

Knowledge-intensive markets and information technology development: conditions and results

Filimonenko I.V.
Ural Federal University
Krasnoyarsk, Russia
ifilimonenko@sfu-kras.ru

Moskvina A.V.
Ural Federal University
Krasnoyarsk, Russia
moskanna@mail.ru

Ryzhkova O.V.
Ural Federal University
Krasnoyarsk, Russia
oks_r@mail.ru

Abstract — The relevance of the formation of new high-tech markets for the transition of the region to an innovative development model is determined. A multisectoral development model focused on “smart” specialization technology has been used as an instrument of formation. Criteria for choosing priority markets and procedures for assessing the opportunities for their development with identification of the expected results are determined. The selection criteria are: compliance with the priorities of technological development of the Russian Federation, confrontation with global challenges, convergence of technologies, the ability of the region to develop, produce, use and maintain technology. A four-stage process for prioritizing the development of high-tech markets has been made. A matrix of promising high-tech markets has been formed with highlighting the direction of information and communication technologies (ICT), a circle of economic sectors has been identified that form the synergistic effects of using their results. A matrix of promising areas of development of high-tech markets in the areas of technological development (ICT, biotechnology, rational environmental management, new materials and technologies) has been compiled. The circle of potential participants in the formation of high-tech markets is determined along the chain of their life cycle from the R&D stage, through production to the consumer. Within the framework of “smart” specialization, three scenarios for the development of markets are proposed.

Keywords — *high-tech sector, ICT, compliance criteria, priority areas, synergistic effect*

I. INTRODUCTION

The relevance of the formation in the region’s economy of new high-tech sectors and fields of activity is determined by the need to accelerate the transition of the region to an innovative development model that responds to the system of global challenges of technological development [1, 2, 3].

Among the global challenges, especially critical for the raw regions of Russia, it should be noted the change in the global energy landscape, the exhaustion of mineral resources; increased influence of new technological changes; the aging of the population of the developed part of the world and the shift

of the center of economic activity to Asia; global synchronization in advanced industries; change of spatial development management systems [4, 5, 6].

In turn, the specifics of the raw material regions and global challenges of technological development hinder the transition to new technologies, impede the implementation of new formats for the interaction of regional authorities with economic agents of the “science – education – production” system, and do not allow to overcome the insufficiency of the institutional environment and infrastructural support for technological development [4].

Thus, the key task at the regional level is the formation of new sectors (new demand markets for the development of advanced technologies) that contribute to the diversification of the structure of the regional economy.

Under the current conditions, the formation of interdisciplinary responses to the global challenge system is possible using a multisectoral development model focused on “smart specialization”, based on both its own and borrowed innovations.

The concept of “smart specialization” allows us to consider [7, 8, 9, 10]:

- technological development of the sectors of the basic specialization of the regional economy (resource and raw materials, infrastructure) to ensure local niche leadership or local competitiveness. A prerequisite is the development of existing local markets for competitive products;
- the formation and development of high-tech sectors of the economy, the creation and development of new areas of activity at the regional level, allowing to explore and discover new technological and market opportunities, open new areas for cultivating regional competitive advantages. A prerequisite is the development and formation of new markets (local, national, international);

- development of the “knowledge economy” sector and the formation of creative industrial activity potential for the future diversification of the structure of the commodity economy, ensuring international technological competitiveness and world leadership of the region in new sectors of the economy, and the creation of new markets. A prerequisite for the creation of “smart” environments, “smart” systems and “smart” industries is the achievement of a synergistic effect from the integration of regional centers of production, consumption and R&D.

At the same time, the high-tech sector plays a leading role in the development of the regional economy, which should accelerate the transition to an innovative model for the development of the region.

II. RESEARCH METHODOLOGY

The development of the high-tech sector affects both the resource-raw and infrastructural sectors of the region’s economy, ensuring their transition to the fifth and sixth technological modes through the production of products capable of applying for “local niche leadership” or “world leadership in the local economy” [11].

As a result of achieving a synergistic effect from the integration activities of the regional centers of production, consumption and R&D, the “knowledge economy” sector is developing. The products of this sector are the creation, dissemination and use of knowledge on the basis of modern ICT for the development of “smart” technologies, industries, systems that ensure international technological competitiveness and world leadership of the region in new sectors of the economy [11]. The formation of this sector is seen as a transition to the sixth technological mode of development (the creation of artificial intelligence and global information networks). The intensity of development of the sector and related markets is determined by the structure of the innovation system, the costs of innovative and intellectual resources, and the development of information infrastructure.

Within the framework of this study, the task of identifying priority areas for the development of the high-tech sector of the region and its competitive positions in the space of strategic alternatives within the framework of global markets and, above all, through the development of ICTs was solved.

The object of the study was the economy of the region and its high-tech sector, focused on the use of information technology. The information base of the study included the results of federal and regional statistical observations, strategies for scientific, technological and innovative development of the Russian Federation and the Krasnoyarsk Territory.

As the main methodological tools, we used systemic and strategic approaches in various versions of their interpretation by Russian and foreign experts, as well as our own methods developed by the authors in previous studies.

III. RESULTS OF THE RESEARCH

Assessing the development opportunities of the high-tech sector of the economy and high-tech markets by prioritizing based on selection criteria was carried out in five stages, presented in Figure 1.

As a result of applying the proposed approach in the Krasnoyarsk Region, the main areas of technological development include [12]:

- active use of information and communication technologies (ICT): large-scale use of computer models, databases, information collection and processing systems;
- development and use of biotechnologies in various areas of the economy (industry, agriculture, medicine, services, etc.) with different goals (obtaining new products, replacing traditional processes and products with biotechnological ones, waste processing, development of biomedicine);
- rational nature management: transition to renewable energy sources; energy and resource saving, non-waste technologies; closed cycles of water use; emission control technologies; environmental restoration; maximum deep processing of natural resources; application of friendly

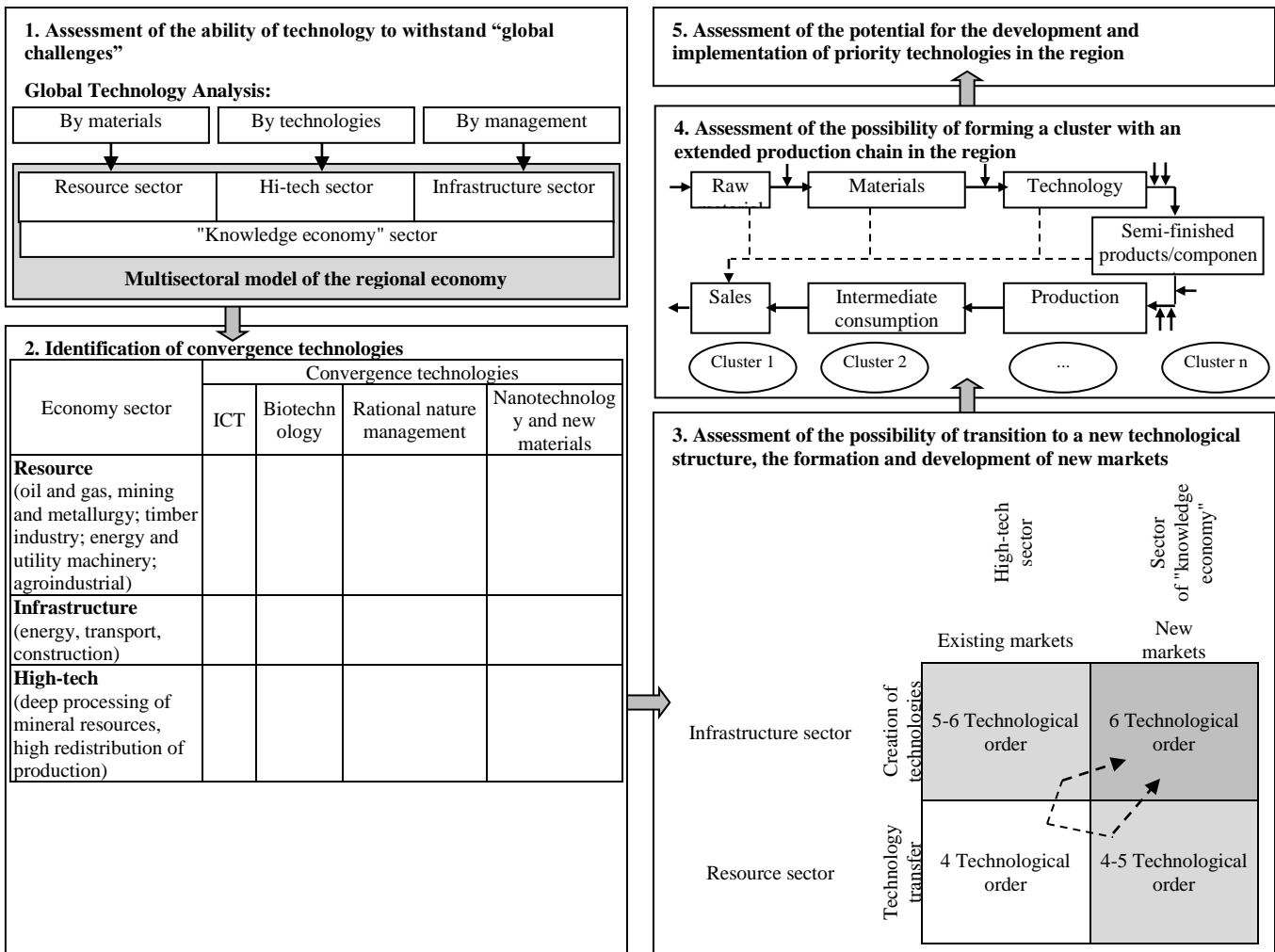


Fig. 1. Stages of prioritization of technological development

environment and human non-toxic and biodegradable materials;

- creation of new materials and the development of nanotechnology - nanostructured and composite materials, materials with special properties, nanoparticles, and nanofibres, etc.;
- Smart Solution (cognitization of large systems) — the creation of "smart" processes, industries, cities (based on the collection and analysis of large amounts of data, optimization of processes with "flexible" behavior), allowing the distribution of network formats for managing production and society.

The introduction of these technological areas in the region's economy is characterized by wide industry coverage and provides maximum synergetic effects of economic, social and environmental development of a particular region and the country as a whole [12].

Priority technologies are assessed over the entire range of criteria (Table I) and transformed into a matrix of promising high-tech markets (Table II).

Four areas were identified as priority ones, among them: ICT and Smart Solution.

TABLE I. PRIORITY AREAS OF TECHNOLOGICAL DEVELOPMENT OF THE KRASNOYARSK REGION UNTIL 2035 IN THE DIRECTION OF ICT

Indicators	Content
Assessed criteria	<ul style="list-style-type: none"> • Corresponds to the priority areas of development of science, technology and technology in the Russian Federation; • Conforms to critical technologies of the Russian Federation; • Corresponds to sections of the R&D ("Markets": AeroNet, NeuroNet, EnergyNet, SafeNet; «Technologies»: digital design and modeling; BigData; artificial intelligence and control systems) • Corresponds to "global challenges"; • Compliance with the targets and development priorities of the Krasnoyarsk Region.
Directions of technological development in the sphere of ICT	<ul style="list-style-type: none"> • Equipment for new generations of communication networks, including information and space systems, with promising access to global markets for technology and high-tech products; • Technologies of computer monitoring, control, forecasting, risk assessment, security in complex systems (transport, energy systems, city, climatic and geological processes); • Technologies for managing complex systems — "smart city", "smart transport", "smart power systems". BigData systems for the city, for medicine, etc. with promising access to global markets; • Technologies of artificial intelligence, machine learning, including relying on supercomputer models of distributed computing; • Technologies for computer modeling of systems and processes for the mining and metallurgical, oil and gas, construction, forestry and agricultural sectors: predictive assessment of deposits, designing their development, modeling and automation of production processes, designing machinery and equipment; • Computer technologies for forest and agricultural resources management, BigData systems for forestry.
Directions of technological development in the direction of Smart Solution (cognitization of large systems)	<ul style="list-style-type: none"> • Technologies for managing complex systems — "smart city", "smart transport", "smart power systems". Big Data systems for the city, for medicine, etc. with the prospect of entering global markets; • Technologies of computer monitoring, control, forecasting, risk assessment, security in complex systems (transport, energy systems, city, climatic and geological processes); • Technologies of artificial intelligence, machine learning, including relying on supercomputer models of distributed computing; • Energy-saving technologies, environmentally friendly technologies in industry and infrastructure sectors; • Technologies of computer monitoring, control, forecasting, risk assessment, security in complex systems (transport, energy systems, city, climatic and geological processes); • Health care system and medical services: telemedicine technologies, high-tech medical services in the field of prevention, diagnosis, treatment, rehabilitation; • A new generation of cognitive technologies for the formation and support of "collective intelligence" using information and communication platforms with the prospect of entering global markets for technologies and high-tech products.

TABLE II. A MATRIX OF PROMISING AREAS OF DEVELOPMENT OF HIGH-TECH MARKETS IN THE FIELD OF ICT

High-tech sector of the economy			
Biopharmaceutica l	Mineral processing	High redistribution of production	High-tech manufacturing engineering products
Development of information models of macromolecules, cells, tissues, organs	Modeling of energy technologies and systems. Modeling and implementation of communication channels of enterprises in remote territories, including the Arctic zone.	Development of technology 3D modeling of processes of opening and development of deposits; Modeling the required level of extraction of the necessary substances from the fields	Design of space information systems. Design of information, control, navigation systems AeroNet, NeuroNet

IV. DISCUSSION OF RESULTS

As a result of the study, priority areas for the development of information technologies were identified. At the same time, one of the main tasks of the development of such technologies is to ensure maximum synergistic effects of the development of the regional economy. In particular, the possible effects are shown in Table III.

The study of the scientific, technological, industrial and educational environment made it possible to determine the circle of potential participants in the processes of the formation of high-tech markets in the direction of using ICTs that form production centers. Below is a snippet of a list compiled for two scenarios for the development of information technology in regional (niche) and international spaces.

Potential production centers capable of ensuring the development of a strategy of international technological competitiveness (creation of own parent technologies and innovative professional competencies; new markets):

1) Development of technologies of geographic information systems for city life management (monitoring and infrastructure management): Krasnoyarsk branch of OJSC Research and Production Center "Nature" (State Information System of specially protected natural territories of the Krasnoyarsk Territory); Technological center of geoinformation systems of LLC Geola (SIS-technologies in geology and geophysics, engineering geodesy); JSC "Cadastre Survey" (projects Interactive map of the city of Krasnoyarsk; single municipal SIS);

TABLE III. PRIORITY AREAS OF TECHNOLOGICAL DEVELOPMENT AND SYNERGISTIC EFFECTS IN THE DIRECTION OF INFORMATION AND COMMUNICATION TECHNOLOGIES [12].

Priority of technological development	Synergetic effects of the development of the Krasnoyarsk Region
ICT	<p>Economy</p> <ul style="list-style-type: none"> • transition to a knowledge-based economy; • e-government; • unification of interagency interaction through electronic state and socially significant services; • deepening cooperation between universities and business; • development of regional e-commerce, the formation of legislative and technological mechanisms for electronic transactions; • the use of IT infrastructure models to overcome spatial differentiation in the regional economy; • the growth of ICT specializations and the number of ICT employees in related industries <p>Social:</p> <ul style="list-style-type: none"> • improving the quality of life of people with disabilities; • citizen involvement in management; • change in the nature and method of employment of workers <p>Ecological:</p> <ul style="list-style-type: none"> • Harnessing ICT Applications for the Environment
Smart Solution (cognitization of large systems)	<p>Socio-economic:</p> <ul style="list-style-type: none"> • ensuring the collection and analysis of large amounts of data, the optimization of processes with "flexible" behavior; • increase in accessibility and quality of services, effective speed and stability of transport communications in conditions of heavy traffic (organization of high-speed and high-speed traffic); • the ability to enter international markets: multimodal transport and logistics systems of freight and passenger transportation; new materials and technologies for transport construction; promising vehicles and systems; space services • creation of a new investment platform for the development of international and Russian business, scientific, educational and business activities; • ensuring comfortable and safe life

2) The development of process optimization technologies with "flexible" behavior based on digitalization and management intellectualization, including:

- vehicles and road infrastructure: INFOCOM LLC (Design and installation of a computer network, outsourcing and service, software development, computer equipment, retail equipment, IT infrastructure (engineering and cloud solutions), Systematics LLC (Software, advertising), Krasprigorod OJSC (Wi-Fi in transport);
- traffic in order to optimize the use of transport routes and cars, to ensure road safety: PJSC Kedr Bank (issuing a transport card combined with a bank card based on hybrid technology);
- the resource efficiency of the functioning of engineering infrastructures (energy networks, water supply, heat supply systems), energy consumption

based on the introduction of new standards (direct: requirements for the efficiency of household appliances; indirect: requirements for housing construction, excluding the possibility of using energy-intensive devices), decentralization of energy systems with the controlling role of urban communities: SVS-Krasnoyarsk LLC (Equipment related to energy-saving technologies, renewable and alternative energy sources: vacuum solar collectors and solar water heaters, solar panels and LED street lighting powered by solar panels, wind generators), CrystalSvet LLC (energy-saving LED products);

- the construction of intelligent buildings, neighborhoods, including those based on energy-information systems for implementing the programs "energy-efficient home" and "energy-efficient city" (SMART GRID): Architectural bureau Nikken Sekkei (Japan), Monolithholding LLC (Krasnoyarsk Region), Preobrazhensky residential complex developer, Sibiryak Insurance Company (Krasnoyarsk Region), Krasnoyarsk-CITI LLC (Krasnoyarsk Region), Sibirsky Scientific and Production Center LLC Research Institute of the Cement Industry (Development of a feasibility study, business plans, technological regulations for the production of cement, a technological audit, development and certification of methods);

3) Creation of multimodal transport and logistics systems of freight and passenger transportation: ISS OJSC, Krasnash OJSC, Radio Plant, Radiosvyaz Scientific Production Enterprise OJSC, Prima Telecom OJSC, Iskra Design Bureau OJSC, Center for Applied Electrodynamics LLC, NPO-Razvitie OJSC, Airtrans Krasnoyarsk Shopping Center, Azimut Shopping Mall

Potential production centers capable of ensuring the development of a niche leadership strategy (import of technology and professional competencies; traditional markets; new markets):

1) Technologies of industrial automation and control of production processes (robots): Sibir-RTSoft (automation of buildings and utilities); Krasnash OJSC (IT-Enterprise production management system; on-line shop management system (MES) based on the IT-Enterprise system);

2) Development of electronic components for power and low-current electronics for use in intelligent energy systems, including for energy conservation: Russian Electronics OJSC (Emergency mobile warning systems. The system sends regular SMS messages to the phones of subscribers located in the emergency zone);

3) CCTV technologies for public safety: Russian Electronics OJSC, Chinese ZTE Corporation (Safe City Integrated Information System), a unique development of creating a special communication system based on GoTa technology based on a domestic software and hardware

complex to ensure the effective operation of operational teams, forecasting and preventing incidents and violations);

4) Distance education technologies (open on-line courses; electronic educational resources): Federal State Autonomous Educational Institution of Higher Education, Siberian State Autonomous University, Federal State Educational Establishment of Higher Education Siberian State Technical University (Distance education in universities of the city of Krasnoyarsk, the possibility of obtaining information in a high-quality, well-structured form, with the possibility of qualified advice and subsequent, professional skills);

5) Digitalization technologies for social services (consulting on computer hardware; software development and consulting; creation and use of databases and information resources, including Internet resources): TIRR plus LLC (Electronic Record in Polyclinics), MedBioTech LLC, Krasinside Company, (Information Support for the Correct and Safe Administration of Medicines), Beeline (Mobile Payments - Pay with your mobile device for parking, for traveling by electric train for takeaway coffee, etc.);

6) Propagation of mHealth, eHealth technologies: "Green squad" (Environmental events: gardening and improvement of the city, environmental campaigns and lessons), Sibiryak Insurance Company, Leroy Merlin shopping mall (Battery public campaign - collection of waste batteries)

In addition to production centers, the basis for the development of high-tech industries and high-tech markets is R&D centers, which provide the scientific basis for the development and implementation of innovations. Among these centers of the Krasnoyarsk Region are the following: Institutes of the SB RAS, Industrial R&D, Institute of OJSC Krasnoyarsk PromstroyNIIproekt, higher educational institutions (for example: SFU, FSBEI HE SibGAU, FSBEI HE SibGTU, Krasnoyarsk State Medical University), Engineering Centers, Industrial Parks (Zheleznogorsk, Divnogorsk, Podgorny).

V. CONCLUSION

Thus, the methodology proposed in the article for identifying promising high-tech markets and the results obtained using it allow us to strengthen the competitive advantages of specialization industries and reconfigure regional management formats based on the existing potential of innovative technology development and breakthrough technologies.

At the same time, the study makes it possible to understand that a significant role in the development of high-tech regional markets and the regional economy is assigned to the development of information technologies that will be involved in various sectors of the economy. From the point of view of

the presence of companies capable of producing and implementing information technology, the Krasnoyarsk Territory has the corresponding potential.

The proposed methodological approach to highlighting promising markets regarding the use of ICT can be used by other researchers.

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