

E-commerce business models include:

– Business to Consumer (B2C). In a business-to-consumer e-commerce environment, companies sell their goods online to customers who are the ultimate consumers of their goods or services. Typically, B2C e-commerce web stores are open to any visitor – a person does not need to log in to make any inquiry related to a product.

– Business to business (B2B). In an e-commerce environment, companies sell their products online to other companies without selling directly to consumers. In most B2B e-commerce environments, logging into the online store will require you to log into the system. A B2B online store typically includes customer-specific pricing, customer assortments, and discounts.

– Consumer to Business (C2B). Consumers usually post their goods or services online, where businesses can post their bids. The consumer reviews applications and chooses a company that meets his price expectations.

– Consumer-to-consumer (C2C). Consumers sell their goods online to other consumers. A well-known example is eBay.

Digitalization of marketing thanks to the use of innovative technical means and advanced digital channels made it possible to establish communications with potential customers on the Internet. Digital marketing infrastructure is represented by a wide range of technologies that involve a combination of specialized software and hardware [109].

Digital marketing tools are:

1. Search engine optimization (SEO) is used to increase organic traffic in the process of using search services by potential customers.

2. Content marketing Specialized content (presented in the form of photos, videos, audio, as well as in text format) can arouse interest in certain groups of users belonging to a separate target audience.

3. Email marketing allows you to establish communications with the target audience thanks to the automatic sending of thematic messages to certain categories of consumers.

4. Marketing in social networks (SMM – Social Media Marketing) is based on the demand of Internet users for social networks, in each of which there are separate communities characterized by certain interests and interested in receiving thematic content.

5. Online advertising is used by companies on the Internet to provide relevant information to potential customers on various web resources. There are the following types of advertising messages: contextual, media, text and teaser ads, landing page, spam, etc.

6. Contextual advertising – provision of advertising content based on a recommendation system that identifies the user according to defined interests

7. Web analytics is integrated into company websites and allows for comprehensive analysis of key processes that occur during users' visits to the resource.

8. Mobile marketing. There are a large number of applications that promote products by providing customers with the opportunity to use services or access themed content on a free basis [103; 190].