Monitoring the Sustainable Development of the Electronic Industry

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ABSTRACT

The **subject** of the study is the Russian electronic industry as a strategically important sector that ensures national security and cybersecurity in all areas of activity. The **relevance** of the study is due to insufficient efficiency and consistency of the results of the existing monitoring of the development of the electronics industry, which is related to the lack of comprehensive information and analytical tools for diagnosis of indicators of sustainable development of industry. The **purpose** of the study is to develop a flexible situational approach to monitoring the electronics industry, taking into account the industry strategy to expand production of civilian products, as well as to justify the effectiveness of financing tools and increasing the sustainable development of the industry. As a result, a monitoring technique based on data from industry statistics, the Spark-Interfax information resource, and big data analytics for organizations in the electronics industry, with eventual industry aggregation, was developed. The sectoral structure was examined in accordance with the methodology, the market situation and business models were evaluated, and the risks and shortcomings of financing the sector were identified. The approach ensures monitoring of the transformation of the industry, creation of a fair competitive market, increase in the share of efficient private Russian companies and their integration into the global ecosystem. The **scientific novelty** of the study lies in the selection of sectoral assessment indicators, the use of information resources and big data technology, which provide regular diagnostics of the industry. The **theoretical significance** of the study is the development and adaptation of industry analysis to the specifics of the electronics industry, as well as the inclusion of sustainable development indicators. The results of the study are of **practical significance** for the professional Association of organizations of the radio-electronic industry of Russia, government regulators and private investors interested in operational information about the state and trends of the development of the industry and its financing tools.

Keywords: sustainability; development; financing instruments; electronic industry; National security; monitoring; import substitution; sanctions

INTRODUCTION

The liberal policy of Russia during the period of the market economy has led to the country's high dependence on high-tech imports and has also contributed to the uncontrolled outflow of capital to the more developed countries. This has resulted in insufficient funding of electronic industry development, which, according to foreign experts, is typical of many, even developed, countries.[1] The current geopolitical situation, dependence on imports of electronic hardware and software create a threat to the national security and economic growth of Russia. At the same time, it serves as a powerful impetus for large-scale structural changes in the country on a qualitatively new basis and contributes to the accelerated transition to the sixth technological system, the core of which is the microelectronics industry and information and communication technologies (further — ICT) [1, 2]. According to expert estimates, "not fully covered by statistics, but sufficiently powerful ICT sector of Russia, especially in the area of contact software, can serve as a factor in accelerating its economic growth", as confirmed by the 2020 ranking of the world's most digital countries.[2] According to the Digital Evolution Scorecard, Russia is ranked in the group of "prospective countries" by criteria of "level of digital development" and "rate of digital growth".[3] However, the electronic industry is scientifically intensive, and its advanced development, especially in the context of sanctions, requires large investments.

The Russian scientists V. V. Ivanter et al. [3], S. D. Bodrunov [4], V. A. Cherkasova and G. A. Slepushenko [5], D. A. Artemenko and S. V. Zenchenko [6] consider attracting investment as one of the main dominants of the sustainable development of the Russian economy.

This is confirmed by the results of our study: import substitution policy, improvement of the system of public procurement, and financial support in general contributed to the growth of important indicators of enterprises in the electronic industry in the period 2017–2021 (equity, assets, share of capital, intangible assets, research and development). According to IEF RAS calculations [7] based on HSE data [8] for the period 2010–2021, gross domestic R&D expenditure in the ICT sector as a whole increased by 18 times. At the same time, in 2021 compared to 2020–2.1 times. There was a trend to accelerate the growth of production, the number of staff, the productivity of labour.

However, key areas of industry development require continuous monitoring to improve financing instruments in new economic conditions. Our analysis of the various monitoring methods confirmed their limitations based on the scope of the objectives, industry or regional specificities. Electronics manufacturers' ratings are insufficiently informative, as they are based only on two indicators of revenue and staffing.[4] The monitoring methodology of A. M. Batkovsky et al. [9] is focused on the evaluation of various processes of transformation and diversification of UICs. The paper also critiques current methods for evaluating government programs for the excessive use of standard indicators and the standard performance audit algorithm.

Our approach to monitoring methodology development is based on industrial analysis methodology, which is consistent with the research of G. B. Kleiner, who considers that it is difficult to "predict crises and prevent their consequences" by confining oneself to macro-

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[1] Blank S. The Semiconductor Ecosystem Explained. Semiwiki 02–06–2022. URL: https://semiwiki.com/semiconductor-manufacturers/307494-the-semiconductor-ecosystem-explained (accessed on 02.02.2023).

[2] World's most digital countries: ranking of 2020. URL: https://hbr-russia.ru/innovatsii/trendy/853688 (accessed on 02.02.2023).

[3] MACROECONOMIC FORECASTING. URL: https://cebr.com/service/macroeconomic-forecasting (accessed on 02.02.2023).

[4] Rating of organizations of the radio-electronic industry of Russia. URL: https://www.instel.ru/upload/files/sec_doc_20/reiting-2020.pdf (accessed on 02.02.2023).

analysis [10]. J. A. Brander et al. [11] also applied a sector-specific approach to assessing the effectiveness of various enterprise financing tools in research-intensive sectors, with the highest efficiency observed in the IT sector (more than 40%) with private venture financing, in the electronic industry— with mixed financing (11.07%).

The importance of a company's environmental impact, as well as the availability of information about its environmental, social, and governmental responsibilities, have significantly increased the requirements of investors today (ESG). Studies by Russian scientists M.A. Fedotova, O.V. Loseva, V.V. Bogatyreva [12], E. Yu. Makeeva and others [13], foreign scientists Tensie Whelan, Elyse Douglas and others prove the impact of sustainable development indicators on business value and indicators of investment attractiveness.[5] Studies by Cornell University scientists S. Freytag et al. [14] estimate the impact of IT and electronics on the climate as approximately 1.8% to 2.8% of global greenhouse gas emissions. At the same time, scientists consider that the introduction of digital electronic systems will help improve energy efficiency, process productivity, reduce greenhouse gas emissions, and mitigate the effects of climate change.

A comprehensive analysis of existing monitoring methods revealed inefficiencies and, in some cases, contradicting results [7]. This is due to the absence of a complete information and analytical toolkit for analyzing indicators of the electronic industry's sustainable development at the objective level and in relation to strategic priorities. Thus, the purpose of the present study was to develop a flexible situation-based approach to monitoring the electronics industry, taking into account the industry strategy focused on expanding production

of civilian products, as well as to justify the effectiveness of funding instruments and increase the sustainability of industry development. At the same time, it should be noticed that complete compliance with all established indicators, including those influenced by different reasons, is impossible. In this regard, sustainability is determined by the correspondence of the main trend of development of the industry to the target in connection with directions and priorities on the basis of established indicators in the aspect of the general concept of sustainable development on the national economy. Monitoring should reflect the changes observed as a result of focused industry transformation measures; diagnose risks; and identify the most effective tools for financing and other government support of the electronic sector's implemented strategic development paradigm.

METHODOLOGY OF RESEARCH

The study focuses on key priorities of the Electronic Industry Development Strategy[6]: inflow of private Russian investments in the industry to develop large consortia, increase investment activity of companies; creation of a fair competitive environment (growth of output of Russian producers, their market share, increase of assets, the number of staff and productivity of labour); restructuring of the industry (increase of the share of Russian private companies, transition to an ecosystem based on a common technological platform or production resource) with gradual integration into the world eco-system [15]. The monitoring methodology is based on the principles of accuracy, regularity and efficiency of information, includes the analysis of big data on organizations of the

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[5] Tensie Whelan, Elyse Douglas. The price of social responsibility. URL: https://hbr-russia.ru/biznes-i-obshchestvo/etika-i-reputatsiya/854831 (accessed on 02.02.2023).

[6] On the Strategy for the Development of the Electronic Industry of the Russian Federation for the period up to 2030 and the plan of activities for its implementation. Order of the Government of the Russian Federation from 17 January 2020 No. 20. URL: http://www.consultant.ru/document/cons_doc_LAW_52009/#cont (accessed on 02.02.2023).
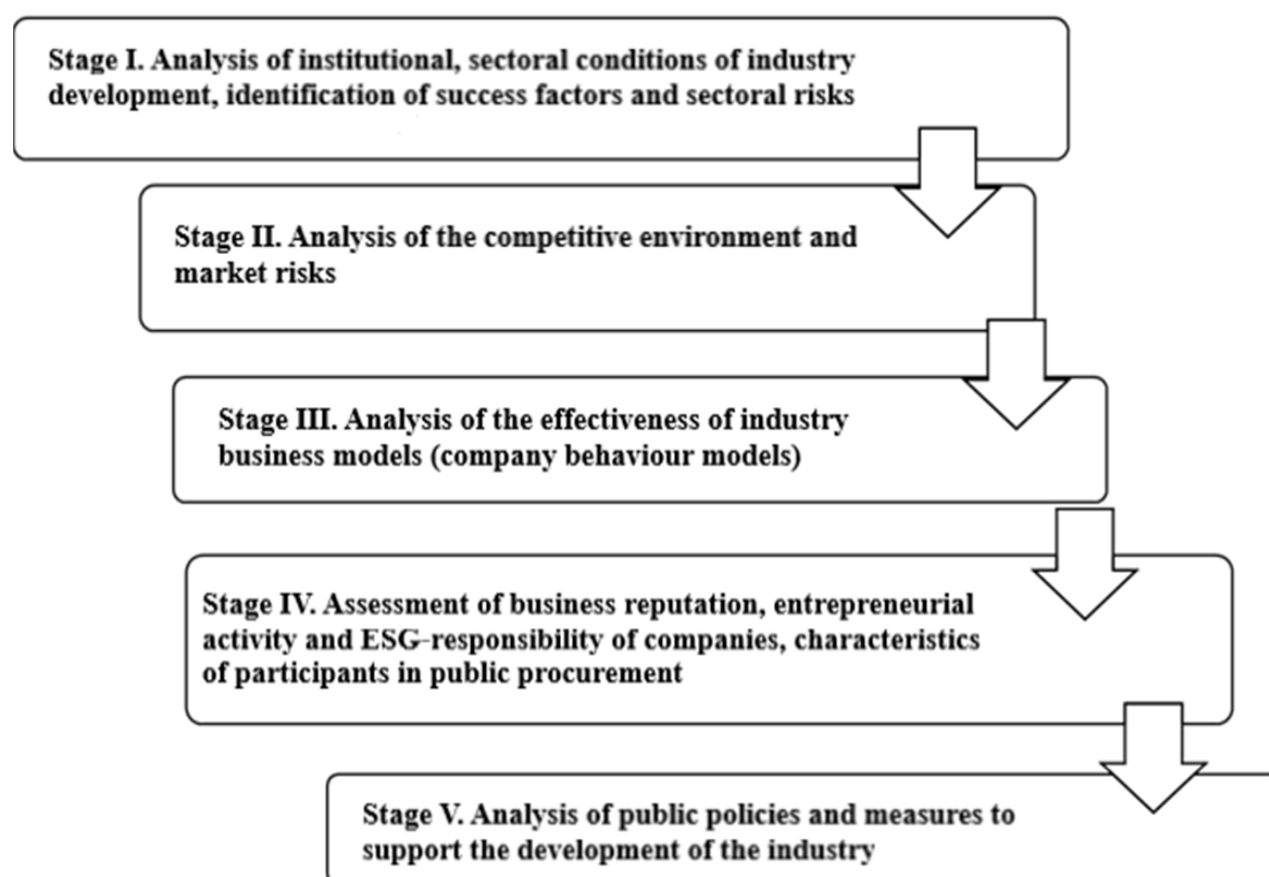
Fig. 1. **Methodology of Monitoring the Sustainability of the Development of the Electronic Industry in Russia**

Source: Compiled by the authors.

electronic industry (OKVED 26 Production of computers, electronic and optical products) and uses the information resource Spark-Interfax.[7] This confirms a more complete circle of monitoring, as opposed to Rosstat data, which is focused on large companies, and allows this methodology to be applied in the system of public procurement, priority area subsidization, and the most effective business models. The methodology stages are presented in *Fig. 1*.

RESULTS OF THE RESEARCH

The first phase of the study revealed that the electronic industry is developing in the form of manufacturing consortia in such segments as telecommunications equipment and communications; computing and data storage systems; control devices and telematics; automotive electronics; medical electronics, security systems, etc.[8] At the same time, the share of civilian production by Russian manufacturers is 31% of total domestic revenue; by segments, the share varies from 7% in the most voluminous segment of telecommunications equipment and communications, which belongs to one of the key indicators of the strategy. There are numerous business models in the industry, but analysts consider vertically integrated companies, as well as innovation centers dedicated to market research, idea generation, science, developing, and producing new goods, to be the most promising [15].

According to the Ministry of Trade, in 2020 the industry included 1 652 organizations

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[7] Spark-Interfax News. URL: https://spark-interfax.ru/ru/statistics (accessed on 02.02.2023).

[8] Electronics Developers and Manufacturers Association (EDMA). URL: http://arpe.ru/ (accessed on 02.02.2023).

Structure and Characteristics of the Electronics Industry by Type of Ownership

Type of ownership	Share of companies by number, %	Share of employees, %	Share in revenue, %	Asset share, %
State	0.94	6.51	4.73	10.93
With foreign participation	4.24	22.06	24.99	22.65
Private	94.82	71.43	70.28	66.42
Total	100	100	100	100

Source: Compiled by the authors.

with a total of 290 thousand employees. At the same time, experts have more than 3 thousand organizations, including state-owned companies that are part of ROSTEC; private small and medium-sized enterprises controlled by the JSRC "System"; companies with foreign participation, and representative offices of global corporations (*Table 1*).

From 2019 to 2020, the following developments happened in the structure of civilian product producers: quantitatively, the share of companies in the public sector and foreign companies has declined by around 1% in favor of the private sector, while the number of employees has increased significantly, with private enterprises employing more than 70% of the employees.

The second phase analyzes important sectoral risks related to falling behind the rest of the world, becoming vulnerable to sanctions, and confronting potential threats to sovereignty. According to experts, a significant proportion of the electronic component base of Russian equipment is imported; the technological lag of Russian manufacturers is from 5 to 20 years.[9] Electronic component manufacturing is characterized by a higher share of added value and is critically dependent on innovation. In this connection, investments in R&D of 15

to 20% of revenue are insufficient to finance industry development. According to Spark-Interfax, in 2020, the industry structure was characterized by the following parameters: the total number of employees — 380 thous. people, revenue — 1 915 mln rubles, assets — 2 407 mln rubles. Generally, it is difficult to identify the type of industry. The industry includes both manufacturing companies and research organizations (design centers). The sectoral market structure is characterized by fairly low competition: the concentration ratio of the three largest companies (CR-3) was 10.23%, the Herfindahl-Hirschman index was 67.11%. At the same time, it is important to remember that the market is divided into segments, and companies may have monopoly positions in individual market segments; that is, the variation of key indicators within the industry can be quite high. *Table 2* shows the calculated barriers to entry and age structures, categorized by specified enterprise groupings. Enterprises that have been in the sector for more than ten years provide the most substantial contribution to the industry in terms of assets, value created, and performance.

The sectoral economies of scale (*Table 3*), estimated on the basis of the enterprises of the industry by revenue, showed that the largest share in the number of enterprises, the size of the own capital, revenue, and net profit have enterprises falling into two groups: with

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[9] Electronics slows without reforms. Industry is asked to support regulation. URL: https://www.kommersant.ru/doc/4323806 (accessed on 02.02.2023).

Table 2

Characteristics of the Age Structure of Electronic Industry Enterprises

Grouping of enterprises by duration of operation (age), years (upper limit – slightly more than the specified figure)	Number of enterprises by group	Average net assets by group, million rubles	Group share in equity capital by industry, %	Average assets groups by industry, million rubles.	Group's share of assets by industry, %	Average revenue groups by industry, million rubles.	Group share in industry revenue, %	Average net profit groups by industry, million rubles	Share of the group in net profit by industry, %
Less than a year	52	1	0	12	0.02	11	0.03	2	0.06
1–4	1 284	60	7.73	91	4.85	64	4.32	3	2.7
4–7	1 546	54	8.34	145	9.33	121	9.74	10	10.15
7–10	1 071	20	2.17	162	7.2	96	5.37	7	5.27
10–13	868	78	6.8	214	7.71	192	8.71	21	12.11
13–16	793	153	12.23	253	8.33	233	9.65	21	10.99
16–19	629	199	12.59	466	12.17	519	17.03	33	13.9
19–22	442	147	6.53	359	6.6	364	8.39	28	8.52
22–25	510	185	9.5	399	8.45	334	8.91	21	7.15
>25	1 007	336	34.12	845	35.33	529	27.84	43	29.17
Total	8 202	121	100	294	100	233	100	18	100

Source: Compiled by the authors.

Characteristics of the Sectoral Economies of Scale

Revenue, million rubles	Share of companies by number, %	Share in equity, %	Asset share, %	Share in revenue, %	Share in profit, %
1–50	65.59	8	6.96	4.02	0.68
51–100	10.57	2.99	2.94	3.26	2.52
101–999	19.92	28.5	25.01	26.05	29.41
1000–1999	2.17	14.06	15.24	12.8	17.32
2000–2999	0.59	4.89	5.04	6.08	7.12
3000–3999	0.29	4.18	3.53	4.23	4.2
4000–4999	0.18	2.95	2.9	3.56	4.11
5000–5999	0.18	3.44	4.32	4.31	2.73
6000–6999	0.13	4.38	4.04	3.33	3.99
7000–7999	0.1	1.49	3.03	3.14	1.41
8000–8999	0.01	0.69	0.32	0.45	0.23
10000–10999	0.04	1.31	2.77	1.67	4.26
11000–11999	0.04	0.93	2.09	1.84	-0.28
13000–13999	0.01	2.55	1.77	0.71	3.59
>15000	0.18	19.64	20.04	24.19	18.71
Total	100	100	100	100	100

Source: Compiled by the authors.

revenue from 100 mln rubles to 2 000 mln, as well as more than 15 000 mln.

The analysis will allow us to conclude that the most effective enterprises belong to groups with revenues that range from 100 to 1 000 mln rubles, 2 000 to 3 000 mln rubles, and 4 000 to 5 000 mln rubles, as demonstrated by their share of revenue above the share of assets and profit above the share of revenue. Furthermore, the analysis demonstrates the existence of significantly different producers in the industry, as well as the absence of a significant positive effect of scale.

The third phase assesses the effectiveness of industry business models on the basis of an analysis of operational, investment

and financial activities, growth indicators and risks. For this purpose, enterprises were divided into 3 groups and average indicators were calculated on the sample as a whole by the largest enterprises and companies participating in public procurement (*Table 4*).

According to 2020, among the top 20 companies, 11 were private, 6 were foreign, and 3 were public. The result of the analysis revealed a high operating risk, as indicated by the high volatility of indicators as well as the rate of variation of the profit from sales above the benchmark, which indicates the instability of industry demand. At the same time, companies participating in public procurement are less vulnerable to market risks, as indicated by the lower rate of revenue

Table 4

Performance Indicators of Sectoral Business Models of Electronics Enterprises

Indicator	Average values for all companies in the sample	Values for the 20 largest companies	Values for companies participating in government procurement	Benchmarks*
Variation coefficient of revenue	0.35	0.33	0.30	No data
Variation coefficient of sales profit	0.66	0.78	0.63	0.47
Share of fixed assets and intangible assets, %	9.61	6.78	7.3	28.3
Asset growth rate, %	8.36	14.28	7.18	No data
Revenue growth rate, %	1.68	23.06	2.38	4.73
Net profit growth rate, %	(13.77)	68.91	(9.37)	10.99
Return on invested capital	2.37	1.70	2.13	1.65
Profitability of sales on profit, %	6.84	9.22	7.94	13.5
Net sales profitability, %	4.24	5.80	5.24	3.74
Return on invested capital, %	16.36	14.63	14.71	7.88
Return on equity, %	20.62	19.17	17.42	7.46

Source: Compiled by the authors.

Note: * Indicators of electronics industry (general) for emerging markets. Website by A. Damodaran URL: http://pages.stern.nyu.edu/~adamodar (accessed on 02.02.2023).

variation. Higher indicators of profitability of own and invested capital compared to benchmarks against the background of declining rates of growth of profits negatively characterize the investment activities of companies. Table 5 presents operational, investment, and financial performance indicators, as well as growth and risk indicators.

Based on the analysis, it can be concluded that enterprises in the industry are characterized by small but generally positive operational efficiency: average increase in labor productivity— 4.14%, increase in revenue — about 5%, profitability of sales — 6.33%, yield exceeds the cost of resources by 1.5 times. Investment activity in 2020 was insufficient. This is demonstrated by the decline in non-current assets and the shortage of investment. At the same time, the rate of dividend payments increased and in 2020 reached 62.97%, which negatively affected

Indicators of Operating, Investment and Financial Activity

Indicator	Averages (medians)
Operating activities	
Average annual revenue growth rate (2017–2020), %	4.96
Return on sales, %	6.33
Return on assets	1.45
Labor productivity, thous. rubles/people	2 960
Average annual salary, thous. rubles/people	689
Annual average labour productivity growth, %	4.14
Average annual growth rate of average annual salary, %	5.4
Net sales profitability, %	3.75
Share of organizations with losses (net financial result for the year), %	16.12
Investment activities	
Share of non-current assets, %	10.2
Investment (CAPEX) to revenue, %	1.41
Growth of non-current assets to revenue, %	(0.07)
Financial activities	
Share of equity in the source of financing, %	44.44
Share of organizations with negative equity, %	8.22
Share of long-term debt in sources of finance	12.67
Dividend payout ratio, %	62.97
Financial leverage	0.46

Source: Compiled by the authors.

the investment opportunities of private companies in the industry.

The fourth phase assesses the parameters of the business reputation of enterprises in the industry, including the participants in public procurement and the state of the entrepreneurial environment. *Table 6* data confirms the positive business reputation of enterprises: low due diligence index, indicating a low probability of one-day companies; their absence in all risk registers of Spark-Interfax; adequate tax burden (11.8%);

high loyalty rates of public procurement participants (above industry averages). At the same time, the index of entrepreneurial confidence in 2020, calculated by Rosstat, shows a negative value.

Analysis of the business reputation of enterprises in the industry from the ESG-responsibility perspective shows positive processes, which confirm the trends of reducing their environmental impact (*Fig. 2*), as well as increasing costs for environmental activities (*Table 7*).

Table 6

Indicators of the Business Reputation of Organizations

Indicator	Averages	Values by government procurement participants
Business confidence index*, %	−6	−
Due diligence index	6	3
Share of companies included in risk registers, %	6.73	6.11
Share of companies with credit limit, %	55.50	55.92
Tax burden on revenue, %	10.84	11.54

Source: Compiled by the authors.

Note: * Business activity of organizations in Russia. URL: https://rosstat.gov.ru/storage/mediabank/89_01–06–2022.html (accessed on 02.02.2023).
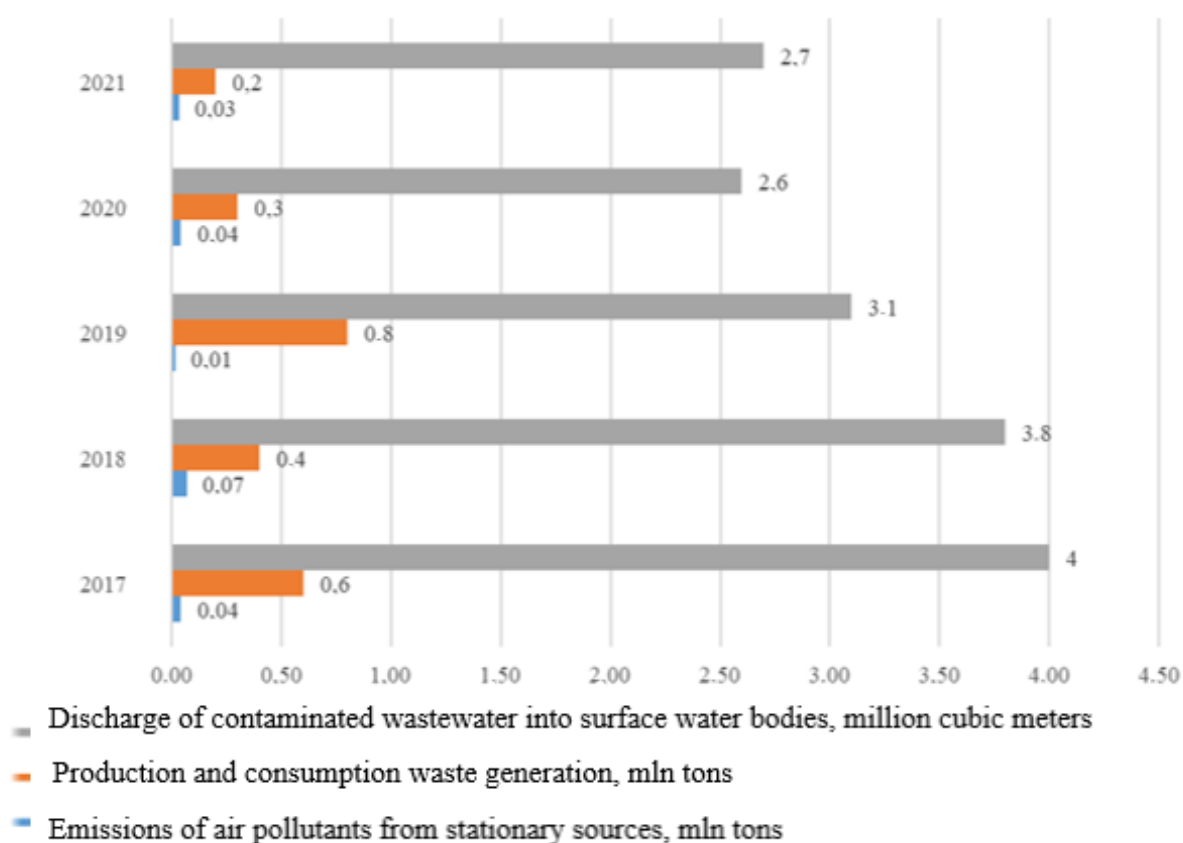

Fig. 2. **Dynamics of Environmental Impact Indicators of Electronic Industry Enterprises**

Source: Compiled by the authors based on Statistical Collection of. Rosstat "Environmental protection in Russia". Moscow; 2022. 113 p.

Table 7

Current Expenditure on Environmental Protection (in Actual Prices, Million Rub.)

Current expenses	2016	2017	2018	2019	2020	2021
For environmental protection, total	1 389	1 408	1 464	1 493	1 445	1 638
Air protection and climate change mitigation	321	375	369	310	339	372
For wastewater collection and treatment	712	720	748	761	797	891
For waste management	240	258	275	339	218	267
Protection and rehabilitation of land, surface and groundwater	11	12	16	20	18	18
Conservation of biodiversity and conservation of natural territories	0.6	0.8	0.8	1	0.7	1

Source: Compiled by the authors based on Statistical Collection of. Rosstat "Environmental protection in Russia". Moscow; 2022. 113 p.

Table 8

Industry-Average Indicators for the Implementation of the Electronics Industry Strategy-2030

Indicator	Industry averages for 2020 (medians)
Rate of increase in equity, %	9.39
Share of fixed assets, intangible assets, research and development in total assets, %	9.61
Asset growth rate, %	10.7
Revenue growth rate, %	3.79
Net profit growth rate, %	0.44
Labour productivity growth rate, %	2.9
Average wage growth rate, %	3.67
Share in GDP, %	1.79

Source: Compiled by the authors.

The fifth phase analyzes the direction and effectiveness of public policy in the industry. The positive results include agreed-upon support for ICT [17] and the electronic industry in 2021; the creation of a register of organizations providing services for the design and development of electronic component products and electronic products; tax reductions; and import substitution incentives.

For the analysis of the impact of public policy on the development of the industry, a system of indicators corresponding to the objectives of Strategy 2030 is proposed and as estimated indicators at the starting point — calculated industry averages for 2020 (*Table 8*).

CONCLUSION

The article discusses the author's approach to monitoring the sustainability of the development of the electronic industry, the benefit of which is the development of relevant industry indicators for assessing sustainable development, the use of information resources and big data technology, and ensuring regular diagnosis of the industry in the context of the ongoing transformation of the national economy.

According to the results of the 2020 monitoring, there was a decline in the sustainable development of the Russian electronics industry, as evidenced by high volatility and a decrease in the growth rates of key financial indicators. Among the positive aspects, assets grew by 10.7%, equity by 9.39% and equity, intangible assets, research and development by 9.61%. At the same time, there is no real (taking into account inflation) growth in revenue, net profit, labor productivity, or average wage. This reflects the impact of a pandemic, global stagnation, disturbances in supply chains, insufficient investment and government support. Only in 2021–2022 did integrated development with the ICT sector and actual budget financing, tax incentives, and active import substitution provide beneficial results. Although institutional and financial-economic processes are quite inertial, already in 2023, we can discuss the growth and sustainability of the development of the industry in a number of key directions of the strategy: exceeding other industries growth in 2022[10] in the field of computer, electronic and optical production; growth of the business confidence index, improved business reputation from the ESG responsibility position. For January-November 2022 compared to 2021, there is an increase in the volume of own production by 11.4% (in computer software development by 30.3%), wage growth by 14.4%.

The theoretical significance of the study is to develop and adapt the methodology of industry analysis to the specifics and needs of the monitoring of the electronic industry in order to ensure the sustainable development of the industry as a whole. The practical results represent value for the professional Association of organizations of the radio-electronic industry of Russia, state regulators and private investors interested in operational information on the state and trends of development of the industry. Further research on the development of monitoring methodology will be aimed at increasing the scope of the companies surveyed, grouping and studying their business models in more depth, and also developing forecasting models to justify the selection of the most effective companies for public procurement, forms of R&D financing, and industry development support.

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[10] URL: https://rosstat.gov.ru/storage/mediabank/osn-11–2022.pdf (accessed on 02.02.2023).

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