The Complex of Interrelations and Mechanisms of Innovation and Investment Balance of Industrial Policy in the Context of the Digital Economy

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Abstract

The purpose of the study is to determine the complex of interrelations and mechanisms of innovation and investment balance of industrial policy in the context of digital transformation. During the research, the following methods were used: the theory of system balance, the methodology of economic security, statistical analysis of industrial development indicators, tabular and graphical methods to illustrate the results obtained. As a result of the research, we propose mechanisms of innovation and investment balance and the complex of the interrelations of innovation and investment balance of industrial policy. These are the interrelations of both the sectoral and functional development of industrial production. The distinctive features of the proposed approach are the combination of the principles of the theory of system balance, the concept of Industry 4.0, and the methodology of economic security. The proposed complex allows analyzing the balance of industrial policy taking into account the organizational and technological structure of digital enterprises, namely, Digital factories; Smart factories; and Virtual factories according to the principles and elements of the Industry 4.0 concept and the Technet roadmap.

Key-words: Industrial Policy, Industry 4.0, Innovation and Investment Balance, Industrial Production Development, Sustainable Manufacturing, Digitalization, Digital Economy.

1. Introduction

Development strategies for industrial production according to the concept of Industry 4.0, aimed at stimulating long-term investments, ensuring the redistribution of financial resources between industries, and creating new markets for goods and services, can provide systemic effects in the industrial sector [1]. At the present stage of economic relations in the conditions of the emerging digital economy, the elimination of the consequences of economic crises, and the strengthening of external economic risks, the interest in exploring the possibilities for forming the foundations of a

balanced new industrial policy is increased significantly. The study of G.B. Kleiner assesses the systemic balance of the Russian economy in the regional context, analyzes the system balance index, calculated for the Russian Federation entities, federal districts, and the entire country is calculated and determines the guidelines of the systemic economic policy of territorial development aimed at increasing the number of systemically balanced regions. The author substantiates the necessity of including in the strategy of the Russian Federation entities a section reflecting the proportions between the development of the object-based, environmental, process-based, and project-based subsystems of the region [2]. At the same time, Kleiner proposes the concept of the industrial future of Russia, where the leading role in the development of production should belong to industrial ecosystems [3].

The monograph edited by M.A. Eskindarov and N.M. Abdikeev examines various development aspects of the real sector of the economy in the context of the new industrial revolution, such as the implementation of industrial policy in the face of digitalization of the Russian economy, institutional changes in the economy in the context of neo-industrialization, strategic directions for improving the competitiveness of domestic industry, new models of socio-economic system management in the digital era, and others [4]. In his article, S.D. Bodrunov clarifies "the conceptual foundations of noonomics as a qualitatively new phenomenon of the neo-industrial society of the second generation" [5]. The author substantiates the necessity of developing completely different fundamental principles for implementing the state's economic policy, and proves that the emergence of innovative technologies does not indicate the transition to a "service society", but the need for reindustrialization on a qualitatively different technological basis which is noonomics, presented in the article as a basic element of the new conceptual platform [5].

An array of scientific works by foreign scientists analyzes the possibilities of a new industrial policy according to the concept of the digital economy. Currently, the development and implementation of industrial policy are changing the usual priorities for the state and society. The main task in the development of industrial policy is its adaptation to the integrated digital transformation, as well as the aspect of economic diversification. These issues were considered in March 2018 at the United Nations Conference on Trade and Development [6].

H. Gruber notes in his research that digital industrial policy should take into account the new opportunities of industrial policy arising as a result of digitalization to address the issues of slowing economic growth indicators, where structural problems and possible market failures associated with the implementation of digital technologies should be identified [7]. Padmashree Gehl Sampath, a

professor at Maastricht University, notes that digital industrial policy should become an independent type of policy [8]. Ch. Rhodes and D. Rathbone note the following problems in the digital economy that require a change in industrial policy: improving the availability of financing; improving the availability of talented personnel; building a world-class digital infrastructure; revising and updating laws and regulations according to up-to-date requirements [9].

Having considered the pre-existing and current debates around industrial policy, A. Andreoni and H.J. Chang propose to focus attention on three important issues: 1) strategic coordination of structural interdependencies arising in the course of industrial transformation; 2) challenges faced by countries in creating institutions and coordinating policies to achieve industrial transformation; 3) the importance of managing existing (and emerging) conflicts of interest and exactly the dynamics of political economy that ultimately affects the functioning of various institutions and the use of tools [10].

Thus, analyzing the existing set of scientific views on the problem under consideration, one can conclude that, as a rule, various aspects of the industrial policy formation and implementation are identified and analyzed in the literature. However, the level of research on the relationship and balance of innovation and investment components in forming and implementing industrial policy in the digital economy is quite insufficient.

The relevance of developing a balanced industrial policy in the current context is due to the following aspects:

- new conditions and factors for forming and implementing industrial policy, new business models for the functioning of industrial structures in the digital economy;
- presentation and analysis of industrial policy as an innovation and investment balanced system operating under risks, financial uncertainty, and digital transformation of industry;
- significant structural imbalances in the sectoral development of industrial production and the preservation of the overwhelming importance of extractive industries in terms of profitability in forming added value, and a significant lag in the development of processing industries [11].
- The study of the factors contributing to the balanced development of industrial production requires defining the concept of "balance". As Kleiner notes, in the case of system balance, this is about the "mutual proportionality" of the four system sectors [1]:
- object-based or organizational sector, at that, object-based sector, in this case, may include enterprises, regions, industries, households, etc.;

- project sector concerns concluding contracts, releasing new products, and penetrating a new market, etc.;

- process-based sector is related to innovation logistics operation, etc.;

- environmental or infrastructural sector involves socio-economic institutions, organizational culture, information and communication space, etc.

- Thus, the innovation and investment balance (proportionality) in industrial policy (according to the theory of systemic balance) should be determined

- by balanced development of basic, leading, and progressive industry sectors;

- by balanced development of basic, leading, and progressive markets;

- by balanced development of basic most important institutions in the economy and the economic order;

- by balanced development of end-to-end advanced production technologies at all stages of the product life cycle;

- by the implementation of the principle of the consensus in industrial policy when coordinating the economic interests of stakeholders.

These elements represent the mechanisms (sources) of innovation and investment balance of industrial policy (Figure 1).

Figure 1 – A model for achieving the systemic effects of innovation- and investment-based balanced industrial policy in the context of the digital economy

Source: *developed by the author*
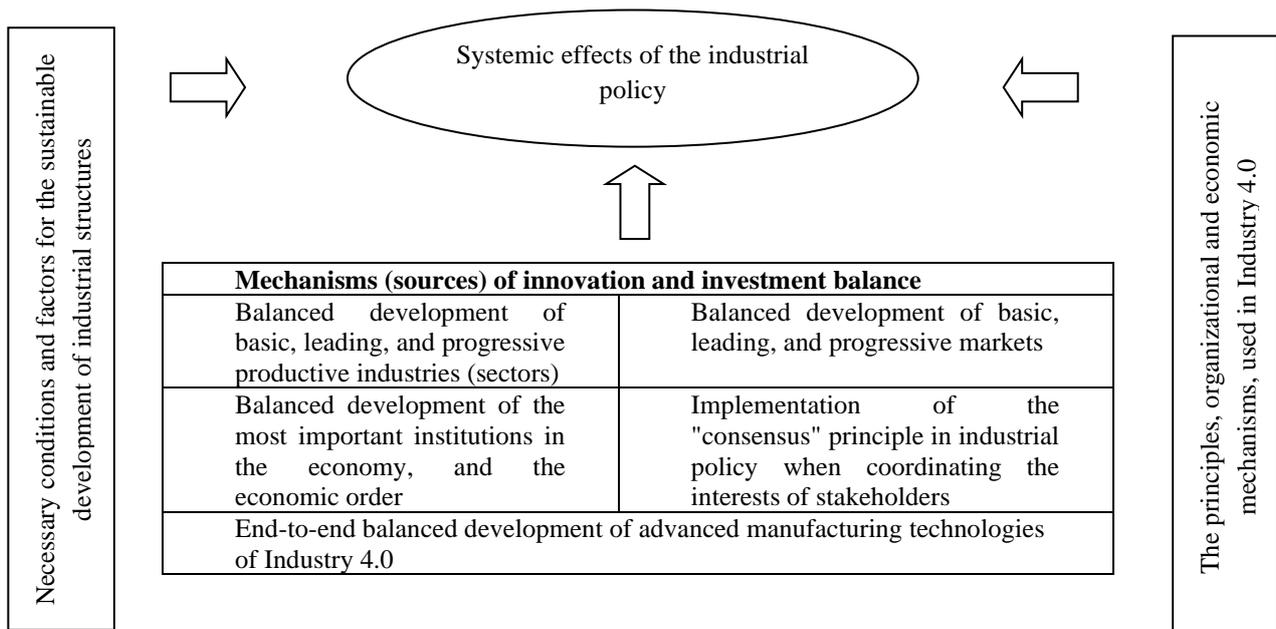
The key components of the development of industrial enterprises are innovation and investment activities. The production and sale of innovative products, the accelerated pace of development of both new and traditional economic sectors require implementing innovation and investment balance in the industrial policy. The innovation and investment balance is based on the interrelationships of both the sectoral and functional development of economic entities [11-15]. With regard to the development of the real sector of the economy, to achieve these goals, it is necessary to identify a set of conditions and factors that ensure sustainability, competitiveness, and effective use of potential, the ability to dynamic economic recovery. The sustainability of the real sector of the economy is characterized by the strength and reliability of its basic elements, vertical, horizontal, and other connections within the system, as well as the ability to withstand internal and external loads [15]. A rationally oriented industrial policy should permeate all the components of the industrial development of the real sector of the economy. It is exactly due to this approach that it is possible to provide conditions for sustainable economic development. The process of forming industrial policy is based on a set of fundamental mechanisms. Today, in the Russian Federation, there are several sectoral strategic initiatives at the federal level, namely, the development strategy for power engineering, the development strategy for the basic engineering industry, the development strategy for the automotive industry, and others [16].

The federal law on industrial policy has been adopted. This law regulates relations arising between entities engaged in activities in the field of industry, as well as organizations that are part of the infrastructure for supporting these activities, state authorities, regional state authorities, local self-government bodies when forming and implementing industrial policy [17]. The Russian Federation entities independently develop regional laws regulating their industrial policy. At present, such laws are in force in many areas. For example, in the Nizhny Novgorod Region, the formation and implementation of industrial policy are regulated by the law "On Industrial Policy in the Nizhny Novgorod Region" [18].

At the same time, the analysis of the main legal documents, published statics, and scientific and technical sources allowed identifying a set of the following problems when forming industrial policy in the Russian Federation [15, 16, 19, 20]:

- inefficient ownership structure;
- low susceptibility of businesses to technological innovations;
- weak intersectoral relations;
- high credit risks in the field of innovation;

- problems of scientific and technical information protection;
- the lack of effective mechanisms for translating new scientific knowledge into applied results.

2. Methods

The following methods were used in the course of the research: the theory of system balance, the methodology of economic security, statistical analysis of industrial development indicators, tabular and graphical methods to illustrate the results obtained.

3. Results

The set of interrelations peculiar to the innovation and investment balance of industrial policy in the context of the digital economy, proposed by us, is considered below. This set consists of the following ten elements that characterize the system relationships of proportional development of industrial production.

1. Balance between the basic, leading, and progressive branches of industrial production. Relationships between industries, as well as the relationship of the industry structure and investment motives, capital overflow (return on sales, etc.), are considered. Indicator 1 is the level of mutual proportionality of the industry structure (in %). Indicator 2 is the level of mutual proportionality of investment motives (in %). The share in the industrial production of the manufacturing industry is 70%; the share in the industrial production of mechanical engineering is 20% [15]. Indicator 3 is the share of the digital industry in industrial production (in %). Currently, for several years, there are significant structural imbalances in the sectoral development of industrial production (Table 1).

Table 1 – The sectoral structure of the industrial production development in the Russian Federation, %
(calculated by the volume of shipped goods of in-house production, works and services performed using own recourses for certain types of economic activity)

Type of activity	2016	2017	2018	2019	2020
Crude oil and natural gas production	14.68	15.73	18.49	17.64	13.64
Production of coke and petroleum products	12.95	13.9	14.93	14.06	11.18
Metallurgical production	8.61	8.75	8.76	9.72	11.44
Food production	10.31	9.27	8.36	8.8	10.21
Providing electric energy, gas, and steam; air conditioning	9.6	9.11	8.1	7.99	8.62
Production of chemicals and chemical products	4.85	4.65	4.69	4.5	5

Production of motor vehicles, trailers, and semi-trailers	3.2	3.6	3.66	3.72	3.77
Production of finished metal products, except machinery and equipment	4.13	3.89	3.52	3.72	4.16
Production of other vehicles and equipment	3.17	3.43	3.11	3.12	3
Providing services in the field of mining	2.99	3.05	2.79	3.14	3.16
Production of other non-metallic mineral products	2.49	2.45	2.3	2.4	2.53
Coal mining	1.71	2.08	2.25	1.91	1.65
Production of computers, electronic and optical goods	2.43	2.23	1.95	2.08	2.1
Production of machinery and equipment not included in other groupings	2.02	1.91	1.79	1.83	2.02
Mining of metal ores	1.78	1.74	1.72	1.65	2.27
Water supply; water disposal, organizing waste collection, and disposal, pollution elimination activities	1.71	1.73	1.7	1.82	1.91
Production of rubber and plastic products	1.81	1.73	1.67	1.67	1.92

Source: *calculated by the author according to Rosstat data [20]*

In the Tables, the data of the Federal State Statistics Service (Rosstat) are grouped in descending order of the turnover of in-house production by certain types of economic activity in the Russian Federation, and the level of profitability for 2018. As a result, about 50% of all products sold represent the turnover of the fuel and energy industries (the return on sales is 26-60%). The analysis of the distribution of industry sectors by the level of profitability has shown the preservation of the overwhelming importance of extractive industries in the formation of added value, and a significant lag in the development of processing industries (Table 2).

Table 2– The rating of the level of profitability of industries, %

Type of activity	2017	2018
Mining of metal ores	47.4	55.9
Extraction of other minerals	41.5	49.6
Extraction of crude petroleum and natural gas	24.1	32.9
Coal extraction	28.4	30
Manufacture of paper and paper products	19.3	27.6
Manufacture of tobacco products	23.6	26.8
Metallurgical production	20.8	25.8
Manufacture of chemicals and chemical products	19	25.2
Manufacture of medicines and materials applied for medical purposes	25	21.6
Wood processing and manufacturing wood products	6.7	13.2
Printing and copying activities	8.7	12.3
Production, transmission, and distribution	11.7	12.1
Manufacture of computer, and electronic devices	15	12
Manufacture of other non-metallic mineral products	9	11.1
Manufacture of other motor vehicles	11.6	10.9

Manufacture of fabricated metal products	10.7	10.4
Manufacture of beverages	10.8	10.2
Producing coke and oil products	8	8.8
Manufacture of clothes	7.7	8.3
Manufacture of electrical equipment	7.9	8.2
Manufacture of food products	7.7	7.8
Manufacture of rubber and plastic products	8.1	7.4
Manufacture of leather and leather products	9.3	7
Manufacture of other finished products	5	6.3
Manufacture of textiles	8.3	5.8
Manufacture of furniture	5.3	4.9
Manufacture of machinery and equipment not included in other groupings	7.6	3.2
Manufacture of motor vehicles	2.6	2.3

Source*: calculated by the author according to Rosstat data [20]*

All this confirms the situation of favoring the free inflow of investments into the extractive industries and the emergence of the problem of redistribution of investments in the sectoral structure into high-tech manufacturing industries in the context of a sound industrial policy. The integrated development of industrial production is impossible without the innovative development of processing industries in the future with a high level of added value. This will allow providing industrial enterprises with the necessary mechanisms and equipment, scientific developments, highly qualified professional personnel, as well as contributing to overall innovative growth.

2. The balance between investment and the economic dynamics of industrial production concerns the relationship between the level of investment and GDP. Indicator 1 is the share of investments in GDP (more than 25%). Indicator 2 is the ratio of the investment growth rate to the GDP growth rate (more than unity) [15].

A generalizing, integral indicator is the share of gross investment accumulation in GDP (Figure 1). Today, the share of investments in Russia's GDP does not exceed an average of 20-22% over the past 5-7 years. At the same time, the structure of the economy is dominated by capital-intensive industries, primarily fuel and raw materials. The development of knowledge-intensive industries will require an even greater increase in capital intensity, including in machinery-producing industries – by an order of magnitude. Therefore, the share of GDP accumulation spent on investments should be gradually increased to 28-30%. In China, during the peak of investment activity in 1987-1996 the share of accumulation in GDP reached 32-34% [15].
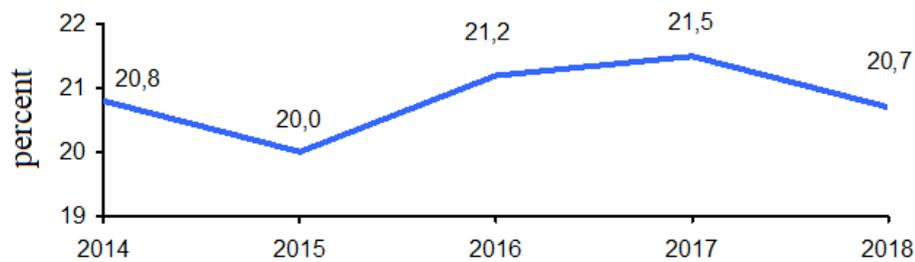
Figure 1 – The share of gross investment accumulation in GDP.

Source: Rosstat data [20]

The interaction of investment and economic dynamics has direct and inverse systemic relationships, namely, an increase in investment in real economic activity contributes to economic growth and, conversely, a decrease in investment can cause an economic downturn. According to the estimates of the Institute of Economy of the Russian Academy of Sciences, every 3% increase in investment entails more than 1% increase in the gross domestic product (respectively, a 3% decline in investment entails a drop in GDP growth of about 1-2%) [15].

In 2010-2018, there was a generally negative dynamics of investment in fixed assets, as well as GDP, especially in 2015 during the crisis (Fig. 2). Moreover, the volume of investments decreased at a faster pace than GDP, which indicates an imbalance in the main proportions. Macroeconomic factors continue to have a restraining effect on the increase in investment activity, including a decrease in the efficiency and profitability of the manufacturing industry, which contributes to a decrease in investment opportunities in industrial activities; deterioration of the financial condition of enterprises in the real sector of the economy and a decrease in the profitability of production due to an increase in energy and material costs caused by an outstripping increase in prices and tariffs in the branches of natural monopolies; a relative decrease in domestic demand for the products of the investment complex industries due to a decrease in profits in the manufacturing sectors of the economy, a high degree of depreciation of fixed assets, and others. The main source of financial investments in the real sector of the economy continues to be the own funds of enterprises and organizations, which accounted for more than 50% of the total volume of financial investments.

Figure 2 – Dynamics of the main macroeconomic indicators (in comparable prices; as a percentage of the previous year)

Source: Rosstat data [20]
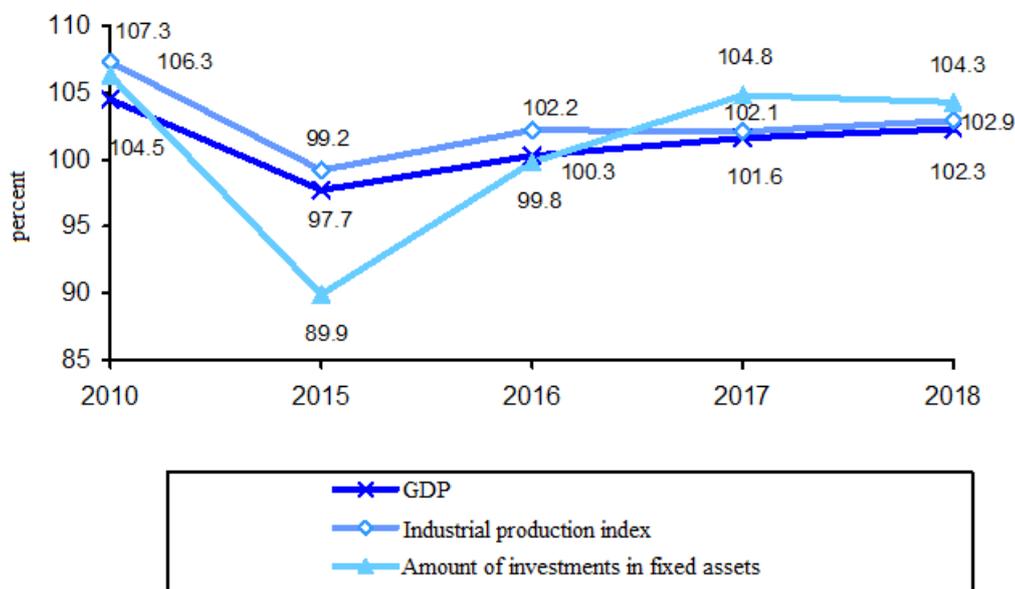
3. A balance between investments in the renewal of fixed assets of industrial production and investment in disposal due to extreme aging concerns the relationship between investment programs to compensate for the disposal of funds and investment programs aimed at the development of innovative processes. The indicator is the ratio of investments in the renewal of fixed assets and investments in disposal (for the Russian Federation - more than 1.5) [15].

A macroeconomic indicator is the level of renewal of fixed capital by investing in the disposal of fixed assets. If the ratio of investments in the renewal of fixed capital and their disposal (written off the balance sheet) due to extreme aging exceed unity, then such an indicator shows the presence of a renewal of fixed capital. In other words, if the investment in the renewal of fixed assets exceeds the compensation for their disposal, one can talk about a positive trend in the renewal of fixed capital. For today's extremely worn-out funds, it is advisable to maintain this safety indicator at the level of 1.5, i.e. investments in the renewal of fixed capital should exceed its disposal comparing with the original cost by 50%. Reaching the limit value of this indicator means that one part of the investment is directed to compensate for the disposal of funds, and the other part is directed to innovations. According to experts, it will take at least 250 billion rubles to restore just industrial and production

fixed assets at the level of 1990 and to increase their technological condition to the level of global competitiveness of manufactured products, this figure will have to be doubled [15].

4. **The balance between the investment demand and supply in the production sector** reflecting the relationship between the amount of income accumulated by economic entities, which can be directed to investment, and the totality of investment objects in all its forms, i.e. relationships between factors that influence investment demand and supply. The indicator is the ratio between the investment demand and investment supply (equal to about 1).

The factors determining the formation of investment demand include the national volume of production, the amount of savings, the monetary income of the population, the distribution of income received for consumption and saving, the expected rate of inflation, the loan interest rate, the tax policy of the state, the financial markets condition, the exchange rate of the monetary unit, the impact of foreign investors, changes in the economic and political situation, and others.

While considering an investment offer as an offer of investment goods, it is affected by the same factors that determine any offer of goods, namely, price, costs, technology improvement, tax policy, expectations, the level of competition, and others. On the other hand, an investment offer is a specific product offer, since investment goods are distinguished by the ability to generate income. This determines the qualitative feature of such a factor as the price of investment goods, which is formed depending on the rate of return. The development of the stock market and the loan capital is an important condition for stimulating the investment offer.

The desire to obtain the highest income at lower costs underpins the decisions of economic entities concerning investing. With a certain structure of the investment offer, investors will prefer those investment goods that will provide the highest rate of net profit on the invested capital with minimal investment risk. The high market price of investment goods, due to their profitability, serves as an impetus for directing significant masses of investment capital into these investment objects. The movement of investment capital, in turn, leads to an excess of investment demand over the supply of these goods, which, all other things being equal, initiates the effect of increasing the price and increasing the supply.

5. **The balance between innovation and the economic dynamics of industrial production,** reflecting the relationship between the level of innovation and GDP. Indicator 1 is the share of high-tech and knowledge-intensive industries in GDP in % (Table 3). Indicator 2 is GDP growth due to innovations (in %).

The contribution of factors of scientific and technological progress in the growth of GDP exceeded 50-60% as early as in the last century in the USA. In the USSR, an increase in national income of up to 40% was ensured due to the factors of scientific and technological progress. Today, the share of new knowledge embodied in technologies, equipment, and production organization in industrialized countries already accounts for up to 80-95% of GDP growth. Investments in knowledge are growing rapidly in the developed countries of the world. Thus, the research and development (R&D) expenditures as a percentage of GDP amount to 2.55% in the USA, 2.26% – in Germany, 2.78% – in Japan, 2.05% – in France, 1.13% – in Italy, and 2.05% – in the UK. At that, 90% of the knowledge amount measured in physical units has been obtained over the past 30 years [15].

According to Rosstat, the share of domestic expenditures on R&D in Russia was about 1.1% during the period from 2006 to 2018, which indicates unfavorable prerequisites for the development of innovation activity (Table 4). While taking into account the share of domestic R&D costs observed in advanced countries, which is on average 3-5% of GDP, then it can be argued that, according to economic parameters, the result of GDP growth is 10-15 times higher than investments in scientific and innovative activities.

Table 3 – Internal costs for research and development, as a percentage of the gross domestic product of the Russian Federation, %

2010	2011	2012	2013	2014	2015	2016	2017	2018
1.13	1.01	1.03	1.03	1.07	1.10	1.10	1.11	1.0

Source: *Rosstat data [20]*

However, a low level of innovative activity of organizations has been maintained over the past decade, and, as a result, the share of the products of high-tech and knowledge-intensive industries in the gross domestic product is still insignificant (Tables 4, 5).

Table 4 – The share of products of high-tech and knowledge-intensive industries in the gross domestic product (data retrieved from OKVED (Russian National Classifier of Types of Economic Activity) 2), %

2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
19.6	20.2	21.0	21.6	21.1	21.3	21.8	21.3	21.8	23.4

Source: *Rosstat data [20]*

Table 5 – The level of innovative activity of organizations in the Russian Federation

2011	2012	2013	2014	2015	2016	2017	2018	2019
10.4	10.3	10.1	9.9	9.3	8.4	8.5 (14.6)	12.8	9.1

Source*: Rosstat data [20]*

[1] In the 3rd (4th) edition of the Oslo Manual

6. **A balance between investments in end-to-end advanced production technologies at all stages of the product life cycle:** Digital/Smart/Virtual factories according to the concept of Industry 4.0. The relationship between the structural elements of industrial production according to the concept of Industry 4.0 is characterized by Indicator 1, which is the share of investments in Digital factories (in %), Indicator 2 – the share of investments in Smart factories (in %), and Indicator 3 – the share of investments in Virtual factories (in %).

7. **A balance between investments in the development of basic, leading, progressive industries and industrial product markets,** reflecting the relationship (correspondence) between the industry structure and the corresponding readiness of the markets. The indicator is the ratio of the amount of investment in the development of a certain industry and the corresponding market (the value equals approximately unity).

8. **Balance between the interests of stakeholders in the production sector**, reflecting relationships between different groups of stakeholders. The indicator shows the level of intersection (correspondence) of the interests of the main groups of stakeholders (in %)

Competitive Industrial Performance index (CIP index) [21] was originally included in the UNIDO([1] United Nations Industrial Development Organization) report "Competing Through Innovation and Learning". Currently, the CIP index is the main diagnostic tool adopted by UNIDO for comparative analysis and measurement of the industrial competitiveness of countries. The CIP index can be used as a diagnostic tool when developing industrial policy and evaluating its effectiveness. The CIP index is an integral index. It makes it possible to consider the relative indicators that characterize the effectiveness of the industrial policy of countries by various sub-indicators. The results of industrial policy can be compared by sub-indicators reflecting the industrial structure, technological and export indicators, and others. The CIP index consists of eight sub-indicators and characterizes certain relationships of industrial policy, which are grouped according to three dimensions of industrial competitiveness.

The first area of assessment is related to the ability of countries to produce and export manufacturing products and takes into account the definition of value-added in manufacturing per capita (MVApc) and exports of manufacturing products per capita (MXpc).

The second area of assessment covers the level of technological development and modernization of industry. For this purpose, two composite sub-indicators are used, namely, the intensity of industrialization and the quality of exports. The industrialization intensification degree is calculated by determining the share of value-added of medium-tech and high-tech industries in the

total value added in the manufacturing industry (MHVAsh) and determining the share of value-added of the manufacturing industry in total GDP (MVAsh). The quality of exports is determined by determining the share of exports of medium-tech and high-tech products in the total exports volume of manufacturing products (MHXsh), as well as determining the share of exports of manufacturing products in total exports (MXsh).

The third dimension of competitiveness assumes the impact of countries' industrial production on world production in terms of their share of value-added in the world value-added of the manufacturing industry (ImWMVA).

The CIP index is a composite index obtained by aggregating sub-indicators that are assigned equal weights. Unlike other currently available competitiveness indices, the CIP index provides a unique cross-country benchmarking of the efficiency of industrial production development and industrial policy. The ratings, presented at the global and regional levels, reflect the status of 152 countries. This makes it possible to compare industrial indicators of a particular country with the corresponding indicators of not only countries of the same region but also with countries being at the same stage of economic or industrial development around the world.

4. Conclusions

Taking into account the above, it seems that the industrial policy should be formed in a balanced way both at the state level and at the level of industries, regions, and interested manufacturing enterprises. At the state level, it is necessary to regulate the interests and co-financing of regional industries, enterprises, and products, prioritize innovations and investments in strategically important areas, regularly monitor and analyze the implementation of a comprehensive development strategy for the country's economy, while at the level of industries and regions – to organize self-regulating associations, regional and international business incubators, technology parks, and innovation clusters. At the level of concerned manufacturing enterprises, there should be a consistent transformation of an idea into a commercial product through the stages of fundamental and applied research, experimental design and technological development, marketing, production, and sales. This should result in a consistent redistribution of investment resources and respectively, in an interconnected innovative development of industry structures, strengthening the development uniformity of the industry sectors of different forms of ownership, including in the regional aspect.

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