

# The role of commercialization of high technologies in scientific and production cooperation

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**Abstract.** The article reveals the role and importance of types of high-tech products, taking into account international practice, domestic official statistics and classification of goods of foreign economic activity. It is established that in some cases innovative and high-tech products are identified. It is revealed that currently the most high-tech is the production of basic pharmaceutical products and pharmaceuticals, biotechnology, the production of computers, electronic and optical products; production of various air and space aircraft. The key regional leaders in the production of high-tech products in the world by region are considered. Based on the results of the consideration of the content of the concepts "innovation" and "technology", "commercialization of innovations" and "commercialization of high-tech products", the author's vision of interpretations is proposed, with the justification that innovativeness actually acts as an additional feature of high-tech products. A study of the types of commercialization of high-tech products was conducted, according to the results of which the author's classification was proposed according to the content, level of efficiency, number of subjects of commercialization, geographical coverage of subjects of commercialization and methods of financing.

## 1 Introduction

The reform of the domestic economy, as well as the strengthening of integration processes of the level of competitiveness of industrial enterprises is determined by many factors, the key of which is innovation activity. It is thanks to innovations that a business entity is given the opportunity to strengthen its market position, improve economic efficiency indicators, and create high added value.

At the same time, ensuring commercialization directly depends on the results of innovative activities of industrial enterprises and entrepreneurs, whose high-tech products maximally fit into the goods and services in demand on the market with the provision of sustainable competitive advantages.

In most scientific papers of a conceptual and methodological nature, the commercialization of high-tech products is presented as a component of the national

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innovation system and at the same time as the final stage of interaction between educational, research and industrial enterprises within technology parks, innovation clusters or other innovative structures.

In turn, in the works of an applied nature, the problems of commercialization are debatable and are more studied from the perspective of marketing with a set of tactical tools for promoting products to consumers, representing a rather limited functionality.

For example, N.M. Fonstein, A.M. Balaban, A.S. Minkov, A.A. Bovin, L.E. Cherednikov, S.G. Polyakov, S.V. Valdaytsev, D.Y. Mironov made a significant contribution to the development of theoretical and applied provisions in the field of commercialization of the results of innovative activities of business entities, including high-tech products, I.V. Baranov, E.E. Pomazkova, O.N. Rumyantseva, etc.

However, despite the presence of a large number of conclusions and developments in this area, a number of urgent tasks remain open and require further research.

Consequently, the indicated directions determine the importance and relevance of the development of theoretical and methodological and methodological-applied fundamentals of commercialization of high-tech products of industrial enterprises.

The purpose of the article is to reveal the essence of the concept of commercialization of high-tech products of industrial enterprises, taking into account the development of classification of its types, achievements of theory and practice, as well as the provisions of the regulatory framework.

## **2 Materials and methods**

The methodological basis is the synthesis of the results of fundamental and applied research of domestic and foreign scientists in the field of commercialization of high technologies in scientific and industrial cooperation. In the process of preparing the article, the methods of theoretical and empirical research were used.

## **3 Results**

The economic history of the development of international, national and regional economies is filled with numerical facts of the dependence of its development on the introduction of innovations. In particular, the founder of the innovation movement J. Schumpeter, in contrast to modern theorists in this field, noted that "... innovations (products, technologies developed for the first time) are extremely rare, their appearance, as a rule, leads to changes accompanied by parallel economic relations and modes of production" [9].

In a competitive environment, when business entities and institutions are continuously working to improve products, services, technologies and solutions, the emergence of a radically new idea, which has no analogues, really provides its bearer with significant advantages. For example, the first developments that appeared as a result of the discovery of quanta, a laser, the creation of the first transistors, etc.

In most scientific papers devoted to the problems of the development of the domestic economy, structural reforms, ensuring the competitiveness of domestic goods, attention is focused on the importance of introducing innovations and organizing the production of high-tech products. The situation has developed in such a way that in some cases innovative and high-tech products are identified [3].

To a certain extent, such identification is justified, however, the Decree of the Government of the Russian Federation No. 773 dated June 15, 2019 "On the criteria for classifying goods, works, services as innovative products and (or) high-tech products"

allows us to assert that not all high-tech products are innovative, as well as not all innovative products refers to high-tech.

First of all, it should be noted that in the domestic legislation the concept of "high-tech products" is not clear enough. For example, in accordance with the legislation of the Russian Federation, high-tech products are "... products manufactured by domestic enterprises using high-tech technologies and compete with the best samples of similar foreign-made products." "High technologies", in turn, are defined as technologies "... developed on the basis of the latest scientific knowledge, which in their technical level exceed the best domestic and foreign analogues and are able to provide advanced positions in the world market of high-tech products" [8].

Guided by these definitions, almost any entity of the enterprise that introduces technological innovations and is engaged in the production of innovative products can position itself as a manufacturer of high-tech products. According to the Federal Statistics Service of the Russian Federation, more than three hundred enterprises in Russia produce high-tech products, including enterprises of the metallurgical, chemical, food and agricultural industries.

## 4 Discussion

In world practice, there are much clearer criteria for classifying products as high-tech. For example, in 1960, the member countries of the Organization for Economic Cooperation and Development (OECD) formed a list of high-tech products according to the codes of the International Standard Trade Classifier (Statistical Classifier of Foreign Trade Goods), the list of which was updated in 1988. Currently, it includes 4346 items of goods. Based on the recommendations of the OECD, Russia in the framework of the decision of the Council of the Eurasian Economic Commission of 14.09.2021 She also created a Single Commodity Nomenclature of the Foreign Economic Activity of the Single Economic Union (EEC), which contains a number of names.

Guided by this classifier, as well as global trends and traditions with the identification of high-tech products in the overall structure of industrial products, it is possible to determine how many enterprises in Russia actually manufacture high-tech products, as well as their import and export, including how innovative these products are.

Until recently, the leading countries in the production of high-tech products (China, Japan, USA, South Korea, Germany, Finland, etc.) included five sectors in this group:

- pharmaceutical production;
- production of office equipment and electronic computers;
- production of equipment for radio, television and communications;
- production of medical equipment, measuring instruments, optical devices and equipment, watches;
- aircraft production, including the space industry.

However, in recent years, only three sectors have been considered high-tech:

- production of basic pharmaceutical products and pharmaceutical preparations;
- production of computers, electronic and optical products;
- production of various air and space aircraft.

It is advisable to recognize that at the global level, the limitation of the number of high-tech sectors occurred due to the recognition by the majority of countries producing high-tech products in these sectors of production, with the exception of the USA and China, where the list of high-tech production sectors is much wider.

Table 2 shows a list of regional leaders in the production of high-tech products on the international market, including the countries of North and Latin America, Central and South Asia, Southeast and East Asia, Oceania and Europe

**Table 1.** Regional leaders in the production of high-tech products in the world in 2022

Region	Rating in regions	Countries	Countries' place in the Global Innovation Index ranking
North America	1	USA	2
	2	Canada	13
Latin America and the Caribbean	1	Chile	48
	2	Brazil	52
	3	Mexico	55
North Africa and West Asian countries	1	Israel	16
	2	UAE	30
	3	Turkey	35
Countries of Africa (sub-Saharan Africa)	1	South AFRICA	59
	2	Botswana	85
	3	Kenya	89
Central and South Asia	1	India	38
	2	Iran	50
	3	Uzbekistan	81
Southeast Asia, East Asia and Oceania	1	Uzbekistan	6
	2	Singapore	5
	3	China	9
Europe	1	Switzerland	1
	2	Sweden	3
	3	Great Britain	4

*Source: compiled by the authors*

In the analyzed context, it is advisable to pay attention to the fact that, for example, in China, a rapidly progressing country, there are no more than 5 high-tech companies. Despite this, according to official statistics, there are 90 innovative companies with a worldwide reputation in China that have their own trademark, their own brand. That is, in China, they do not identify all innovative products with high-tech. They do not do this in Finland, the USA, Germany and other countries.

In Russia, according to the legislation, there is no clear boundary between innovative and high-tech products. In federal and regional programs, innovative development and high-tech production are so intertwined that it follows from them that any innovation in industry is aimed at technological changes and its result is the production of high-tech products [2].

Empirical evidence shows that this is far from the case. According to various estimates, there are more than 2,000 such organizations in Russia. Of these, there are 646 applicants for entry into the system—forming ones (important for the country's economy, like Apple or Google for the USA), 21 of them have already been accepted into the list.

As for the export of their own high-tech products, half of the manufacturers did not exceed 30%. Domestic enterprises exported about 96 types of high-tech products, far from covering those nomenclature items that are fixed by the Foreign Economic Activity of the EEC.

Regarding the statistical data that characterize innovation activity in Russia, it is necessary to distinguish their more optimistic nature from the indicators reflecting high-tech production, however, they are characterized by negative dynamics of changes in comparison with previous years, as well as the dynamics of indicators of other countries.

First of all, it should be noted that in the European, and recently in the domestic statistical tradition, it is generally recognized that it is advisable to distinguish between scientific and innovative activities. One of the most successful examples of such differentiation was the construction of the European Innovation Scoreboard [4].

The development of Scoreboard content was based on the results of empirical evidence that the outcome of scientific research turns into innovation and affects the economic development indicators of enterprises and countries only if they are commercialized. This fact is especially important in the post-Soviet countries, in particular in Russia, where scientists annually receive hundreds of patents for inventions, developments and utility models (Table. 2), which subsequently do not find practical production.

**Table 2.** Statistics of valid protection documents for intellectual property objects, units as of 01.12

Indicator	Years					Growth rate (2022/2015)
	2015	...	2020	2021	2022	
Patents for inventions (valid patents)	248336	...	263688	264587	259020	+4.3
Utility models	33576	...	42256	42876	45301	+34.9
Industrial designs	36779	...	38658	42376	44688	+21.5
Number of registrations the name of the place of origin of the goods;	157883	...	194096	240610	270271	+71.1
Trademarks	587671	...	457570	760162	612364	+4.2
Number of registered orders by exclusive right (patents granted)	56889	...	66707	68048	70860	+24.5

Source: compiled by the authors based on data from [10]

There is a rather paradoxical situation when, on the one hand, the country's industry is in dire need of technological renewal, and on the other hand, the existing innovative developments are not in demand and remain not implemented. For reference, as of 01.01.2023, according to official statistical information, there are 259.020 protection documents for inventions in state registers.

Intellectual property, in general, and patents, in particular, are the link between innovation and the competitiveness of the company.

Based on the data of the World Patent Organization (hereinafter – WIPO) for the period from 2009 to 20122, more than 143 million were issued worldwide. protection documents (including patents for inventions, utility models, industrial designs and trademarks).

The largest percentage increase in security documents over the specified period of time is demonstrated by "Utility Model" - 585%, "Trademark" - 344%; "Industrial design" - 176%, "Patent" - 174%. In quantitative terms, the largest increase is demonstrated by the "Trademark" – 8.17 million units.

In general, according to WIPO experts, in the last decade the leadership in patent activity has been gradually shifting from the countries of Europe and North America to the countries of Asia. China accounted for 84% of the total back in 2017.

China, the United States and Japan are among the three countries with the largest registration bureaus, with China receiving three times as many applications as the United States or Japan.

The most active investor in R&D today is Gazprom PJSC. According to the world rating 1000 Global Innovation 1000 study of R&D spending, the company is the only largest registered in the Russian Federation that invests in research and development, and ranks 512th in this rating with an investment volume of about \$ 0.281 billion. By the way, there are at least 320 such companies in the USA with R&D expenses up to 68% of similar expenses in the country.

In turn, the countries whose economies are in the phase of economic growth are characterized by the active commercialization of high-tech innovations. At the same time, numerous facts are known that these countries often do not have a well-developed national fundamental and applied science. This trend indicates that the processes of commercialization of innovative high-tech products are crucial for the economic development of business entities.

Considering the role of innovations in the creation of high-tech products and the importance of their commercialization for obtaining positive economic effects at the micro and macro levels, it is advisable to clarify the existing categorical and conceptual apparatus in the field of commercialization of high-tech products and specify its types.

For example, in the Big Economic Dictionary, "commercialization" is presented "... as an opportunity to turn something into a source of profit, into an object of purchase and sale" [5]. A similar definition is given in the works of Y.N. Grik, where commercialization is understood as "... subordination of the activities of an enterprise, institution or organization to one goal - profit" [1].

Regarding the concept of "innovation", a review and generalization of the scientific literature allow us to interpret the tool as an innovation, which may take the form of a new product, technology, method of implementing a specific goal. An innovative product can be manufactured using both primitive and high-tech technology. Innovation can also be the idea of using well-known products and technologies or certain methods of achieving goals in areas where they have not been used before.

That is, products or technologies can be an innovation for the market or an innovation only for an enterprise that introduces a new technology for itself, masters the production of a product that has not been produced before.

The following terms, the essence of which plays an important role in clarifying the interpretation of the concept of "commercialization of high-tech products of the enterprise", are products and technology. As you know, products are the product of production activity, which can have different forms and be expressed both in kind and in monetary terms. Products are a set of products that are produced by a separate enterprise, a certain industry, agriculture or the entire national economy [6].

There are various classifications of the types of products of the enterprise. Let's focus on the types of industrial products based on their innovativeness (products that are innovative for the enterprise and products that are innovative for the market) and manufacturability (high-tech products and products that are not high-tech). In this case, the essence and types of commercialization of high-tech products of industrial enterprises according to classification criteria and the types of products allocated within them indicate that the criterion of innovativeness does not carry the characteristics of whether the products are high-tech or not, since the main feature of classifying products as high-tech is the knowledge intensity and complexity of the production technology [7].

A review of statistical data and literature indicates that high-tech products are traditional in the production of primary pharmaceutical products and pharmaceuticals, computers, electronic and optical products, air and space aircraft. The level of complexity of the technology is determined at the design stage of the technological production system by the nature of the distribution of functions of this system. Complex technologies provide for linear, parallel and combined in time and space implementation of many technological operations, the implementation of which is accompanied by the use of knowledge-intensive means of labor.

Table 3 shows the signs on which the definition of "commercialization of high-tech products of an industrial enterprise" is based.

**Table 3.** The signs on which the definition is based, revealing the features of the "commercialization of high-tech products"

Categories and concepts derived from them	Essential features
Commercialization	Process
	Profit
Innovation	The result of search activity
	Availability of a product, technology or method that is qualitatively different from existing ones or analogues of which are not available on the market
Technology	Knowledge, information
	Process
	Production operations
Products	Production result
High-tech products	Knowledge intensity
	Complexity of production technology

Source: compiled by the authors

Thus, based on the results of the evaluation, as well as taking into account the research carried out, it is proposed to interpret the commercialization of high-tech products as a process of organizing the production, marketing and promotion of high-tech products in the market in volumes that provide the expected economic effect to the enterprise. In turn, innovation is an additional feature of high-tech products. The higher the level of innovation characterized by the company's products, the greater the chances of ensuring the effectiveness of its commercialization.

A review and generalization of literary sources, as well as the results of the research carried out, make it possible to identify various types of commercialization (Table 4).

**Table 4.** Types of commercialization of industrial products

Classification features	Types of commercialization
By geographical coverage of the subjects of commercialization	-commercialization of a high-tech product on the national market; -commercialization of a high-tech product in a foreign market; -commercialization of a high-tech product, both on the national and foreign markets
By the level of efficiency	-commercialization of a high-tech product, which provided the expected economic effect; - commercialization of a high-tech product that did not provide the expected economic effect
By content	-commercialization carried out by an entity that is a developer of high-tech products, its manufacturer and distributor in one person; - commercialization carried out by an entity with intellectual property rights to a high-tech product through licensing of business partners; - commercialization carried out by an entity with intellectual property rights to a high-tech product through the use of franchise agreements; - commercialization carried out by an entity with intellectual property rights to a high-tech product through the use of a leasing agreement; - commercialization carried out by an entity with intellectual property rights to a high-tech product by combining the above methods of commercialization
By the number of subjects of commercialization	- monosubject of commercialization of a high-tech product; - bisubject of commercialization of a high-tech product; - polysubject of commercialization of a high-tech product
By the method of	-commercialization of a high-tech product, which takes place at the

financing	expense of venture banks and funds; - commercialization of a high-tech product, which takes place at the expense of budgetary and extra-budgetary trust funds; - commercialization of a high-tech product, which occurs at the expense of the own funds of the subjects of commercialization; - commercialization of a high-tech product, which takes place at the expense of funds from various sources of financing
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*Source: compiled by the authors*

The above classification can perform an informative and reference function. Its practical application is advisable by business entities in the process of choosing the optimal options for commercialization of high-tech products, as well as by heads of public administration bodies when making decisions to stimulate specific types of commercialization.

In reality, commercialization carried out by an entity that acts as a developer, manufacturer and distributor of high-tech products in one person takes place only at the level of large industrial and economic formations, TNCs, various associations of enterprises, associations, consortia, etc.

The main difference between this type of commercialization from others is that an economic entity that commercializes high-tech products simultaneously acts as the owner of intellectual property rights to high-tech products, carries out its production and marketing.

If it has sufficient potential for commercialization, then, depending on the technological complexity of the product being put on the market, there may not be a need to patent the product.

In turn, all other types of commercialization are practically impossible without the protection of intellectual property rights for a high-tech product that is being commercialized. It is the system of intellectual property rights protection that makes it possible to legitimize the satisfaction of the economic interests of all subjects of the commercialization process.

## 5 Conclusion

Thus, based on the conducted research, a number of the most significant conclusions can be drawn, in particular, based on the results of considering the content of the concepts of "innovation", "commercialization", "products" and "technology", it is proposed to interpret the commercialization of high-tech products as a process of organizing the production, marketing and promotion of these products in volumes that will provide the company with the expected economic effect. At the same time, it is proved that innovativeness is a sign of high-tech products.

The features are disclosed and an assessment of the types of commercialization of products related to high-tech products is carried out, according to the results of which signs (financing methods, regional coverage, etc.) are identified that help entrepreneurs and managers form an idea of their diversity and decision-making in innovation management.

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