

CHAPTER 3
INSTITUTIONAL FOUNDATIONS
OF THE HIGH-TECH PRODUCTS
COMMERCIALIZATION DEVELOPMENT

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3.1. Institutional Model of Innovations

Various models of commercialization of high-tech products acquire real meaning only in the appropriate institutional environment, which actively promotes or, on the contrary, inhibits the process. In turn, the institutional environment is determined by the foundations of the socio-economic system.

The analysis of the institutional foundations of the commercialization of high-tech products is based on theoretical developments in a conditionally separate direction of economic theory – institutionalism. The theory of institutionalism: from its founders to modern representatives, T. Veblen, L. Thevenot, W. Mitchell, F. Émar-Duvernay, D. Clark, D. Commons, R. Coase, O. Williamson, D. North, R. Nelson, S. Winter, D. Hodgson, L. Boltyansky – emphasized the concepts of social and economic activity of a person. Today, the theoretical foundations of institutionalism are based on an in-depth analysis of three fundamental categories of institutional theory – institution, institute and organization.

An in-depth analysis of the institutional foundations of the commercialization of high-tech products requires a clear definition of these basic categories in order to practically determine those institutional foundations that will most effectively promote the commercialization of high-tech products within the limits of the modern knowledge economy. The opinion of O. Inshakov and D. Frolov is opposite regarding the main problem of commercialization of the high-tech industry, where the problem of insufficient development of commercialization institutes is highlighted [84].

The most controversial issue is the definition of the categories "institution" and "institute". Some researchers consider these concepts identical and suggest using only one of them in the scientific field.

For researchers of the rational choice school, institutions are either structures, that is, forces that lead subjects to choose an equilibrium state,

or equilibria, that is, sets of strategies from which no agent has incentives to “refuse” if no other actor “refuses” “. According to both definitions, institutions can be considered as rules – regardless of whether these rules are considered exogenous laws that structure choices or established patterns of equilibrium behavior. Modern institutionalism of rational choice is the culmination of two lines of research – one in the theory of social choice, the other in the new classical school, which intersected in the early 1990s.

The distinction between institutions, institutes and organizations enables a unified presentation of the ensemble of invariant forms of economic cooperation, namely: functional (institutions), genetic (institutes) and structural (organizations) [114; 120]. For example, high-tech products are an institution, enterprises are an institution, the company "NanoMedTech" is an organization.

The given approach, in accordance with the postulates of dialectics, will make it possible to retrospectively and evolutionarily analyze the prerequisites for the creation and formation of the institutional environment and the development potential of the commercialization of high-tech products. In the table 1.8 defines the category "institutional environment".

Thus, in our opinion, the institutional environment is a fundamental system of political, social and legal norms and rules that creates the basis of social reproduction (that is, institutions) and is embodied in specific socio-economic institutions that act as a genetic basis for the formation of various organizations that act in accordance with the requirements clearly outlined by this system.

Such an understanding of the institutional environment allows us to outline those norms and rules, institutions that at the basic level determine the process of commercialization of a high-tech product of enterprises, to outline the main institutions involved in this process, and to carry out an analysis of the activities of specific organizations that carry out the generation and commercialization of innovative ideas.

Such agents from the point of view of the institutional basis of commercialization of the high-tech product of enterprises are a set of existing institutions, which for each specific high-tech enterprise take the form of various organizations that can functionally be consumers, partners or competitors of this enterprise. However, such institutions are based on innovative and infrastructural institutions (Figure 3.1).

Table 3.1

Definitions of the "institutional environment" economic category

Author	Institutional economic category environment definition
T. Veblen	Conventional methods of influence on motivations and the structure of production and economic systems and the social way
D. Hodgson	Long-term systems of rules that have developed and took root and form the structure of social interactions
O. Williamson	Rules of the game, which determine the context in which economic activity is carried out; basic political, social and legal norms that form the basis of production, exchange and distribution
D. North, L. Davis	Fundamental political, social and legal rules that create a basis for production, exchange, distribution and consumption
M. Danko	Fundamental political, social, and legal rules within which production and exchange processes are carried out (constitutional, production, contract law); rules governing relations in the private sector (property theory); rules of behavior of economic agents on a contractual basis (theory of corporations, theory of regulation of structures); specific rules of behavior of economic agents (customs, traditions, moral, ethical and religious institutions)

Source: formed based on [52; 73; 136; 188; 192; 202; 205]

It should be noted that all institutions that directly affect the process of commercialization of a high-tech product are separated purely formally. In the realities of the operation of a high-tech enterprise, they are closely interconnected.

Therefore, the innovative system of norms and rules for the commercialization of a high-tech product includes the motivation of high-tech research, the support of high-tech ideas, scientific research, venture financing and the transfer of high technology. The infrastructural system of norms and rules for the commercialization of a high-tech product combines regulatory and legal foundations, information and personnel support, and support of small and medium-sized enterprises.

The institutes themselves represent a set of agents embodied in various specific organizations involved in the process of commercialization. Therefore, the next step in the analysis of the institutional environment is to identify and outline the system of institutions, the emergence and development of which are based on the above-mentioned institutions.

CHAPTER III

The starting point of the innovative component of the institutional environment for the commercialization of a high-tech product of domestic enterprises is research and development institutes. We consider such institutes not as academic organizations, but as an element of the institutional environment. In this context, the system of research and development institutes includes all subjects of scientific, research and design activity, from powerful scientific organizations to isolated researchers who generate ideas in the field of high technologies and are at the stage of generating ideas.

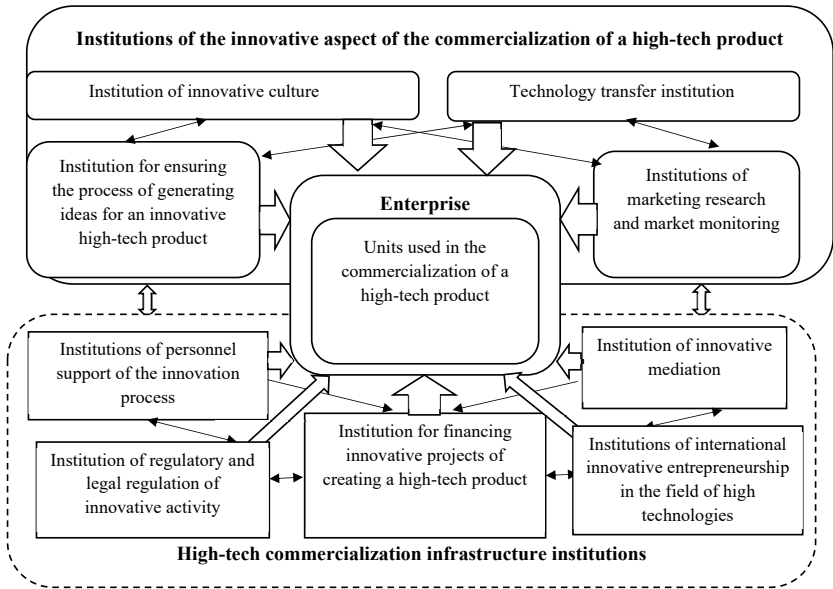


Figure 3.1. The system of institutions in the context of the model of the sixth generation of commercialization of a high-tech product

Source: author's concept

That is, based on the institutional theory of development regarding the development and commercialization of a high-tech product, an individual inventor (for example, such personalities as S. Jobs and I. Musk, who start

high-tech start-ups with a market orientation), should determine research and development institutes from the point of view of institutional foundations of commercialization of a high-tech product.

Today, the scientific activity of higher education institutions is also gaining special importance, whose scientific and research developments in the field of high technologies and products increasingly acquire not so much a theoretical as a practical character and are oriented to the requirements of the market. That is why the task of forming an effective mechanism for the commercialization of university scientific research is urgent. In our opinion, the main requirements for an effective mechanism of commercialization of university innovations were formulated clearly enough by M. Olievska, namely:

1) regional decentralization (which allows solving the task of investment support of the full innovation cycle on the ground);

2) high level of market, innovation, investment and scientific and technical potential of subjects of innovative and scientific research activity;

3) full integration of infrastructural and organizational components of the mechanism of commercialization of university innovations with financial and credit support of the business sector;

4) the presence of a developed system of information support for the interaction of subjects of commercialization of a high-tech product;

5) active use of information technologies;

6) high flexibility and adaptability of the process of creation, development and commercialization of a high-tech product;

7) universality of the innovation process (allows investment support for the process of creating innovations in various branches of production or non-material spheres);

8) professionalism based on high-quality service to investors of the commercialization of a high-tech product;

9) availability of infrastructure facilities to ensure the efficiency of the innovation process;

10) formation of mechanisms for accumulating experience in market interactions [141]. This problem is closely intertwined with the process of forming and ensuring the effective functioning of technology transfer centers. In the structure of the modern global technology market, the institute of high technology transfer centers functions in the form of various

subjects of all structural levels of the international economy. This structural element of the institutional environment of commercialization of a high-tech product has a vertical, multi-level structure (Figure 3.2).

Thus, one structural element of the institutional environment (technology transfer centers) can manifest itself in the form of various organizations. The effective operation of such institutes as research and development institutes and technology transfer centers should be based on effective systems of motivation for high-tech research. Objective reality causes an urgent need to develop a mechanism for motivating the creation and commercialization of a high-tech product by enterprises. With the correct construction of such a mechanism and understanding of the principles and specifics of its functioning, depending on specific conditions, the peculiarities of the interrelationships of the constituent elements, extraordinary solutions in this area are possible.

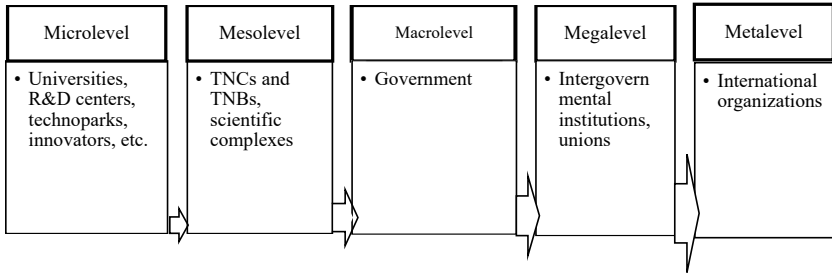


Figure 3.2. Levels of high technology transfer subjects

Source: formed based on [56]

World practice shows that state stimulation as the basis of the high-tech research motivation system can be implemented in direct and indirect ways. Direct stimulation is the allocation of resources for the creation and development of high-tech industries, which includes a system of direct budget financing and subsidies. Indirect stimulation is carried out with the help of tax benefits (investment discounts, accelerated depreciation, deductions in whole or in part of current R&D expenses from taxable

income, income tax discounts, small business benefits), preferential credit, non-economic methods of stimulation. It should be noted that the motivation systems of high-tech research today practically do not meet the demands. This especially applies to small and medium-sized enterprises.

3.2. The Concept of the National Innovation System

In connection with the shortening of natural resources, the process of high-tech development takes the leading place in overcoming crisis phenomena and further economic growth, also the reformation of the social method of production is taking place. Despite the above, intensive development is only an element of the constructive evolutionary process, which also involves the refragmentation of the technological method and culture of consumption, modification of the entire palette of the set of social relations and the economic mechanism.

That is why the issue of international experience in the commercialization of high-tech products is of particular importance. The basis of the study of experience is the formation of invariant national innovation systems and the constant search and improvement of their integration and diffusion, the use of the features of one or other national innovation system in order to increase the efficiency of commercialization of high-tech products.

The unorthodox absorption of such experience depends on the totality of the diagnosis of technical and economic formats, immanent to the post-industrial process, which are unflexible in relation to the traditional academic method. Classical political economic indicators of volumes, efficiency and production factors are now unable to fully reflect the economic processes. Innovations have an unstable and unpredictable nature that is not subject to classical econometric formalization with basic cyclic patterns in abstraction. Depreciation of the means of production was a fairly long process for decades, today the picture has changed in the direction of a radical acceleration of its renewal. Radical innovations today have an ultra-short, virtually instantaneous value chain from R&D to its further commercialization. According to research, the usual period of absorption of innovations during 1885-1919 was 37 years, 1920-1944 – 24 years, 1945-1964 – 14 years, over time it began to reach from 3 to 5 years for the most modern advanced inventions [115].

CHAPTER III

The anticipated acceleration of innovative progress will continue in the future. The relevance of this trend can be seen in the modification of the relationship between science and production, which depends on the strengthening of the latter's dependence on science in contrast to the prevalence of empirical experience in the past.

The intensification of the production of inventions and the clustering of fundamentally new directions of research, which over time prove their own self-sufficiency are the root cause of the moral depreciation of the existing means of production and technological maps. Depreciation of fixed capital initiates a fall in profits and a crisis of competitiveness. This is what caused the shift in the vector of competition on the world market from the sphere of material production to the direction of science-intensive high technologies.

As a result, the task of forming effective mechanisms and models for the commercialization of high-tech products has been updated. Thus, with the rapid development of high technologies, the process of cognition can no longer remain on the evolutionary basis of development. The enormous speed of the emergence of fundamentally new information, its scope and modification determines, in order to maintain high competitiveness, the need to create a new format and principles of response to the results of scientific and experimental activities.

That is why in the "Report on Global Competitiveness 2019" special attention was paid to the development of the innovative potential of national economies as a prerequisite for the formation of competitive economic systems [211].

Today, the concept of the "knowledge economy" is inextricably linked with the constant cycle of innovative development, the ability to create new knowledge, technologies, processes, the ability to access information and the ability to effectively use it commercially. It should be noted that international cooperation in the process of commercialization of a high-tech product, cooperation in the field of research and development are becoming a powerful driving force for the development of the industry in the world economy, the main form of international industrial cooperation, the core of the transnationalization of production, the material base of the processes of international economic integration and globalization of the world economy.

A critical understanding of various aspects of the international experience of intensification of the commercialization of a high-

tech product was reflected in the works of A. Asaul, V. Voynarenko, V. Geets, V. Zakharchenko, R. Kuzmenko, S. Sokolenko, V. Tretyak, and others

The change in the place and role of international cooperation in the modern world economy is due to its objective advantages. Among them: a synergistic effect, a sharp reduction of investment (one-time) and current production costs of the implementation of cooperation projects by each of the participants, as well as terms of mastering production and updating products, joint or coordinated solution of a complex of interrelated problems of the entire innovation cycle of reproduction (production, technologies, management, marketing, sales and after-sales service of products, R&D, improvement and creation of products). Today, such international interaction has actually transformed into international scientific and industrial cooperation. This is evidenced by the analysis of many international cooperation projects and relevant agreements conducted by the United Nations Economic Commission for Europe.

On its basis, the following five main models of international scientific and industrial cooperation can be distinguished, which characterize the predominant specificity of the relations between the cooperators, the licensor and the licensee.

Model 1. Under the cooperation agreement, the licensor transfers technologies, licenses for the use of industrial and (or) intellectual property rights, certain types of technological equipment to the licensee. The received is paid by the licensee with the products produced by him, as well as, at the request of the former, with services and own licenses.

Model 2. Contains an additional obligation of the licensor to supply the licensee with a part of components of its own production.

Model 3. Unlike the first model, it involves the transfer of complete technological lines (and not individual types of equipment) together with the relevant technologies under the terms of financial leasing.

Model 4. Contracting cooperation, under which the contractor fulfills the licensor's order for the production of intermediate products. At the same time, the necessary technical documentation is transferred to the licensee, and in some cases, separate equipment and part of the components produced by the licensor.

Model 5. Joint production of an agreed range of products, accompanied by the exchange of some types of equipment and mutual supplies of finished and intermediate cooperated products. Joint R&D projects are often envisaged at the same time.

However, the mentioned variants of forms of cooperation are only part of a complex and diversified pool of possible tools for the commercialization of high-tech products. The intensification of the transnationalization of global economic processes, the invigoration of competitive requirements, and the progress of innovation have significantly strengthened the expansion of existing varieties of forms of cooperation between enterprises that are residents of different economic territories and agents of sovereign national innovation systems. The following can be considered relevant modern forms of cooperation today: consortium (alliances), technological clusters, technoparks, innovation funds.

The term "consortium" (or "alliance") arose at the end of the 20th century in the form of an outline of a number of agreements on long-term technical and economic cooperation between enterprises, educational institutions and scientific institutions. R. Wallace sees a set of the following components: reducing moral risks, postulating common missions, goals and tools; segmentation of the product group for the consumer, critical reflection, establishment of communication and partner contact, specification of restrictions on cooperation, clear delineation of project start-up boundaries, consolidation of good neighborly relations, guarantee of the right to independence, legal support, business exit plan [204].

Cooperation between partner entities of the formed consortium (alliance) may consist in the essence of the following forms:

- a complex consortium, where agents interact in all areas of business activity, from fundamental research of prospective development to the stage of its commercialization, inclusive;
- limited consortium, which is functionally simplified in terms of interaction: in this case, attention is focused on a limited number of areas of responsibility. The intensity and prospects of cooperation between partners are determined by the goals of each of them.

In the case of technological clusters, differentiation is possible according to the international or interstate nature of the clustering. The classification of variants of the form of cooperation depends on the definition of the

cluster itself:

1) cross-border cluster – association of economic agents with different centers of economic interest in relation to each other from the supply and demand side, territorially concentrated in neighboring regions;

2) transnational cluster – an international formation of clusters consisting of interacting agents effectively connected by joint technical projects, which also have fruitful cooperation with border economic entities (including the entire available complex of economic infrastructure), sovereign national and cross-border institutions, global financial and specialized economic non-profit organizations and mechanisms with the aim of intensifying the development of constituent units of the cluster and the cluster as a whole, as well as the national economy [77] (Figure 3.3).

Today, the theory of network cluster formation is based on M. Porter's cluster theory. According to his definition, a network cluster combines forms and features of international competition, specific features of countries, highlighted in the theory of comparative advantages and differentiated subjects of the cluster formation of different states. V. Chernykh claims that the network international cluster is not necessarily formed in the territories connected by the geographical principle, usually the basis of the idea of the defined cluster formation is laid: indicators of the effectiveness of the activities of its agents, the influence of the synergistic effect, the expediency of cooperation, the absence of significant limitations of institutional, economic, of a production and financial nature, the depth and profile of the partners' specialization and their ability to cooperate. A feature of the international network cluster is the free transfer of technologies, diffusion of knowledge and competences within the cluster [12].

Clusters encompassed a large number of diverse participants, unencumbered by geographic location, time zones, and other stationary constraints. Virtualization of cooperation makes it possible to create large-scale high-tech, radically innovative projects.

The creation of network clusters is preceded by a PEST analysis to identify the peculiarities of the development of the national economies of the cluster's partner countries, the opportunities and prospects for the development of the main, supporting and related industries, the level of competitive interaction and confrontation, the quality, diversification and mobility of the resource base are determined [12].

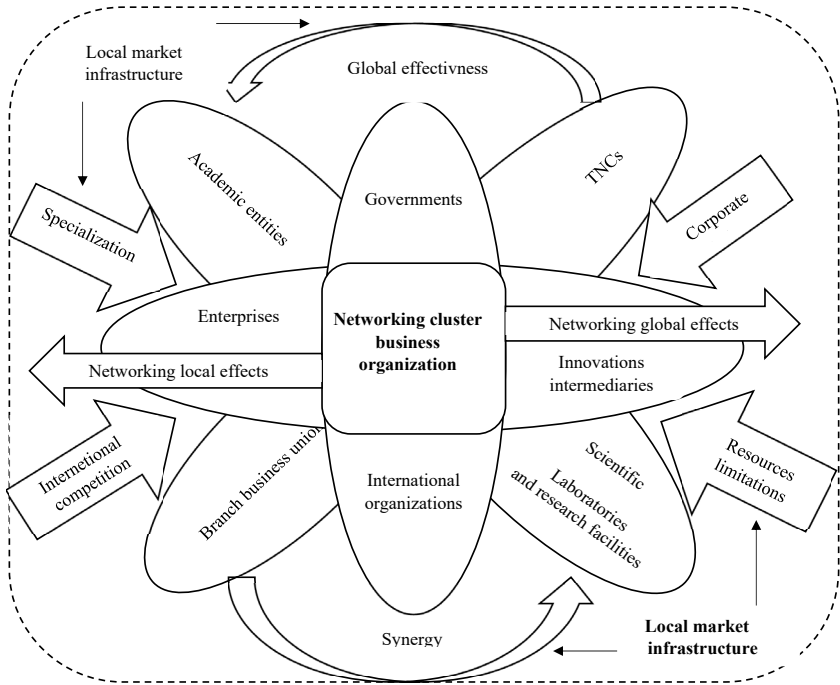


Figure 3.3. High-tech product production network cluster formation

Source: formed after [40]

The concept of “Technological Platforms” was developed by the European Commission in 2002 as one of the tools of the thematic development of the European Union. Today, technological platforms are a mechanism for coining scientific and technical priorities. A distinctive feature of technological platforms is their direct focus on the practical implementation of scientific achievements by medium and small businesses, the commercialization of developments and the accelerated release of a high-tech product to the consumer. To date, considerable experience has been accumulated in the operation of European technological platforms, which were created, on the one hand, due to the pooling of intellectual and financial resources of the European Union itself and the

largest European industrial producers, on the other hand, for the purpose of carrying out scientific research necessary for modern industrial production. Currently, more than 36 ETPs are operating, covering the most important European technological sectors, which generally reflect the efficiency and effectiveness of cooperation between science, business and the state.

Network technoparks rely on the expansion of opportunities that allow providing a wider range of services, achieving improved performance indicators and ensuring a presence in areas significant for the technopark or in promising territories for the purpose of more operational interaction with partners. Network technology parks are a type of regional or university technology parks.

When choosing one or another form of international cooperation in the creation of a high-tech product, the main modern globalization trends should be taken into account, namely:

- wide diffusion of high technologies in industry and the service sector, which is accompanied by changes in the production and management system;
- impact on the processes of globalization of powerful and adaptive information technologies, causing the formation of new innovative contours;
- active interaction between market entities;
- expanding opportunities for development and increasing the efficiency of the financial sector;
- impact of global financial and economic crises on international and interregional economic activity (to a lesser extent – in the high-tech sector);
- interdependence of the development of national economies and globalization processes;
- significant influence of globalization on the production and development of national innovation systems;
- use of new forms of automated systems, adaptive to consumer requests.

The mentioned global trends, on the one hand, determine the directions for improving the strategy of commercialization of high-tech products on international markets, and on the other hand, they are the basis for such improvement.

It would be appropriate to note that effective international cooperation in the creation of high-tech products is possible only on the basis of the formed progressive model of the national innovation system. In addition, if various models of innovation systems interacted in this process, it would have been necessary to build cooperation in the high-tech industry taking into account the peculiarities and specifics of each of the involved.

The growing relationship between financial markets and new technologies, the strengthening of the social orientation of new technologies, large-scale nature of the creation and use of knowledge, technologies, products, and services led to the emergence of national innovation systems as an institutional basis for the innovative development of countries. It is the national innovation systems that act as the fundamental basis for the formation of various models of international cooperation in the creation and commercialization of high-tech products.

The concept of the national innovation system was proposed by K. Freeman in the late 1980s to explain differences in the technological development of countries. The concept was later developed by B. Lundvall and R. Nelson. The research was based on the results previously obtained by J. Schumpeter (theory of economic dynamics), F. Hayek (the concept of dispersed knowledge), D. North (institutional theory), R. Solow (the role of NTP in economic growth), P. Romer and R. Lucas (new theory of growth).

The concept is based on the idea of innovation as the processes and results of many random interactions involving different people and organizations. Each of the authors offered their own definition of the national innovation system, focusing on individual elements and relationships. At the same time, they all followed general methodological principles:

- knowledge plays a special role in economic development;
- the main factor of economic dynamics is innovative competition between entrepreneurs;
- the institutional environment is system-forming in relation to the influence of the content and structure of innovative activity.

The following main characteristics of the national innovation system are noted in the domestic literature:

- 1) systemic nature, that is, consideration of the phenomenon as a set of interacting elements in a special way;

2) the institutional aspect, that is, the influence of formal and informal institutions existing in society on the pace and scale of innovation development;

3) dissemination of new knowledge and technologies as the main function of NIS.

In his writings, K. Freeman defines the economic system as a joint formation of economic subjects and institutions in the legal environment of the state, which participate in the creation, storage, dissemination and transformation of new knowledge into new technologies, products and services consumed by society [67].

According to the classic definition of B. Lundvall and R. Nelson, innovation is a complex process that unites various participants (enterprises, educational institutions, technological and analytical centers, innovation intermediaries), which form an innovation system. The overall results depend not only on each element of the national innovation system, but also on the interaction of the components of the collective system of creation and use of knowledge, supported by public institutions, values and norms. The theoretical definition of the national innovation system is a special type of the country's economic system, developed taking into account its institutional features, based on an innovative model of interaction of economic entities, the purpose of which is to increase the role of competition between entities based on the introduction of innovations as a key factor in economic dynamics, which directly affects both the structure and content of the state's economy. In international practice, there is the following more practical definition: the national innovation system is a set of institutions belonging to the private and public sectors, which individually and in the process of cooperation with each other determine the development and spread of new technologies within the borders of a specific state. Elements of the national innovation system include:

- innovation-oriented enterprises;
- state and private institutes;
- system of higher education;
- macroeconomic environment and structure of the economy.

In recent years, the concept of elements and subsystems of the national innovation system has significantly expanded – it began to include not only higher education, but also the entire educational system, services,

CHAPTER III

culture, and even cognitive elements. Summarizing the results of domestic and international research, economists present the structure of the national innovation system as a system of ten blocks:

- 1) strategy and priorities of innovation policy;
- 2) regulatory framework in the field of development and stimulation of innovative activity;
- 3) innovative infrastructure;
- 4) system of generation and dissemination of knowledge;
- 5) innovative business, including TNCs of a scientific and technical profile;
- 6) institutions in the field of education and professional training, which train personnel in the organization and management of the innovative sphere;
- 7) market conditions conducive to the introduction of innovations;
- 8) marketing and financial components of the system of creation and commercialization of innovations;
- 9) a system of cooperation within the international innovation environment;
- 10) mechanism of innovative development, which reflects the system of relationships between defined elements [216].

The main measurements of the national innovation system are the number, volumes and degree of centralization of business agents, the structure of financial, human and physical resources, the innovative effect in form of patents, products, technologies and publications. The main structural feature of the national innovation system is the ratio of state and private business funding in R&D.

So, on the basis of the conducted research, we can offer our own definition and content of the category of the national innovation system, namely:

- it refers to a set of institutions, that is, conditions and rules under which organizations operate, the purpose of which is the production and distribution of new technologies, innovations and methods of business organization, commercialization within the boundaries of a specific state in the form of an object of intellectual property;
- the national innovation system as an open system is manifested in the interaction of organizations of various forms of ownership, engaged in

the production of scientific knowledge, objects of intellectual property and their preparation for further commercialization within national borders and on the world market;

– the result of the activity of the national innovation system as an open system, which involves the entry of new organizations and sanation of previously active ones, is the market of intellectual property objects;

– the subjects of the national innovation system include structural divisions of large companies engaged in the creation of scientific knowledge and objects of intellectual property, in addition, laboratories and departments of universities, academic divisions, technology parks, innovative small enterprises engaged in the commercialization of objects of intellectual property property, and a complex of legal, financial and social institutions that ensure innovative processes;

– the economic results of the national innovation system are a component of the national wealth that produces and accumulates scientific knowledge as public goods, which, in turn, take the form of intangible assets and constitute part of the national wealth, which is reflected in the balance sheet of various structures, in the GDP, in the value structure of national wealth.

Our own vision of the category of the national innovation system consists in defining it as a set of institutions, rules, and conditions that ensure the emergence within the national economy of such intangible assets (part of the national heritage), which are called innovations in the form of intellectual property objects, ready for commercialization.

3.3. Evaluation of International Experience in Innovative Infrastructure Formation

Taking into account the abovementioned characteristics of the national innovation system, we will consider the peculiarities of international cooperation models in the implementation of commercialization by market leaders of high-tech products. The most diversified national innovation system operates in the USA. It includes at least ten thousand scientific organizations and organizations that produce scientific products or new technologies. They include scientific centers and laboratories of large corporations, state research institutions, research centers of universities, and thousands of small science-intensive companies.

CHAPTER III

The USA is home to the world's most famous innovation cluster – Silicon Valley. 48 of the 100 companies included in the Forbes ranking of innovative companies in 2017 are of American origin [69]. This rating was compiled on the basis of the size of the innovation premium, which is calculated as the difference between the company's market capitalization and the net present value of its cash flows from the existing business.

Structurally, the American model of commercialization of a high-tech product today sufficiently fills the gap in the financing of innovative projects through state, local and international financing (Figure 3.4).

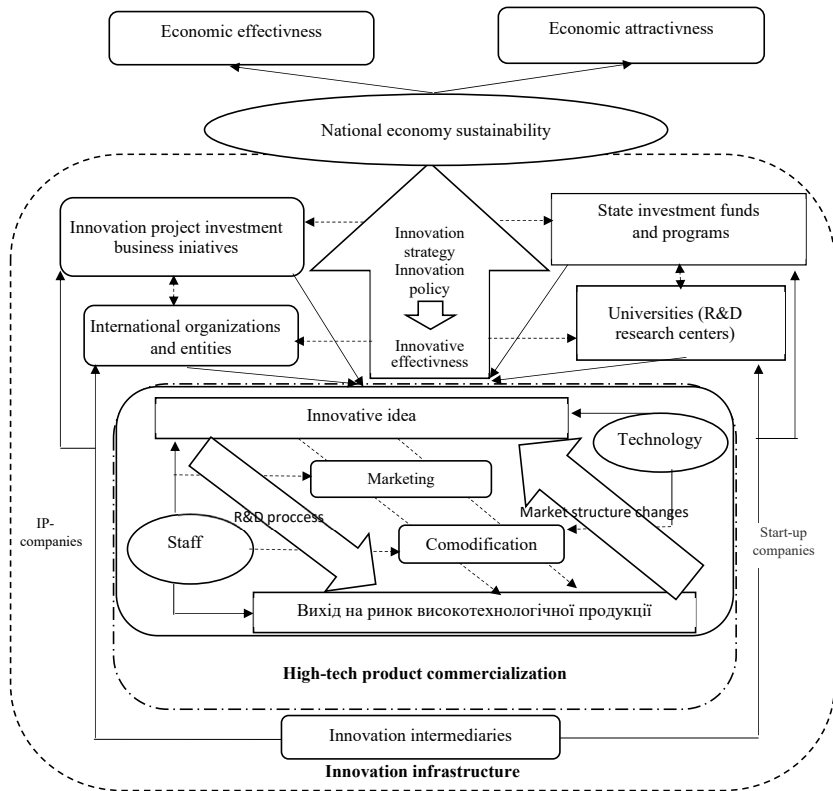


Figure 3.4. American high-tech commercialization model

Source: author's investigation

The most important element of the American national innovation system throughout its evolution has been private companies and their research laboratories. But at the same time, the role of the state and public-private partnership, without which the success of US private companies and their research laboratories would be impossible, should not be underestimated. It is also necessary to take into account that historically in the USA research universities are a particularly important source of scientific knowledge and innovative ideas.

The growth of high-tech products and technology transfer in the amount of exports (up to 20%) contributes to the creation of innovation-investment partnerships, cluster formations, development, research and commercialization departments at enterprises and educational institutions. The goal of the American model is to fill the vacuum between the object and the subject of the innovation process by forming a state platform for financing the creation and commercialization of innovations, ensuring the commercial success of educational institutions due to the increase in the number of received protective documents: licensing of intellectual property objects, patenting of inventions and utility models, implementation market research, etc. [198].

A special place in the US high-tech product commercialization model is occupied by start-up companies that implement the most innovative ideas for creating new products and services, and innovative intermediaries that make up the largest and most active part of the US innovative market infrastructure. The innovation market is characterized by the use of non-financial institutions, which become temporary but important agents for the innovation process through the provision of consulting, engineering, auditing and other services. An important advantage of the system of financing the process of commercializing a high-tech product is the high level of diversification of the activities of commercial banks, which leads to wide opportunities for obtaining funds for financing innovative activities.

The economic evaluation of the American model of commercialization of a high-tech product, like models of other countries, will be determined by the ratio of costs and results of innovative activities, especially R&D, the share of high-tech product in exports, etc.

In 2015, the total expenditures of the United States of America on R&D amounted up to 499.3 billion dollars, of which funding from the federal

budget amounted to 113.1 billion US dollars (less than 23% of the total). In 2020, the growing trend was replaced by a decline, total expenditures amounted to 476.5 billion dollars. USA, and this is for 90 billion dollars. less than in 2019 (Figure 3.5).

It is important to emphasize that the high role of the state in the US economy is not expressed in the desire to replace business in the economic process, there is no question on this – but in the fact that the state is a reliable partner of business in the organization of economic processes, in encouraging progressive changes, in regulation of rules and norms of operations, etc.

In essence, the USA has developed a system of interaction between business, which is the driving force of development, and the state, which acts as a regulator and gives development an organized character. The role of the state in the national innovation system of the USA is not in planning, but in maintaining an environment favorable for the development of innovations, in stimulating supply and demand, development of important infrastructure, etc.

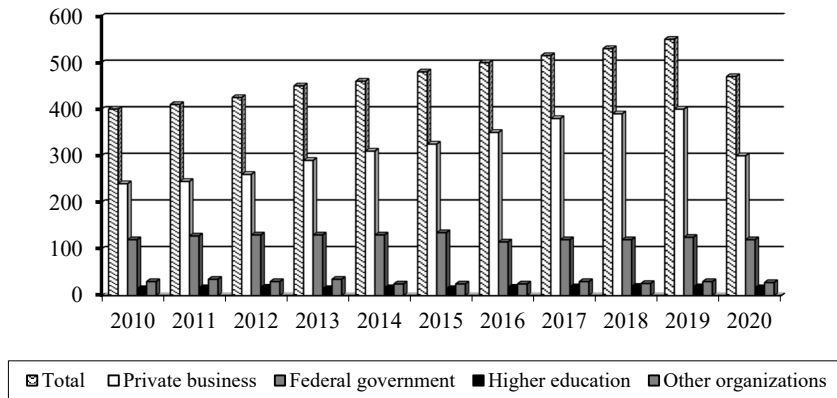


Figure 3.5. Dynamics and structure of total expenditures on R&D in the USA in 2012-2022, billion USD

Source: formed after [197]

In the USA, federal support for research and development covers a wide range of tasks: national defense, health care, space, energy, natural

resources and the environment, science in general, etc. Financing of R&D aimed at the goals of national defense is a priority (Figure 3.6).

The “triple spiral” model is a network mechanism for coordination of actions and formation of public consensus in decision-making, based on the principle of collaboration (coordination). In the administrative-planned economy, there were no real partnership interactions between the players at all – business and science remained under the full control of the state. In the industrial market system, they enter into paired interactions with feedback, forming double spirals (state and business, science and business, state and science). In the post-industrial network economy, the paired format of relations is no longer sufficient for making optimal management decisions, the interaction of all three actors in the network mode is needed, that is, the formation of a full-fledged “triple spiral” by them.

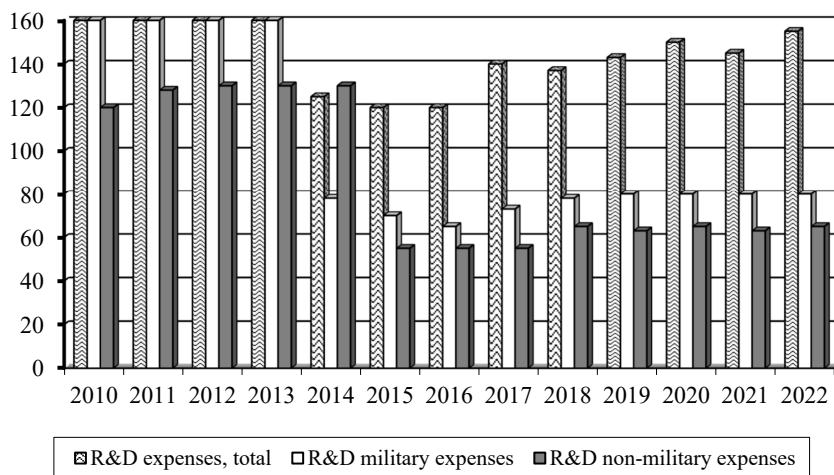


Figure 3.6. The main directions of spending of the US federal budget on development and research, billion US dollars, in comparable prices of 2005

Source: formed after [197]

The “triple helix” model is radically different from the public-private partnership model of the industrial era, not only in the nature of the

interactions of the three players, but also in their functional role in the economic process.

First, in the modern economy, science (instead of the former leadership of the state) becomes the key player determining the direction of development – as the main generator of constantly updated knowledge.

Secondly, the three links do not simply cooperate interactively, interweaving connections, but take over the inherent functions of each other, becoming hybrid network organizations that provide an integral synergistic effect of continuous updates – both for each player individually and for the entire economy as a whole, creating a special model that shapes modern international product commercialization interactions.

The national innovation systems of large Western European countries work somewhat differently. The model of national innovation systems of the countries of the European Union is called the Euro-Atlantic model. The Euro-Atlantic model is a model of a complete innovation cycle – from the emergence of an innovative idea to the mass production of a finished product. This model is used by countries leading in the rankings of global competitiveness of national economies.

Budget financing is an important element of state regulation of innovative activity in the countries of the European Union. In the European Union, the dominant approach is often called the “policy of the triangle” – the stimulation of innovations, which, in turn, contribute to the dynamic development of the economy by increasing competitiveness on international markets. Sweden, Austria and Denmark are the leaders of state investments in R&D in terms of their ratio to GDP [Eurostat.]

The prerequisites for the formation of the “triangle model” are the peculiarities of the development of countries – innovative leaders in Europe.

Germany, France and the United Kingdom are leading the European continent in terms of the volume of gross domestic expenditures on research and development (Figure 2.19). In 2010-2020, gross domestic spending on research and development in Germany increased by 29.5% and amounted to more than 118.2 billion US dollars in 2020. In France, this growth amounted to almost 16.7%. In Great Britain, gross domestic spending on research and development during this period increased by 19.3% and amounted to almost 52.5 billion USD in 2020. It should be noted that in the European Union as in the USA, the main source of allocations for R&D are private enterprises,

both in the European Union as a whole and in the leading countries, the share of private business in R&D expenditures reaches almost 2/3 of all expenditures. In many European countries, the trend of increasing the role of universities in the allocation of research and development is clearly visible (Appendix C).

Germany's innovative strengths as a leader in the European Union still lie in those industries that gained popularity in the 19th century. For example, Germany still has strong developments in the automotive, mechanical, electrical and chemical industries. The German government took this aspect into account when developing a practically new innovation policy. This policy includes four strategic areas:

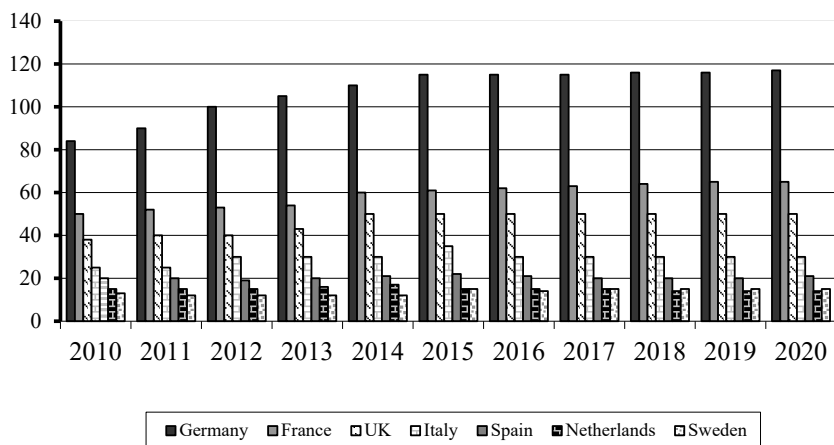


Figure 3.7. Gross domestic expenditure on research and development (GERD) at current prices and purchasing power parity of 10 leading European countries for 2012-2022

Source: formed after [143]

– increasing state funding of innovative developments with an emphasis on key areas of science and technology (health care, IT, nanotechnology, environmentally friendly technologies);

CHAPTER III

- improvement of conditions for the introduction of innovations in the private sector, stimulation of the use and improvement of the mechanism of transfer of state-owned technologies;

- conducting institutional reform of scientific organizations;

- implementation of administrative reform in order to improve the coordination of innovative developments by state bodies.

Back in 2006, the German government approved the “Strategy of high technologies” – a comprehensive program of innovative development. The federal government adopted a unified strategy for all federal agencies with the aim of making the country a world leader in the most important global markets of innovative products and services by 2025. At the state level, an ambitious goal was formulated and presented to society: in the long term, to consolidate Germany’s position among the leading countries in the field of high-tech products, which, according to the German establishment, in modern realities is a determining prerequisite for sustainable long-term growth and, therefore, successful implementation of urgent social programs.

One of the main goals of the strategy is to create conditions for the maximum freedom of scientific development and the elimination of bureaucratic obstacles in the implementation of innovative developments, the transition to a free and competitive society of knowledge. In this context, it provided:

- the development of domestic markets of advanced, knowledge-intensive technologies that stimulate the development and implementation of innovative products and services (17 areas of innovative development are defined in the strategy);

- strengthening of ties between science and industry on the basis of state support for innovative developments carried out jointly with the private science-intensive sector;

- accelerating the process of commercialization of state-owned technologies, revealing the nation’s talents, especially within small and medium-sized innovative businesses, which create the largest number of jobs.

In accordance with the goals of the strategy, interdisciplinary and interdepartmental coordination will be strengthened in the country, the positive aspects of global competition in the field of innovation will be taken into account, and a “global talent incubator” will be built.

The organizational structure of the national innovation system of Germany is a rather complex and extensive system, which includes state management bodies, a system of scientific and educational organizations, as well as knowledge-intensive business, primarily small and medium-sized firms. The structure of the national innovation system of the country is formed from the following structural elements – subsystems:

- implementation of innovative development in the public and private sectors of the economy;
- professional education and retraining;
- innovative activities in industrial production and in the service sector;
- formation of new high-tech industries;
- application of information and communication technologies.

About 460,000 people are employed in the field of innovative development, of which 50% are scientists and engineers, the other half is roughly equally divided into technical and support staff, including management. The entire volume of innovative development is carried out in higher educational institutions, the private (industrial) sector and federal research institutions [1].

The scientific, educational and innovative policy of Germany is developed by the Federal Ministry of Education and Scientific Research, whose functions contribute to the following areas:

- strategy and general issues;
- European and international cooperation in education and science;
- professional education and continuous training;
- scientific systems;
- key technologies and innovative research;
- biological sciences and research in the field of health care;
- provision of future generations (research in the field of culture, fundamental problems and sustainable development).

According to the national policy on the future development of science, technology and innovation, the German government has defined a general goal – the formation of a “new culture of innovation”, which should cover all spheres of social life, and the development of the innovative economy should become a criterion for the effectiveness of state policy. At the government level, it is recognized that only innovative technologies and services ensure global competitiveness. In this regard, the government’s priority areas of development and implementation are:

- high-tech strategy;
- European R&D program;
- the strategy of development and application of future technologies (biotechnology, nanotechnology, IT sphere, etc.).

In an effort to strengthen the position of Germany at the expense of world-class science, both the investments themselves and the efficiency of their use by universities and research institutions are increasing by means of improving the quality of research and training, as well as cooperation with the business sector [166] (Figure 3.8).

The following systemic advantages of the organization of innovative developments in Germany can be outlined: a significant role of the federal states in the organization and financing of innovative development, which reduces the burden on the federal budget and increases the total amount of funding; a relatively high level of independent innovative developments in the entrepreneurial sector combined with effective science funded by the state; the presence of a large number of scientific societies, associations and foundations that finance and organize fundamental scientific research; a high concentration of innovative subjects (especially the fundamental direction of research) in universities that combine education and scientific research into a single system; high educational level of the working population; combination of own competence in the field of technological development with imported technologies; the openness of Germany's national innovation system in connection with the growing internationalization of innovative development programs, which makes the country attractive for foreign enterprises and scientific organizations.

However, the national innovation system of Germany has certain shortcomings. For example, there is a lack of researchers with a natural education. There is a strong bias towards scientific publications on economics, which to some extent leads to a decrease in the competitiveness of German science as a whole. There is a significant shortage of venture capital to stimulate innovative activities of private sector industrial firms.

The East Asian model of the national innovation system differs from other models primarily in its structure, where universities as a center of fundamental development play a much less significant role than corporate research laboratories. This also determines the characteristic features of Asian countries in the process of international cooperation on commercialization.

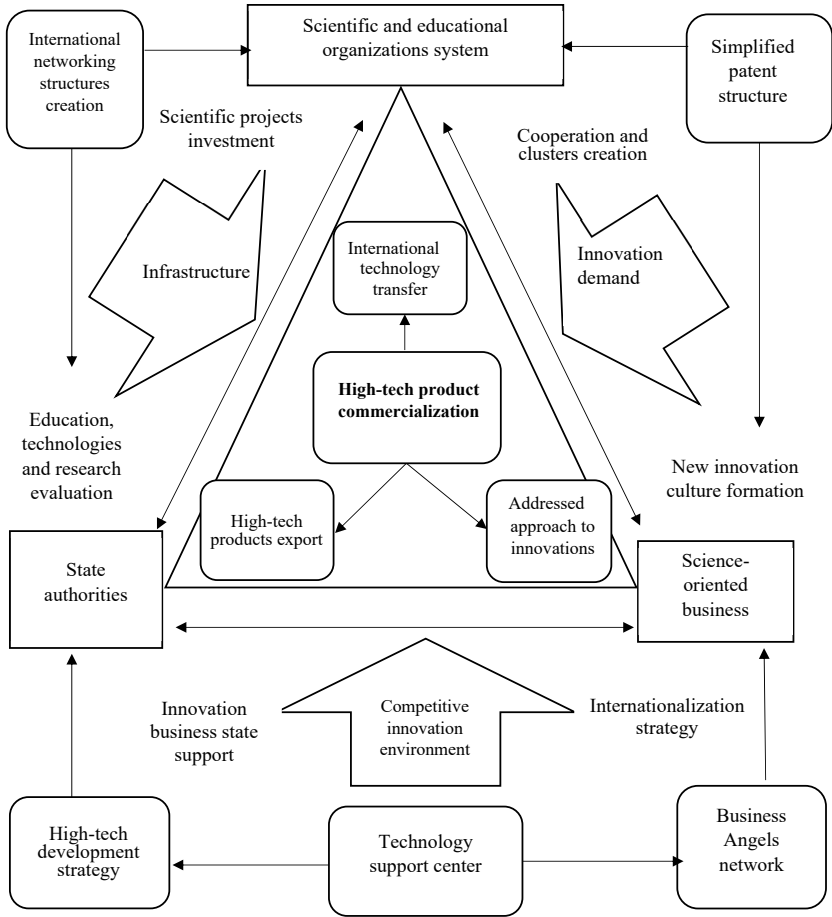


Figure 3.8. The place and task of high-tech product commercialization in the structure of the National Innovation System of Germany

Source: author's investigation

A typical example of this kind of national innovation system is Japan, where the system is focused on technical innovations and high technologies rather than fundamental developments. That is why, when considering

the study of the model of commercialization of high-tech products in the first chapter, special attention was paid to the Japanese model of commercialization of innovations.

One of the key specifics of the Japanese approach to innovation is that, in contrast to the Western philosophy of competition, the production of innovations in the Japanese sense is primarily determined by a group style of interaction.

In the national innovation system of Japan, a special role belongs to the state management mechanism. This mechanism determined the general rules of interaction of various subjects of innovative activity. In particular, the foundations of cooperation between business and science were formed, which were embodied in the so-called “san-kan-gaku” system – tripartite cooperation of industry (san), government (kan) and the academy of sciences (gaku). In fact, this system is an intersectoral cooperation in which the state is responsible for initiating and implementing the corresponding idea in practice, as well as for determining the rights of participants to use the results obtained during joint work. The latter is the most important, because it is determined by the need to motivate participants and create mechanisms to control their activities.

In the 1960s and 1990s, Japan’s national innovation system was focused primarily on imitating and improving products and processes developed abroad. During this period, inter-corporate innovation ties were formed, which contributed to the growth of intellectual potential and formed high professionalism of personnel in innovative firms. The national innovation system of Japan during this period was built on the closedness and self-sufficiency of business, a rigid system of lifelong hiring and promotion, as well as on the training of personnel within the company. Self-sufficiency was also supported by a closed financing system, which includes a separate bank for each large company.

In key sectors of economy, Japan achieved global competitiveness of its innovative products by 2001, taking second place after the United States in the export of high-tech products. However, today Japan has lost its world leadership in the production of laptops, semiconductors, telecommunications equipment and biotechnological products. The decrease in the level of competitiveness of Japan in the market of innovative goods continued with a high level of costs investment for innovative development (more than 3%

of GDP). However, low returns on investments led to a serious reassessment of the principles of innovative activity in the country.

The Japanese government, taking into account international and own experience, developed a block of documents regulating the innovative activities of the country – “Innovations 25” – a comprehensive strategy for the development of the innovative economy until 2025, with the help of three councils that are part of the government of Japan. It should be especially noted that the main emphasis in it is on interdisciplinary and interdepartmental coordination of the most important innovative projects. The interdisciplinarity of solving social problems has direct and inverse relations with the possibilities and goals of innovation and investment activity, reform of higher education. For example, the road map of technological innovations includes innovative projects that have the greatest social effect (for example, the creation of innovation incubators).

Japan strives to increase the economic efficiency of the process of diffusion of technologies and their commercialization, the dissemination of scientific and technical information within the entrepreneurial sector, and an increase in the level of use of already created intellectual property. The innovative strategy of this country unites three main goals:

- achieving a new level of well-being of the Japanese nation in the future;
- formation of “Greater Asia” and activation of innovative cooperation with the rest of the world;
- the formation of a highly creative nation that is willing to take risks of innovative development.

The formation of “Greater Asia” is one of the most important components of the strategy. Solving this task is related to the structural reform of Japanese business and increasing its global competitiveness, ensuring Japan’s innovative leadership, and defining its technological niche in the system of international entrepreneurship.

The “Innovations 25” strategy foresees various scenarios of innovative development, based on the report of the Scientific Council on the development and society of the country, as well as on technological reviews of the National Institute of Science and Technology Policy. Within the framework of the strategy, more than 60 innovative technologies are presented, which are planned to be developed by 2025 in the following areas:

- 1) medicine and health care;
- 2) ecology, water resources and energy;
- 3) advanced technologies and industrial development;
- 4) safety and comfortable life of the population.

Japan ranks third among G7 countries in terms of gross domestic spending on innovation, behind only the US and China, and well ahead of Germany, with the bulk of this spending in the industrial sector.

However, OECD experts believe that Japan has entered the XXI century with worse results than other G7 countries. According to the estimates of the country's Science Council, the effectiveness of national expenditure on innovative development in priority areas was half as low as in the USA and EU countries (Figure 3.9).

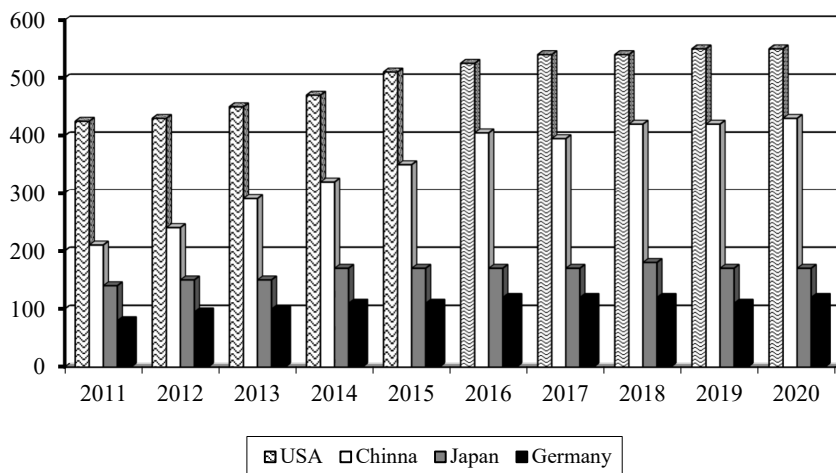
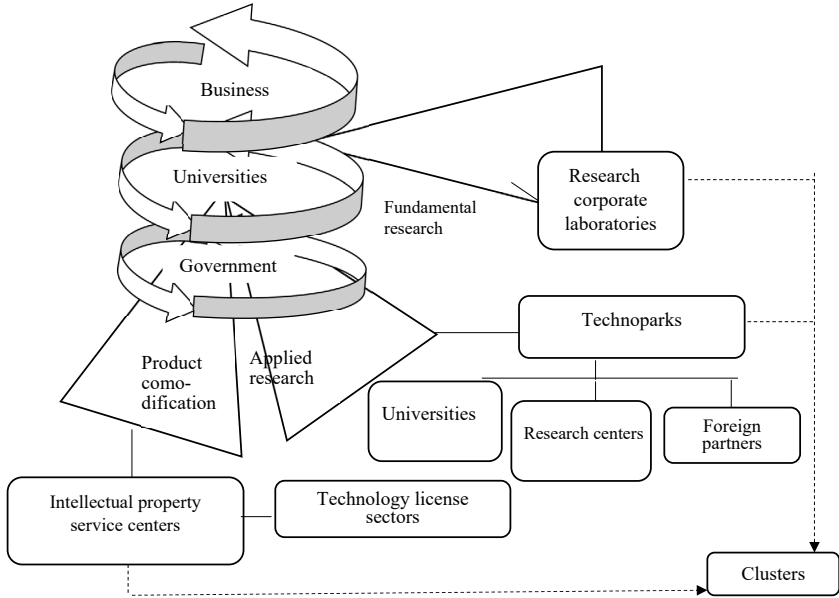


Figure 3.9. Dynamics of gross domestic expenditures on research and development in 2013-2022, billion US dollars

Source: formed after [81]

One of the most important directions of Japan's modern innovation policy is its increasing openness to direct foreign investment, which contributes, firstly, to the introduction of innovations into the domestic economy, secondly, to the creation of new production capacities, and thirdly, to the acquisition of new management technologies, patents and know-how.

When studying the specifics of innovative development in Japan, the Japanese model of science parks deserves special attention (Figure 3.10).



**Figure 3.10. “Triple spiral”
high-tech product Commercialization model**

Source: author’s investigation

For the first time, this concept of creating Japanese science parks was presented in 1980 in the “Policy Perspectives of the Ministry of Foreign Trade and Industry for the 80s”. According to the requirements developed in the document, science parks must be created in areas where science-intensive industries are poorly developed. All research institutes and enterprises of the leading countries of the NTP should be no more than half an hour away from their “parent cities” (with a population not less than 200,000 people) and no further than 1 day from Nagoya, Tokyo or Osaka. The choice of places for the construction of technology parks is influenced by the state of the transport network. First of all, the presence of an airport is taken into account, since air transport is a priority for science-intensive

industries, both for the transportation of oversized, even miniature products, and from the point of view of the delivery of materials.

Location in the area of a university capable of taking on the role of R&D coordinator, training of qualified researchers and specialists is also considered a prerequisite for the creation of a technology park. With the strength of the Japanese economy, the country's national innovation system lags behind the leading positions to a large extent. Only the solution of such problems as the creation and development of a fundamental scientific research base, the encouragement of independent R&D and the development of venture business will allow Japan to strengthen its position as a world leader in the future and improve its own position in international cooperation on the commercialization of products.

A separate place in the analysis of national innovation systems belongs to China. Although the formation of national innovation systems in this country somewhat resembles the implementation of the East Asian model, which was summarized on the example of Japan, there are a number of significant differences.

China is becoming an increasingly important player in the field of innovation. If in 1985, according to UN data, the country was not among the first 25 in the world in terms of exporting high-tech goods, then in 1998 China rose to 11th place. Since 2004, exports of such goods began to exceed imports [211].

Researchers are amazed by the speed of development of the Chinese innovation complex, which turned out to be almost three times higher than what analysts expected.

China's conceptual roadmap for creating a national innovation system was developed in 2006 by government decree. In 2012, the program was revised in order to analyze the task of forming a national innovation system and achieving a leading result in 2025. In 2013, the Secretary of State declared the implementation of this program to be of vital importance to the nation. Until recently, international capital began to completely dominate the production and import of innovative products. This course created a significant number of new jobs and opened up global markets for Chinese exports, turning the country into the largest holder of gold and foreign exchange reserves. Nevertheless, China did not reduce its technological lag, turning into an accessible market for the West –

maximizing profits at the expense of cheap labor and privileged business conditions.

In 2015, China launched the pioneering program “Mass Entrepreneurship and Innovation”, which fully corresponds to the country’s goals – reorientation from labor-intensive production to an intensive knowledge-intensive model of economic growth driven by innovations and their effective commercialization. The country also has a huge domestic consumer base.

The progress of China’s national innovation system is evident in the following directions:

- 1) the triangle of the strategy for the formation of the national innovation system, formalized as “state policy” – “invisible hand of the market” – “autonomous innovations in business”;
- 2) differentiation of elements of the national innovation system;
- 3) optimization of the elements of the national innovation system through the liberalization of the educational space and the autonomy of scientific institutions and institutions;
- 4) significant capitalization and increase in technological orders for the purpose of training and retraining of scientists, increasing the quality of scientific periodicals.

The country’s capabilities in the high-tech field, despite considerable efforts, remain insufficient. Business has a serious shortage of advanced specialized factors of production capable of a full cycle of R&D and commercialization. The low level of investment in human capital and the weak level of training of management personnel are becoming increasingly noticeable. The country still remains import-dependent in terms of technology. Summarizing, we identify the state of the basic parameters of China’s NIS:

- openness to capital investments – ineffective return on investment;
- rigid management system – low motivation – inconsistent pattern of development;
- managed centralized administrative system;
- shortage of developed factors of production.

However, the intensive innovation policy stimulated the growth of high-tech business fourfold over the last decade. The intra-corporate policy of imitations for real production of radical innovations has also changed, the

CHAPTER III

expansion of national business in the system of international entrepreneurship continues. Local business leaders Baidu, Alibaba and Tencent own the world's most influential online businesses. It is worth noting that China is principally and confidently implementing its own vision of the formation of a national innovation system.