

# High-Tech Complex as a Strategy for Sustainable Industry Development in a Commodity Region

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**Abstract—** Relevance of this study is caused by the lack of effectiveness and effective mechanisms for managing the innovative and technological development of new sectors (high-tech sector, knowledge-intensive sector) in the conditions of a commodity region which ensure the sustainability and quality of economic growth. To solve this problem, an analytical approach is proposed that allows a preliminary assessment of the potential and effectiveness of the economy of the Krasnoyarsk Territory and its manufacturing industries with their innovative activity. The emphasis was made on the activities of high-tech complex as an active carrier of innovative and technological solutions for the development of existing and new sectors of region's economy. Statistical parameters used for the analysis as factors, in an indicative form, will make the basis for the development of scenarios for the strategic development of the sectors of region's high-tech complex. Diagnostics of the state and assessment of the positions of high-tech complex allow finding new sources of economic growth, creating conditions for their implementation using network-based approaches to management and creation of integral effects of technological development.

**Keywords—** development sustainability, high-tech complex, potential, resources, innovative activity.

## I. INTRODUCTION

High-tech complex (HTC), with its significant multiplying effect, stimulates the development of different industries and fields of activity. A significant share of high-tech complex is made up of enterprises and organizations producing strategic products. In this regard, the problem of developing high-tech complex on an innovative basis which influences the country's competitiveness in world markets is becoming urgent. It is estimated that 70% of scientific products in these sectors are in military-industrial complex which nowadays has exhausted the existing potential for extensive growth and is forced to move toward innovative development.

The Krasnoyarsk Territory is in the middle position in the terms of development of high-tech complex both in its resources with a share in the high-tech complex of the Russian Federation of 1.6% and in activity with the share of 1.4% of the overall volume of Russian complex. The contribution of region's high-tech complex to production, export, and taxes of the Russian Federation slightly exceeds 1%.

The same group of the subjects of the Russian Federation includes: Krasnodar Territory, Leningrad, Tula, Kaluga, Saratov, Volgograd, Tyumen and Irkutsk Regions. In general, in the development of high-tech industrial production and in ensuring conditions for development, the Krasnoyarsk Territory, despite a number of negative trends, takes the 14th position among the regions of the Russian Federation, and the 16th one in terms of productivity. According to the contribution of high-tech complex to the formation of region's GRP, the Krasnoyarsk Territory is in 71st position among 82 subjects of the Russian Federation what surely affects the general level of region's economic development [1].

Changing situation is possible by activating innovative processes in the complex, taking into account the exclusion of the following unfavorable for development situations:

- relatively high depreciation of machinery and equipment;
- unstable dynamics in the number of employees and a small share of high-productivity jobs;
- low diversification of production and dependence on demand for basic products;
- reduction of costs for technological innovations since 2015 and their low efficiency;
- negative balance of foreign trade in technologies and unsatisfactory level of competitiveness of products made.

For the intentional development of innovative processes in high-tech complex and for assessing the development opportunities for certain directions of its activity represented in region's economy, for determining their strategic positions which together give the required stability to the economy, the following tasks were defined:

1. To analyze the dynamics of regional economy development with highlighting of manufacturing industries with the qualitative assessment of the ongoing investment and innovation processes.
2. To describe the high-tech complex of the region and its constituent entities, their resources and results.

3. To perform their positioning and to define the factors of innovative activity that can ensure high-quality economic growth and required sustainability.

Solution of these problems will allow assessing the priorities for the development of economy and high-tech complex of the region.

## II. RESEARCH METHODOLOGY

The informational basis of the study was formed by the data of federal and regional statistics, materials of Unified Interdepartment Information and Statistical System and Interfax Professional Market and Company Analysis System.

Analysis methodology was based on hypotheses put forward by the authors with respect to the factors having an impact on resource base and the effectiveness of innovative activities in the region which were divided into the following groups:

1) Geographical location and production localization. Size and age of companies being evaluated.

2) Investment potential of renewal of technical and technological basis of the manufacturing industries of high-tech complex.

3) Innovative activity and its effectiveness for sustainable economic growth.

In the framework of the first hypothesis, the position of manufacturing industry in the structure of regional economy and HTC role were considered. Testing the hypothesis regarding HTC was carried out using parameters of gross value added and gross output, since there is no statistics on types of economic activity, except the reporting of companies included in it [2-4].

## III. RESEARCH RESULTS

In the analyzed period (2010-2017), regional GRP (GVA), as well as the contribution of manufacturing, increased (Table I). The capital productivity of fixed assets in the Krasnoyarsk Territory in 2017 for GRP amounted to 0.52 RUR/ RUR, for manufacturing – 12.85 RUR/RUR what should be recognized as a good result. However, the capital intensity of region's economy indicates insufficient innovation, technical and technological equipment – 1.91 RUR/RUR, in manufacturing sector - 0.77 RUR/RUR.

TABLE I. GRP ANALYTICS FOR THE KRASNOYARSK TERRITORY IN 2010-2017. (BILLION RUR)

Parameters	2010	2012	2014	2016	2017
Gross regional product (gross value added) at current basic prices, billion RUR	1055.5	1183.2	1410.7	1745.7	1882.3
Section D. Manufacturing	364.6	351.4	438.9	558.6	591.5

The processes of fixed assets renewal in the Krasnoyarsk Territory as a whole are positive (Table II).

TABLE II. RENEWAL AND RETIREMENT COEFFICIENTS OF FIXED ASSETS OF THE KRASNOYARSK TERRITORY (%)

Parameters	2010	2012	2014	2016	2017
<b>Coefficient of renewal</b>					
Total in economy	7.9	12.0	10.5	9.4	9.3
Manufacturing	8.7	16.2	7.5	16.5	-
<b>Coefficient of retirement</b>					
All fixed assets	0.7	0.9	0.7	1.0	-
Manufacturing	0.8	0.9	0.8	2.0	-

In manufacturing, there is a rapid renewal of fixed assets while maintaining the existing obsolete production potential. On average, depreciation of fixed assets is at the level of 46-48%. More than the half of fixed assets in building (59.6%), in transport and communications (59.3%), in healthcare and provision of social services (53.5%) is depreciated.

Since 2017, 67167 new highly productive jobs have appeared in the economy of the Krasnoyarsk Territory, 16.4% of which are in manufacturing. In general, the increase in the number of high-performance jobs in 2017 amounted to 4200 compared to 2016, and in 2018, 4.5 times more – 18900.

Dynamics of the average annual number of people employed in the economy of the Krasnoyarsk Territory was unstable (Table III). In 2017-2018, this value increased but did not reach the 2010 values which are baseline for this study. It happened, to a large extent, due to manufacturing (+8 thousand). In the structure of employment, the share of manufacturing is consistently 13-14% of all employed in the economy. The share of high-productive jobs in the total number of employees in 2018 was 30%, in manufacturing – 44.7% increasing for 6.5% since 2017.

TABLE III. AVERAGE ANNUAL NUMBER OF EMPLOYEES IN THE ECONOMY OF THE KRASNOYARSK TERRITORY BY TYPES OF ECONOMIC ACTIVITY (ACCORDING TO THE BALANCE OF COSTS OF LABOR RESOURCES; THOUSAND PEOPLE)

Parameters	2010	2012	2014	2016	2017
Employed in economy – total	1432.7	1439.0	1422.7	1391.3	1411.2
Manufacturing	210.8	194.6	187.2	185.6	197.6

The quality of human capital which is determined by the level of education, qualifications and experience [5] has a significant impact on the innovative activity in economy. It, in turn, creates additional external effects that influence on labor productivity [6], the interchangeability of types of technologies and the efficiency of their use [7]. In manufacturing factories of the Krasnoyarsk Territory, the share of specialists averages about 52% what indicates the high innovative potential of economy, and it is constantly increasing. Parameters of labor productivity also testify to the quality of human capital.

Labor productivity in the economy of the Krasnoyarsk Territory in 2018 amounted to 1.33 mln RUR per employee; it increased by 0.59 mln RUR compared with 2010.

Investment activity in region's economy as a whole was unstable. However, from 2010 to 2016, in manufacturing sector, investments in fixed assets steadily increased, and decreased only in 2017 (Table IV).

**TABLE IV. DYNAMICS OF INVESTMENT IN FIXED ASSETS OF THE KRASNOYARSK TERRITORY ON FEA (AT ACTUAL PRICES; MLN RUR)**

Parameters	2010	2012	2014	2016	2017
Investments in fixed assets – total	214681	330140	312151	381779	375271
Manufacturing	42392	86997	79848	111876	81053

So, since 2010, the volume of investment in fixed assets has increased by 1.75 times by 2017. In 2017, this value compared to 2016 decreased by 6508 mln RUR.

In 2017, manufacturing occupied a share of 21.6% in the structure of investments in fixed assets having changed by 7.7 percentage points compared to 2016.

In relation to the GRP (GVA) of the Krasnoyarsk Territory, investments in fixed assets are constantly in the zone of safe economic security at 20%. For 1 RUR of investment in fixed assets, the region produces GRP of 5 RUR.

Considering physical capital as a factor of innovative activity, it should be borne in mind that it largely determines the rate of economic growth in medium term and is a complementary factor along with knowledge [5] reducing the risks of uncertainty when creating innovations.

Innovative activity of organizations in the Krasnoyarsk Territory in terms of foreign economic activity in 2017 as a whole and in the areas of innovation is most characteristic for manufacturing, information technologies, research and development.

The cost of technological innovations of the organization in 2017 amounted to 35.017 billion RUR, 55.3% of which accounted for research and development (Table V). Manufacturing accounted for 25.7% of total technological innovation costs.

**TABLE V. COSTS FOR TECHNOLOGICAL INNOVATIONS OF ORGANIZATIONS BY TYPES OF ECONOMIC ACTIVITIES IN 2017.**

Parameters	Mln RUR	%
In total, for studied types of economic activities in the field of innovations:	35017.7	-
manufacturing	8991.7	25.7
information technologies	39.5	0.1
research and development	19385.8	55.3

The dynamics of organizations' participation in technological innovations are in line with the costs incurred (Table VI). Thus, the largest share of participation can be observed in the field of research and development (10%), manufacturing (9.2%), and mining (8.3%). For almost all types of economic activity, there is a decline in values. The proportion of organizations implementing technological innovations decreased from 7.9% to 6.1%, in manufacturing – from 11.8% to 9.2%.

**TABLE VI. DYNAMICS OF THE SHARE OF ORGANIZATIONS IMPLEMENTING TECHNOLOGICAL INNOVATIONS IN THE KRASNOYARSK TERRITORY, FOR THE GENERAL NUMBER OF INVESTIGATED ORGANIZATIONS**

Parameters	2010	2012	2014	2015	2016
Total:	7.9	8.3	8.4	7.8	6.1
Mining	2.4	9.8	11.6	9.4	8.3
Manufacturing	11.8	13	10.8	11.3	9.2
Production and distribution of electricity, gas and water	10.8	8.1	10.5	6.1	6.7
Communications	13.5	9.1	8.7	10.5	6.5
Activities related to the use of computer and information technologies	10.5	7	4.5	2	1.9
Research and development	-	31.6	33.3	50.0	40.0

Stimulating the activity of organizations by type of innovation allows us to talk about the preference of technological innovations – in the Krasnoyarsk Territory in 2017; it was 6.1% of the participants in the survey (Table VII). Organizational and marketing innovations were not excluded [8] – their largest share was in research and development, 8.0% and 2.9%, respectively.

**TABLE VII. SHARE OF FEA ORGANIZATIONS IMPLEMENTING PARTICULAR INNOVATIONS IN THE KRASNOYARSK TERRITORY IN 2017, FOR THE GENERAL NUMBER OF INVESTIGATED ORGANIZATIONS, %**

Parameters	Total	Technological	Organizational	Marketing
Total for the types of economic activity surveyed:	7.1	6.1	2.3	1.0
Industrial production	9.8	8.5	2.5	1.2
Manufacturing	10.9	9.8	2.2	1.2
Information technologies	10.7	10.7	7.1	-
Research and development	23.5	20.6	8.0	2.9

Of the total costs of technological innovations in 2017 (35,017.7 mln RUR), 63.2% accounted for research and development of new products, services and methods for their production, new production processes (Table VIII). This is a positive trend in recent years: in 2010-2012, own developments accounted for no more than 15% of the costs of technological innovations.

**TABLE VIII. DYNAMICS OF COSTS FOR TECHNOLOGICAL INNOVATIONS BY TYPES OF INNOVATIVE ACTIVITY IN KRASNOYARSK TERRITORY, MLN RUR**

Parameters	2010	2012	2014	2016	2017
Total technological innovation costs	14618	24980	84719	38440	35018
Research and development of new products, services and methods for their production (transfer), new production processes	1747	6102	55509	21910	22133
Industrial engineering, design and other developments (not related to research and development)	744	399.6	567.2	20.5	4.2
Acquisition of machinery and equipment related to technological innovations	8339	13330	19868	11642	8081

Parameters	2010	2012	2014	2016	2017
Acquisition of new technologies	39.6	15.8	54.1	52.6	668.4
Of these, rights to patents, licenses for the use of inventions, industrial designs, utility models	0	0.1	0	-	0.1
Software acquisition	23	106	122	213	1140
Other types of production preparation for the release of new products, implementation of new services or methods of their production	35	52	8019	3524	741
Personnel education and training related to innovations	9.1	13.5	25.3	22.6	17.7
Marketing researches	0	15.7	16.4	-	0.1
Other costs of technological innovations	3682	4945	538	1055	2232

Thus, despite the small share of manufacturing in region's economy what is characteristic of commodity regions, it has stable dynamics determined to a greater extent by quantitative and qualitative parameters of HTC organizations.

HTC holds a share of 14-15% in region's GRP structure. It includes foreign trade activities of a high and medium technological level and knowledge-intensive industries (OKVED 21, 26, 30.1; 3, 20, 27, 28, 29, 30, 32. 5, 33; 50) [9] (Fig. 1, Table IX).

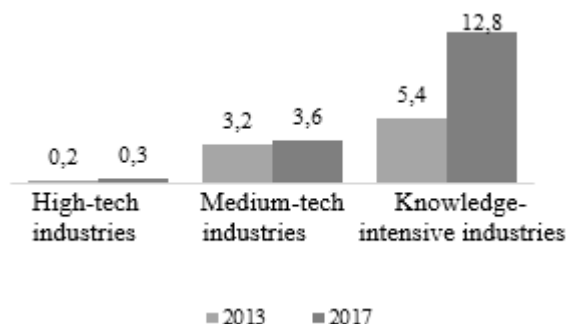


Fig. 1. The share of high-tech and knowledge-intensive industries in the GRP of the Krasnoyarsk Territory, %

In the economic literature there are several factors that determine the level of innovation activity [10-13].

In HTC analysis, the emphasis was made on parameters that have an impact on innovative activity, such as localization, size, age, and the availability of own financial resources. So, the concentration of production has an impact on the diffusion of external effects from innovation what increases the rate of creation and distribution, thus making stable feedbacks [2].

TABLE IX. RATING OF HIGH-TECH AND KNOWLEDGE-INTENSIVE SECTORS OF THE ECONOMY OF THE KRASNOYARSK TERRITORY BY SHARE IN GRP, 2017

Place	Sectors (OKVED code)	Share in GRP 2017 (%)
1	Activities in the field of architecture and engineering design; technical testing, research and analysis (71)	6.3
2	Activities of air and space transport (51)	3.8

Place	Sectors (OKVED code)	Share in GRP 2017 (%)
3	Repair and installation of machinery and equipment (33)	1.6
4	Water transport activities (50)	0.6
5	Healthcare activities (86)	0.5
6	Manufacture of motor vehicles, trailers and semi-trailers (29)	0.5
7	Chemical and chemical products manufacturing (20)	0.5
8	Activities of head offices; management consulting (70)	0.4
9	Manufacture of electrical equipment (27)	0.4
10	Computer software development, consulting in this field and other related services (62)	0.3
11	Telecommunications activities (61)	0.3
12	Manufacture of other vehicles and equipment, excluding 30.3 (manufacture of aircrafts, including spacecrafts, and related equipment) (30)	0.2
13	Manufacture of machinery and equipment not included in other groups (28)	0.2
14	Legal and accounting activities (69)	0.2
15	Manufacture of computers, electronic and optical products (26)	0.2
16	Research and development (72)	0.1
17	Production of medicines and materials used for medical purposes (21)	0.1
18	Education (85)	0.1
19	Job placement and staff recruitment activities (78)	0.06
20	Information technologies activities (63)	0.05
21	Veterinary activities (75)	0.01
22	Social security services (88)	0.009
23	Manufacture of medical instruments and equipment (32.5)	0.003
24	Residential care activities (87)	0.002
25	Manufacture of aircrafts, including spacecrafts and related equipment (30.3)	0.002

Size, according to the concept of I. Schumpeter, also determines the propensity of enterprises to innovation activity. Larger enterprises have large resources, they are able to bear losses in the case of failure and have the ability to attract qualified personnel.

Sharing of knowledge and experience of companies of different ages working on the same technological and scientific base also has a positive effect [14].

The presence of own financial resources is critical for the process of innovation activity [15]. Among the barriers to innovations, the lack of such resources, especially among small companies, ranks first [6].

The ownership form of companies determines their ability to receive innovation support from the innovation community and the government.

Average age of companies in terms of their manufacturability varies – it is higher in industries of high technological level and in knowledge-intensive industries (about 18 years); private companies prevail at all levels of manufacturability. Primary localization is in the city of Krasnoyarsk.

Table X shows the distribution of companies by high-tech industries.

TABLE X. CHARACTERISTICS OF HIGH-TECH PRODUCTIONS OF THE KRASNOYARSK TERRITORY ON JAN 01, 2019 [16]

Parameters	OKVED 21	OKVED 26	OKVED 30.3
Number of companies, pcs	4	42	2
Spatial arrangement (localization)			
– Krasnoyarsk	+(2)	+(38)	+
– Other	Zheleznogorsk (1)	4	-
Average age, years	more than 20 years – 1 less than 10 years – 3	more than 20 years – 12 from 10 to 20 years – 11 less than 10 years – 19	6.5
Type of ownership	PAO – 1 OOO – 3	AO – 4 OOO – 38	Private (OOO)

These tables confirm the conclusions made above.

Water transport activities related to knowledge-intensive ones are represented in the Krasnoyarsk Territory by 39 business entities involved in the carriage of goods and passengers by inland waterways. They are mainly concentrated in the city of Krasnoyarsk – 28 (71.8%), they are also located in the Taimyr and Dolgan-Nenets Autonomous District, in the city of Lesosibirsk, the Yenisei region. Among them, organizations registered in the form of OOO prevail; there are also 4 AOs with state participation (10.2%) and one small enterprise.

Average age of companies with state participation is 19.5 years; private companies are very different: 4 have been working on the market for more than 20 years (11.4%), 7 (20%) – from 10 to 20 years, other – up to 10 years.

The distribution of high-tech and knowledge-intensive industries of the Krasnoyarsk Territory by share in gross revenue and its growth rate is shown in Figure 2. Separately by technological level – in Figures 3-4.

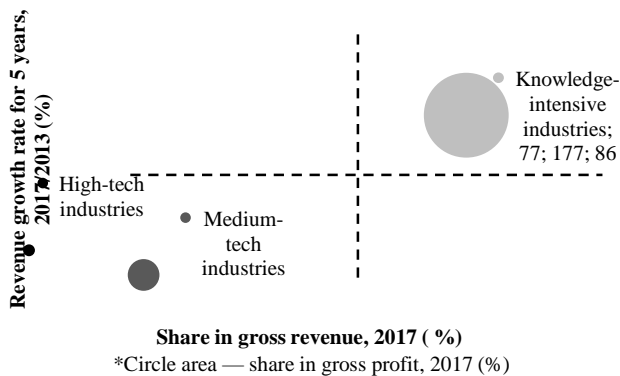


Fig. 2. BCG matrix of high-tech and knowledge-intensive industries of the Krasnoyarsk Territory [calculated according to Interfax]

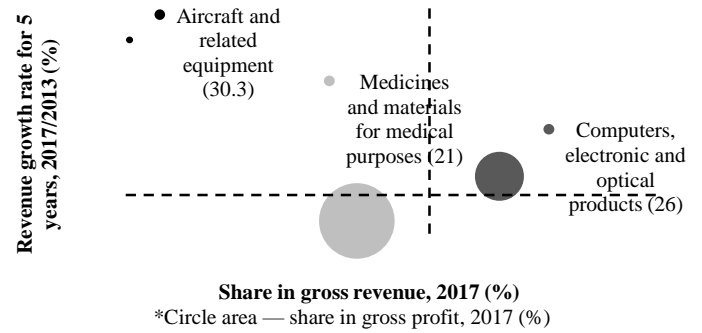


Fig. 3. Figure 3 – BCG matrix of industries of high technological level in the Krasnoyarsk Territory [calculated according to Interfax]

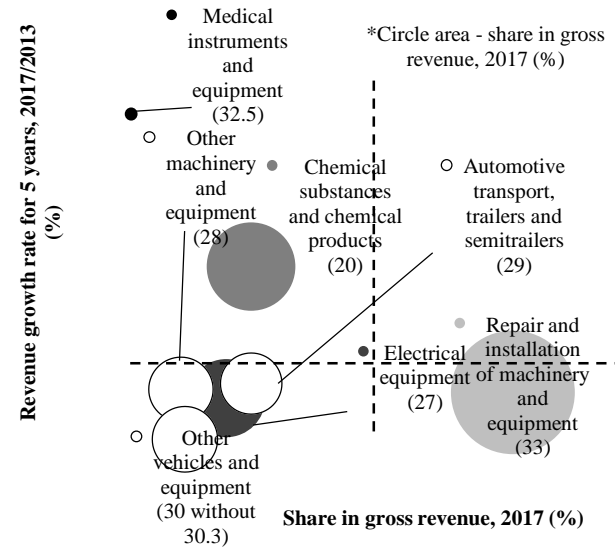


Fig. 4. Figure 4 – BCG matrix for industries of medium high-tech level of the Krasnoyarsk Territory

In terms of revenue and profit, high and medium technological levels are distinguished, with higher demand for their products and high capital turnover and with low capital intensity of production (Fig. 5).

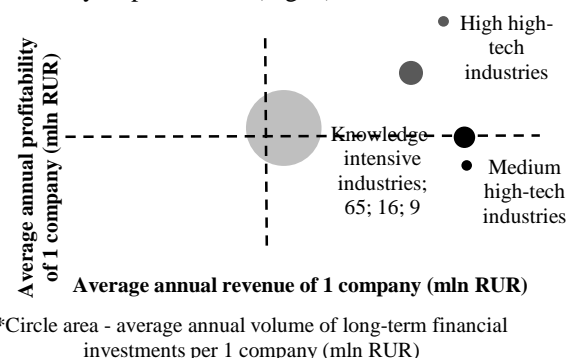


Fig. 5. Figure 5 - Positioning map of high-tech and knowledge-intensive industries of the Krasnoyarsk Territory by average financial values for 2017. for 1 company (revenue, profit) [calculated according to Interfax]

The analysis of factors having an impact on the innovative activity of region's economy and its high-tech industries allows us to draw up their competitive map which can become the basis for developing scenarios of their economic growth on an innovative basis (Table 11, 12).

TABLE XI. COMPETITIVE MAP OF HIGH-TECH AND KNOWLEDGE-INTENSIVE INDUSTRIES OF THE KRASNOYARSK TERRITORY (PART 1)

Share in gross revenue		> 10% (leaders)	3%-9% (Sectors with a strong competitive position)
Revenue growth rate		1	2
> 400% (sectors with intensively improving competitive position)	1	Activities in the field of architecture and engineering design; technical testing, research and analysis (71)	-
100%-400% (sectors with fast-growing competitive position)	2	Air and space transport (51)	Production of chemicals and chemical products (20)
1%-100% (sectors with improving competitive position)	3	Repair and installation of machinery and equipment (33)	Manufacture of motor vehicles, trailers and semi-trailers (29) Water transport activities (50) Healthcare activities (86)
<1% (sectors with declining competitive position)	4	-	-
Designations: - High-tech industries - Sectors of medium high-tech level - Knowledge-intensive industries			

TABLE XII. COMPETITIVE MAP OF HIGH-TECH AND KNOWLEDGE-INTENSIVE INDUSTRIES OF THE KRASNOYARSK TERRITORY (PART 2)

Share in gross revenue		1%-3% (Sectors with a weak competitive position)	<1% (outsiders)
Revenue growth rate		3	4
> 400% (sectors with intensively improving competitive position)	1	Activities of head offices; management consulting (70)	Manufacture of aircrafts, including spacecrafts and related equipment (30.3) Manufacture of medical instruments and equipment (32.5) Residential care activities (87)
100%-400% (Sectors with fast-growing competitive position)	2	Manufacture of computers, electronic and optical products (26)	Information technology activities (63) Veterinary activities (75) Social security services (88)
1%-100% (sectors with improving competitive position)	3	Manufacture of electrical equipment (27) Manufacture of machinery and equipment not included in other groups (28) Telecommunications Activities (61) Computer software development, consulting in this field and other related services (62) Activities in the field of law and accounting (69)	Production of medicines and materials used for medical purposes (21) Research and development (72) Job placement and staff recruitment activities (78) Education (85)

Share in gross revenue		1%-3% (Sectors with a weak competitive position)	<1% (outsiders)
Revenue growth rate		3	4
<1% (sectors with declining competitive position)	4	Manufacture of other vehicles and equipment, excluding 30.3 (30)	-
Designations: - High-tech industries - Sectors of medium high-tech level - Knowledge-intensive industries			

#### IV. CONCLUSION

High-tech industries are currently not in a favorable competitive position. If the production of computers, electronic and optical products (OKVED 26), having a small share in the gross revenue of region's high-tech complex, is in the sector with high growth rate of gross revenue which indicate the demand for basic products; then the other two activities (OKVED 21, 30.3) are outsiders in terms of share in gross revenue (less than 1%). However, their competitive position in terms of revenue growth allows, under certain circumstances related to the innovative renewal of technical and technological basis, securing a foothold in the market and increasing production turnover. It is supposed to find such opportunities using the factors mentioned in the study in order to model strategic decision making options.

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