ISSN 0798 1015

REVISTA ESPACIOS

HOME Revista ESPACIOS ÍNDICES A LOS AUTORES

GERENCIA • GESTÃO • MANAGEMENT Vol. 39 (Nº 01) Year 2018. Page 2

Institutional Anomalies of Russian Nanoindustry: «Gaps», «Traps», Dysfunctions and Failures

Anomalías institucionales de la nanoindustria rusa: «brechas», «trampas», disfunciones y fallas

Daniil P. FROLOV [1]; Anna V. LAVRENTYEVA [2]; Ivan D. POLYNTSEV [3]

Received: 01/11/2017 • Approved: 30/11/2017

Contents

ABSTRACT:

Institutionalization of new general purpose technologies includes a range of stages that are peculiar for typical institutional anomalies. At the stage of recognition, acknowledgment, and start of lobbying of general purpose technologies, various forms of heteronomy are manifested – i.e., co-existence of the institutes of the previous and new modes (including institutional "holes", "emptiness", "gaps", etc.); hypogenesis (insufficient development) of the institutes that support the new mode; high risks of formation of fuzzy institutes. The stage of active state support, complex formal institutionalization, and expansion of general purpose technologies are peculiar for the following risks: development of state's "failures", including incorrect determination of top-priority directions of budget support under the influence of rent-oriented behavior of sectorial lobby; lock-in of the technological evolution on a sub-optimal trajectory under the influence of very tough standardization and excessive regulation; distorted collaboration, peculiar for a complex balance of cooperation and opportunism. The stage of social legitimization of general purpose technologies is related

RESUMEN:

La institucionalización de nuevas tecnologías de propósito general incluye una serie de etapas que son peculiares para las anomalías institucionales típicas. En la etapa del reconocimiento, del reconocimiento, y del comienzo del cabildeo de las tecnologías de fines generales, se manifiestan varias formas de heteronimia- es decir, la coexistencia de los institutos de los modos anteriores y nuevos (incluyendo "agujeros institucionales", "vacío", " brechas ", etc.); hypogénesis (desarrollo insuficiente) de los institutos que apoyan el nuevo modo; altos riesgos de formación de institutos difusos. La etapa del apoyo activo del estado, la institucionalización formal compleja y la expansión de las tecnologías de propósito general son peculiares para los siguientes riesgos: desarrollo de los "fracasos" del estado, incluida la determinación incorrecta de las direcciones de prioridad superior de apoyo presupuestario bajo la influencia del comportamiento orientado al alquiler del lobby sectorial; bloqueo de la evolución tecnológica en una trayectoria subóptima bajo la influencia de una estandarización muy estricta y una regulación excesiva; colaboración distorsionada,

to development of mental anomalies (negative mass stereotypes) and pathologies (technofobia). Institutional anomalies of formation of nanoindustry in the RF include negative effect of path dependence, related to establishment of the model of overtaking development; deficit and fuzziness of normative institutes (underdevelopment of terminology and classification of nanotechnologies and products of nano-industry, absence of professional standards, etc.); irrational mental models (deficit of trust, technophobia, etc.); hypogenesis and disfunctions of the institutes of development due to high rates of their implementation and weak complimentarity. For overcoming the anomalous forms of nanoindustry's institutionalization, involvement of the wide circle of stakeholders into the process of creation of institutes and mechanisms of its regulation is very important.
Keywords: Russian Nanoindustry; institutional anomalies; active state support

peculiar para un complejo equilibrio de cooperación y oportunismo. La etapa de legitimación social de las tecnologías de propósito general está relacionada con el desarrollo de anomalías mentales (estereotipos de masa negativa) y patologías (technofobia). Las anomalías institucionales de la formación de la nanoindustria en el RF incluyen el efecto negativo de la dependencia de la trayectoria, relacionada con el establecimiento del modelo del desarrollo del sobrellevar; déficit y ambigüedad de los institutos normativos (subdesarrollo de la terminología y clasificación de las nanotecnologías y productos de la nanoindustria, ausencia de estándares profesionales, etc.); modelos mentales irracionales (déficit de confianza, tecnofobia, etc.); hypogénesis y disfunciones de los institutos del desarrollo debido a los altos índices de su puesta en práctica y de complementariedad débil. Para superar las formas anómalas de la institucionalización de la nanoindustria, es muy importante la implicación del amplio círculo de partes interesadas en el proceso de creación de institutos y mecanismos de su regulación.
Palabras clave: nanoindustria rusa; anomalías institucionales; soporte activo del estado

1. A general overview

Institutional anomalies form not only progressively, slowly "gnawing" the existing institutions and fixing various forms of agent behavior regularities' going beyond social norms, but in a revolutionary way, thus accompanying radical innovations. Establishment of new technological mode at the beginning of the 21st century is, in our opinion, an example of institutionalization speed lagging behind the rates of progress of "breakthrough" technologies, which led to quick emergence of the complex of various institutional anomalies. According to the most experts, nanoindustry could become inter-sectorial basis of the new mode, so analysis of anomalous forms of its institutionalization has theoretical and practical significance – the more so because study of negative forms and effects fo institutional development of nanoindustry is an object of small number of works.

Nanotechnologies is a very wide term, relating to many high technologies which operate with extremely small objects, the sizes of which vary in the range of several hundreds of nanometers. The sense of nanotechnologies consists in the fact that in nano-scale, classical laws of physics give way to quantum laws which often lead to materials' having completely new and unique features. According to many experts, nanotechnologies can become the general purpose technologies (GPT) - like electricity, steam engine, and computer. Specifics of this type of technologies is related to their application in many spheres of economy (industry, agriculture, trade, communication, transport, healthcare, education, etc.), which creates multiplicative effect of influence on other technologies, thus stipulating labor effectiveness and leading to substantial social changes. At that, being productive in short-term, mid-term, and long-term, the GPT could lead to painful structural shifts in economy and suppose large investments – primarily, into infrastructure.

Institutionalization of the GPT and industries, which are based on them, is a multi-stage process and includes a range of stages, each of which is related to typical anomalies of institutional nature:

1. The stage of informal and stochastic institutionalization of GPT includes determination of the direction of scientific search, conduct of fundamental research, inventions, creation of scientific groups, and expansion of presence in informational environment. Collaboration (creative cooperation) at this stage has an informal nature, resource base is unstable, and goals and perspectives of the research are unclear and not obvious. This stage is primarily peculiar for mental anomalies, crated by inertia of public, on the whole, and intra-science stereotypes, related to top-priority directions of research, and evaluation of perspectives of new inventions.

In this sense, example of nanotechnologies is very vivid: although, the basic concept of scanning tunnel microscope – the main tool for study of nano-particles – was developed in 1981, in the mid-1990's this problem was researched only by several scientific groups.

2. Stage of recognition, first acknowledgement, and start of lobbying of the GPT is related to conduct of fundamental and applied research, R&D works, promotion of their results, attraction of influential lobbyists, creation of influence groups, and development of forecasts and reports in potential and perspective of new GRP. At this stage, various forms of generonomy appear, i.e., co-existence of institutions of previous and new modes, including institutional "holes", "emptiness", "breaks", etc. Besides, this stage is peculiar for hypogenesis (insufficient development) of institutions which support new technological mode: there are no coalitions and groups of interests, research programs, strategies of state support, etc. At that, risks of formation of unclear institutions are high: in particular, in the process of development of the National nanotechnology initiative of the USA, the notion of nanotechnologies became more and more obscure for the purpose of receipt of budget financing for the least possible range of breakthrough research.

3. The stage of active state support, complex formal institutionalization, and expansion of the GPT includes development of strategic documents (initiatives, strategies, and programs) of research and infrastructural development, inclusion of new GPT into the list of priorities of scientific & technical development and corresponding change of policy of budget and non-budget (grant and venture) financing, formation of specialized structures (centers, institutes, departments, etc.), and development institutions. This stage is characterized by risks of state's "failures", including incorrect determination of the structure of top-priority directions of budget support. Even foresight-forecasts, created on the basis of attraction of wide range of experts, cannot predict the future of emerging technologies, due to fundamental uncertainty of perspectives of their development, spheres of practical application and commercialization. It is noted that foresights often become a kind of "translators of intellectual fashion", i.e., actual set of high expectations in regard to the rapidly developing technologies ("mass technological mythology") 4. Thus, in 1960's, mass character was peculiar for expectations of quick colonization of space and the Moon, creation of orbital productions, development of the bottom of the World Ocean, development of ultrasonic passenger transportation, etc. In 1970's, expectations, related to intense "green revolution" and solving the problem of hunger on the planet, won. In 1980's, mass expectations were related to creation of artificial intelligence and large-scale use of robotics in the sphere of production, service, and everyday life. These high expectations, as irrational stereotypes of public conscience, are fixed in stable anomalous forms of mental institutions. Besides, various interested groups, related to the new GPT, often lobby specific directions of research and development, in which they have competitive advantages, and do not wish to create an objective picture of technological development in the process of foresight. As V. Mau notes, lack of objective criteria of identification of technological and sectorial priorities of state support "may lead to the top-priority sectors being the ones which have maximal lobbying capabilities" 5, which would change the trajectory of technological development of economy under the influence of rent-oriented behavior of sectorial lobby.

This stage is also characterized by high probability of improper use of institutions, including manipulating and disguising the R&D and business activities which have very slight relation to the new GPT. This is caused by the fact that any innovational technologies are the result of technological evolution and usually have many-generation structure. Insufficient account of this circumstance at the stage of formal institutionalization of the GPT leads to obscurity of institutions (including laws, strategies, etc.), allowing manipulating them and receiving budget support for research and development of traditional nature. In particular, the classification of bio-industry, used in China, takes into account biotechnologies of various generations – traditional, modern and future: for example, traditional ones include technologies of zymolysis (ferments), traditional Chinese medicine (extracts, ointments, etc.), and biologically active additions (nutrients, functional food products, etc.), while perspective (future) biotechnologies include bio-chips, cloning, genome technologies, nanobiotechnologies, bioenergetics, development of biocomputers, etc. [6] It is obvious that volumes and forms of state support for corresponding industries differ a lot. On the contrary, in the Complex program of development of biotechnologies in the Russian Federation until 2020, bioindustries and biotechnologies are differentiated inly in sectorial aspect, which creates a risk of scatter of budget assets for support for different generations of biotechnologies. Similarly, in the sphere of nanotechnologies, the process of their differentiation in the process of accounting, forecasting, and support just begins. Experts emphasize that most of forecast of development of nanotechnologies are focused at evolutional nanotechnologies, related to miniaturization [7]. These, for example, are technologies of production of semi-conductors, nano-powders, etc. – studies in these spheres has been conducted since 1950. Revolutionary nanotechnologies are related to realization of molecular self-assembly and construction of objects at atomic level ("atom-by-atom"). This, even with simplified binary classification, there is a necessity for more detailed approach to regulation of nanoindustry. Besides, at the stage of early institutionalization, the set standards and strategies with too tough directions and purpose of development of GPT lead to the growth of lock in risk of technical evolution at sub-optimal trajectory; in other words, excessive specification at this stage is harmful and may lead to anomalous institutionalization of GPT.

One of the specific forms of institutional anomalies in the sphere of high technologies is anomalous collaboration. Collaboration is a creative cooperation in innovational sphere, related to joint research and developments, which results in receipt of common intellectual product. However, confidentiality of commercial information and proprietary (based on private property and patent law) nature of nanotechnologies and nanomaterials is a significant obstacle for cooperation, stimulating opportunistic behavior. At that, without collaboration of nanotechnological companies, including attraction of universities and R&D institutions, receipt of existing scientific & applied results is impossible, as innovational processes in nanoindustry are capital-intensive and suppose collective use of complex and costly equipment, as well as creation of the groups of researchers, engineers, and market specialists for development of offers which are in demand by market. That's why distorted models of collaboration appear which are characterized by complex balance of cooperation, opportunism, and fraud.

Besides, it is necessary to emphasize the risk of emergence of specific inter-institutional "gap" at the viewed stage of GPT evolution. As Y. Sergienko noted, at the stage of emergence of technological mode (and corresponding GPT), innovators act under the conditions of tough resource and, in particular, financial limitations, which is a motive for their cooperation, creation of informal groups and institutions. With expansion of informational field of the new GPT and start of its wide state support, creditors (banks, venture funds, etc.) more often pay their attention to innovators and support their projects actively. As a result, innovators' need for institutions of informal cooperation disappears, and they pass to competitive struggle in formal and legal field [8]. The success of the viewed stage of institutionalization of new GPT depends in the level of cost of transfer from domination of informal institutions to prevailing of formal ones.

4. Stage of involvement of large private capital, "technical fuss", and "bandwagon effect" supposes high-quality increase of investment activity of private business against the background of highly optimistic forecasts of GPT development, quick growth of the number of stakeholdersв (from researchers to speculators), "boom" of startups, formation of new markets, and deepening of their niche structure – with transfer to re-assessment of GPT personnel, realistic correction of forecasts and rationalization of volumes and structure of investments. The main institutional anomaly at this stage is market's "gap" – in particular, of the venture investments market and fund market. Thus, in the end of 1990's, under the influence of general euphoria before beginning of the "new economy" – which was forecasted by many experts – quick growth of prices for Internet-companies (dotcoms) shares began – it ended in 2000 with the fall of the NASDAQ index. At that, investors were ready to invest into any projects related

to IT and E-commerce, and startups directed most of attracted investments into advertising and brand promotion. According to C. Perez, this tendency is peculiar not only for IT but for any developing technologies which pretend for the role of GPT 9. High expectations, based on blind trust into continuous technological progress 10, strengthen cumulatively and lead to growth of financial "bubble", which then is negatively reflected on the rates and directions of GPT development. Besides, at this stage, risk of disfunctions of the mechanism of commercialization of innovations, based on the new GPT, with the "overshooting effect" is rather high. Sense of this effect consists in offering the product, technological parameters of which exceed the needs of targeted groups 11. According to N. Carr, in the sphere of IT, needs of users do not observe the Moore law, according to which efficiency of computers grows exponentially and is doubled every two years 12. This difference leads to the moment when excessively functional models of computer technics become unwanted and are driven from the market by cheaper analogues.

At this stage, there could be defects and obscurity of the legal base and disfunctions of development institutions, which is caused by high inertia and, correspondingly, low adaptability of institutional structure as compared to technological structure of economic mode. For example, in case of nanotechnologies, defects and disfunctions of the system of regulation are caused by lack of generally accepted and precise definitions of nantotechnological companies and products, which complicated collection of information and leads to inadequate strategic solutions. Due to quick development of nanotechnologies, regulatory measures are performed in the regime of permanent underrun; at that, there is not enough time for formation of empirical base for risks of nanoinnovations – in particular, their toxicity, ecological danger, cancerogenic and teratogenic effect, etc. The problem is that many of the existing legal acts and regulating documents in the sphere of food products, chemicals, cosmetics, etc. could be theoretically applied to nanomaterials, but it is unclear how effective their application will be and whether they need to be adapted. The result could be the growth of obscurity of regulatory institutions and increase of costs of market adaptation of nanotechnologies**.**

At the modern stage of development of the system of regulation, main efforts and solutions are focused at national and regional levels, while international aspects of coordination and regulation of nanotechnologies development rarely are the center of international cooperation. Thus, the foundation for future institutional "gap" 13 is set, as globalization of nano-science and quick growth of international trade of nano-products in mid-term will need transnational coordination and harmonization of existing legal regimes in the direction of elaboration of unified global regime of nanoindustry regulation. Despite common (universal) features), approaches to regulation of nanotechnologies and specific legal regimes in various countries differ significantly (in particular, in the EU and USA), which increase the risk of the path dependence effect, which will hinder the international convergence (approach) of regulation systems. As new risks of nanotechnologies could be determined in the process of their wide use, regulatory institutions will constantly change. It is highly probable that in mid-term, there is a need for framework international convention, similar to the Vienna Convention on Ozone Layer Protection and the Montreal Protocol on Substances that Deplete the Ozone Layer.

5. The stage of social institutionalization is related to public acknowledgement and "quickening" of GPT, or its refusal and survival. At this stage of institutionalization of the new GPT, a key role belongs to its correspondence to public expectations, ideas, beliefs, and values, so it is difficult to overestimate the meaning of image, reputation, and social capital (i.e., resource of support for loyal social base). In case of new GPT, at the stage of its full-scale implementation and application in various spheres of life, people face (as in case of any completely new phenomenon) total uncertainty, which stimulates emergence of mental anomalies: irrational beliefs, negative stereotypes, and technological phobias. In particular, in 1980's, "radiophobia" and expectation of "folding" of research and projects in the sphere of energetics acquired mass character; in 1990's, destructive stereotypes formed regarding gene engineering and genetically modified organisms, which significantly restrained the progress of biotechnologies.

Misbeliefs regarding new GPT have a tendency for turning into mass stereotypes, which are very difficult to change. That's why, according to T. Eggertsson, a very important, though most often ignored, tool of institutionalization of innovational technologies is belief aimed at creation of new and change of existing beliefs and ideas 14. Social legitimization (acknowledgement and approval) of GPT shows availability of powerful social base which allow, on the one hand, performing mass production of popular markets of high-tech products of consumer purpose, high demand on which will be ensured by formation of new norms, models, and consumption standards. On the other hand, "fixing" of GPT in society means expansion of types and methods of activities (professions, model of consumption and leisure, types of business, etc.), i.e., institutions. For example, success of Internet technologies was largely predetermined by their deep integration into the system of social division and cooperation of living, which led not only to wide specter of specialties and professions, types of E-business and service, but to formation of multiple forms of behavior related to the Internet (web-surfing, purchase in the Internet stores, online banking, blogging, role online games, communication in social networks, use of mobile applications for self-development, etc.), due to which these technologies became the basis for habitual practices of everyday life of a lot of people.

At that, new GPT often generate destructive models of behavior. Network can emphasize negative behavioral schemes or even create unexpected social pathologies 15, such as grabbing (interception of Internet traffic), spamming (mass sending of ad messages), fishing (unlawful receipt of logins and passwords), trolling (placement of provoking messages), carding (stealing money from E-account and banking cards), etc. In their turn, nanotechnologies can lead to appearance of new types of fraud, illegal collection of information, and even terrorism. Wide use of bio- and nanotechnologies covers a large circle of ecological and ethical problems, which, if ignored, can be a factor of restraining the nanoindustry development 16. For example, nano-materials are an "invisible" component of many consumer goods, which are already in the market (from sports equipment and household appliances to construction materials and cosmetics), so appearance of significant risks, which are peculiar for any specific nanotechnology or even specific nanomaterial could – is mass conscience – be transferred to all nanotechnologies and nanoindustry on the whole, which would lead to quick decline of demand and decrease of sales markets. Nevertheless, forecasts and reports, strategies and programs of development of nanotechnologies almost do not influence the issue of their approval by society 17 and, which is wider, their institutionalization, which can - with high level of probability – be manifested in development of mental anomalies and pathologies (technophobias).

Substantial communications, which form relations and exchange of opinions of stakeholders, are especially necessary for social institutionalization of nanotechnologies which are skeptically treated by the public. Traditional approach to interaction of science and society, based on informing the society on the results of scientific progress, becomes less preferable. Society does not like patronizing and explanatory tone of scientists, so there is a need for subtler approach, based on science's understanding of needs and ideas of society, including its illusions and phobias. There is a necessity for interactive dialogue with various social groups, supposing their interested involvement with the field of nanoscience. Besides, if printed mass media are inclined to emphasize positive sides of nanotechnologies and related sensational inventions, population is largely troubled with risks that thy bear. It is obvious that risk factor is the most important communicational problem – in particular, related to subjective treatment and evaluation of real risks of nanotechnologies. Evidential empirical base, which confirms their presence and peculiarities for various nanotechnologies and nanomaterials, is still at the stage of formation. That's why society needs strong proofs and fair discussion of negative aspects of nanotechnological process.

In general form, institutional anomalies, peculiar for various stages of institutionalization of new technologies of wide use and based on technological modes are shown in Table 1.

Table 1

Institutional anomalies of various stages of institutionalization of new technological mode

Stage	Content of stage	Institutional anomalies
Stage of informal and stochastic institutionalization of GPT	Conduct of fundamental research, expansion of informational presence, and development of informal institutions of collaboration and financing	Mental anomalies (inertia of public and intra-science stereotypes regarding perspectives of technological progress)
Stage of recognition, first acknowledgment, and start of lobbying of GPT	Conduct of fundamental and applied research, R&D works, promotion of their results, creation of influence groups, and development of forecasts and reports	Getronomy of institutions of old and new modes (institutional "holes", "gaps", "breaks", etc.), hypogenesis of normative and structural institutions, creation of obscure rules and strategies
Stage of active state support, complex formal institutionalization, and expansion of GPT	Development of strategic documents (initiatives, strategies, programs) of research and infrastructural development, inclusion of new GPT into the list of priorities of budget financing, formation of infrastructural institutions (centers, departments, laboratories, technological parks, business incubators, etc.) and development institutions	"Gaps" of the state, including incorrect determination of priorities of budget support; models of rent-oriented behavior of sectorial lobbyists; improper use of institutions (disguise of pseudo-innovations); tough regulation and standardization, lock in on sub-optimal trajectory of GPT development, distorted models of collaboration; high public expectations; "gap" during transfer from informal institutions to formal ones
Stage of involvement of large private capital and market institutionalization of GPT	High-quality increase of investment activity of private business against the background of very optimistic forecasts of development of GPT, quick growth of the number of stakeholders, "boom" of startups, formation of new markets – with re-evaluation of GPT potential, realistic correction of forecasts, and rationalization of volumes and structure of investments	"Gaps" of market, in particular, of the market of venture investments and stock market; disfunctions of institutions of development and commercialization of innovations; defects and obscurity of legal base; "trap" of permanent underrun of the system of regulation from progress of GPT; international institutional "gaps" due to excess of national regulation systems
Stage of social legitimization of GPT	Public acknowledgement and expansion of GPT, or its refusal an marginalization	Mental anomalies (irrational beliefs, negative stereotypes, and technophobias).

Risks of emergence of specific institutional anomalies are peculiar not only for each of the stated stages but for the processes of transition from one to another. For example, C. Perez emphasizes the presence of institutional "gap", related to recomposition (restructuring) of the system of institutions after downfall of financial "bubble" and correction of market. According to her, "duration of recession will depend on the society and public authorities' capability for establishment and direction of institutional changes for restitution of trust" 18. Similarly, during transition from state's domination to prevailing of private capital, obscurity and disfunctionality of regulating GPT become a critical factor of determination of trajectory of further technological development.

---

2. Nanoindustry in Russia

Institutionalization of nanotechnologies in Russia takes place according to general multi-stage logics of this process, but has a vivid peculiarity, related to overcoming nature of development of nanoindustry as compared to most of countries of the world which develop or just create innovational economy.

Preconditions and impulses of nanoindustry development were formed under the conditions of multiple general systemic institutional anomalies, set during liberal and market reforms. Particularly, there was quick narrowing of monetary range (financial base) of R&D institutes and departments (Table 2).

Table 2
Financing of R&D in Russia (1995-2013)

Indicators	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**
Expenditures of federal budget, %							
as to expenditures of federal budget	0.31	1.69	2.19	2.35	2.87	2.76	3.19
as to gross domestic product	1.60	0.24	0.36	0.51	0.56	0.57	0.64
internal expenditures for R&D, %							
as to gross domestic product	0.85	1.05	1.07	1.13	1.09	1.12	1.12

Source: compiled on the basis of: Russian statistical yearbook 2014. P. 488-489; Russian statistical yearbook 2011. P. 556; Russian statistical yearbook 2003. P. 531.

Budget expenditures for R&D reduced from 2.43% of GDP in 1992 to 0.24% in 2000 and then increased gradually, reaching in 2013 the level of 0.64% of GDP. Starting from 2000, internal expenditures of companies for R&D (against the background of favorable foreign economic policy, in particular, stable growth of oil prices) grew very slowly. It is not by chance that in 2012 Russia was only 32th in the ranking of countries as to total (state and private) expenditures for R&D (1.16% of GDP), being behind a lot of developing countries.

In post-Soviet era, there was a vivid tendency of reduction of the number of organizations which conduct R&D and are employed in scientific and technological sphere (Table 3).

Table 3
Dynamics of organizations which perform R&D in Russia (1995-2013)

Indicators	1995	2000	2005	2010	2011	2012	2013
Total number of organizations	4,059	4,099	3,566	3,492	3,682	3,566	3,605
including:							
R&D organizations	2,284	2,686	2,115	1,840	1,782	1,725	1,719
construction departments	548	318	489	362	364	340	331
design and design & survey providers	207	85	61	36	38	33	33
pilot plants	23	33	30	47	49	60	53
educational establishments of higher							

professional education	395	390	406	517	581	560	671
R&D and engineering departments in organizations	325	284	231	238	280	274	266

Source: compiled by the authors on the basis of: Russian statistical yearbook 2014. P. 481; Russian statistical yearbook 2011. P. 545.

Total number of organizations which conduct scientific R&D reduced over 1995-2013 by 11.2% - but such slight reduction should not disorient, as it is caused by growth of the number of universities, in particular, in private sector (by 69.9%). At that, number of construction departments reduced by 39.6%, R&D institutes – by 24.7%, design and design & survey providers – by 84.1% (by more than 6 times). At that, "during privatization of sectorial R&D institutes, construction departments, and scientific development and production centers, many of them lost their testing base… With disappearance of organizations which implement the results of development into production, disassembly of the previously existing innovational system of the country (which hadn't been strong in the past) ended" 19. It resulted into complex disfunction of institutional mechanism of interconnection of science and production, which became a restraining factor of formation of institutions and mechanisms of commercialization of innovations. Besides, beginning from mid-1990's, number of scientific employees reduced by 31.5%, including the number of researchers – by 28.9% (Table 4), stabilizing at the level of indicators of the USSR in 1960's.

Table 4

Dynamics of the number of personnel in the sphere of R&D in the RF (1995-2013), people

Indicators	**1995**	**2000**	**2005**	**2010**	**2012**	**2013**
Total number of personnel	1,061,044	887,729	813,207	736,540	726,318	727,029
including:						
researchers	518,690	425,954	391,121	368,915	372,620	369,015
technicians	101,371	75,184	65,982	59,276	58,905	61,401
support personnel	274,925	240,506	215,555	183,713	175,790	175,365
other personnel	166,058	146,085	140,549	124,636	119,003	121,248

Source: compiled by the authors on the basis of: Russian statistical yearbook 2014. P. 482; Russian statistical yearbook 2011. P. 547.

Targeted attempts for provision of impulse for innovational development of Russian economy were conducted from the beginning of 2000. In the middle of 2000's, there was introduced the Concept of socio-economic development of the RF until 2010, prepared by the Center of strategic developments and unofficially called "Strategy-2010". One of its key paragraphs was devoted to innovational development as a necessary conditions of modernization of economy. However, against the background of growth of the global prices for energy products and quick growth of Russian economy, this task was pushed to the periphery of state attention.

At that, in 2002 and 2006, there were issued Orders of the President of the RF "On adoption of top-priority directions of development of science and technologies in the Russian Federation and the list of critical technologies of the Russian Federation" which determined landmarks and priorities of technological development. At the end of V. Putin's second term, presidential initiative "Strategy of Nano industry development" was issued (2007), in which revolutionary nature of nanotechnologies was stated which led to formation of nano world, tasks of nanoindustry development were set – among which liquidation of excessive institutional, legal, and economic barriers for development of markets of nanoproducts and nanoservices was declared, and the complex of institutions for nanoindustry development was determined 20. In 2007-2008, federal targeted program "Development of infrastructure of nanoindustry in the Russian Federation for 2008-2011" and the Program of nanoindustry development in the Russian Federation until 2015 were adopted, and in 2010, according to the Decree of the Government of the RF, formation of national nanotechnological network began.

In 2009, the President of the RF, Dmitry Medvedev, adopted the Concept of socio-economic development of the RF until 2020, based on the concept of human development. This strategic document set new targeted landmarks for modernization and stage-by-stage transition to innovational type of economic development. In 2011, the Federal law No. 254-FZ on implementing changes into the law No. 127-FZ "On science and state scientific and technical policy" dated August 23, 1996 was passed. The text of the law featured significant additions, related to determination of key terms on innovational activities and Chapter IV of Paragraph 1 "State support for innovational activities" which fixed main goals and principles of such support, subjects and forms of its provision, order of evaluation of effectiveness, and list of critical technologies. The law set eight such technologies: security and counter-terrorism; industry of nanosystems; informational and telecommunicational systems; life sciences; perspective types of weaponry, military and special technology; rational natural use; transport and space systems; energy efficiency, energy saving, and nuclear energetics 21. However, the rank (level) of priority of these technologies and corresponding directions of scientific and technical development was not determined, which still creates certain difficulties during distribution of limited budget resources.

Beginning from 1990's, the Russian fund of fundamental research and the Bortnik Fund were functioning in Russia – they financed fundamental research and science-based startups, correspondingly. At the end of 1990's, first private venture funds appeared, which in 1997 united into the Russian association of venture investments. In 2006-2007, the Russian venture company and the Vneshekonombank were established, the functions of which were connected to financial support for large innovational projects. In 2007, the main institution for nanoindustry development was created – the Russian corporation of nanotechnologies, which was established by the Federal law dated July 19, 2007 No. 139-FZ 22, and the Government of the RF contributed RUB 130 billion for provision of its activities.

The Federal law "On science and state scientific and technical policy" (2011 edition) sets various forms of support for scientific, scientific and technical, and innovational activities, including financial (special funds, subsidies, grants, credits, etc.). The Tax Code of the RF featured changes, according to which, beginning from 2012, companies received a possibility to reserve 3% of the sum of income tax for the purposes of R&D 23. At that, according to S. Glaziev, formation of new technological mode in Russia is impossible without threefold increase of expenditures for science and innovations, which, in its turn, supposes radical increase of accumulation norm in economy 24. In 2011, the Ministry of Economic Development and Trade of the RF presented a new project of the strategy of innovational development named "Innovational Russia 2020" 25, which supposed increase of the share of innovational products in total volume of industrial production to 25-35%, from 5% in 2010. However, realism of the set goal causes well-reasoned doubt.

It is hard to acknowledge that measures taken by the federal authorities, aimed at stimulation of innovational business and commercialization of innovations, do not bring significant results. Thus, according to V. Polterovich, by 2014, there were 70 technological parks, more than 120 business incubators, more than 100 centers of technologies transfer, and more than 10 special economic areas in Russia 26. At the beginning of 2015, the structure of national nanotechnological network included 13 nanotechnological centers, 87 R&D centers, 141 centers of collective use and scientific & educational centers, 258 scientific & production enterprises, 11 investment funds and venture companies, and 80 project companies of ROSNANO OJSC 27. There is positive dynamics of main indicators of development of nanoindustry of the RF (Table 5) – however, it is obvious that this process is very slow and has institutional distortions.

Table 5
Dynamics of main parameters of nanoindustry of the RF (2008-2013)

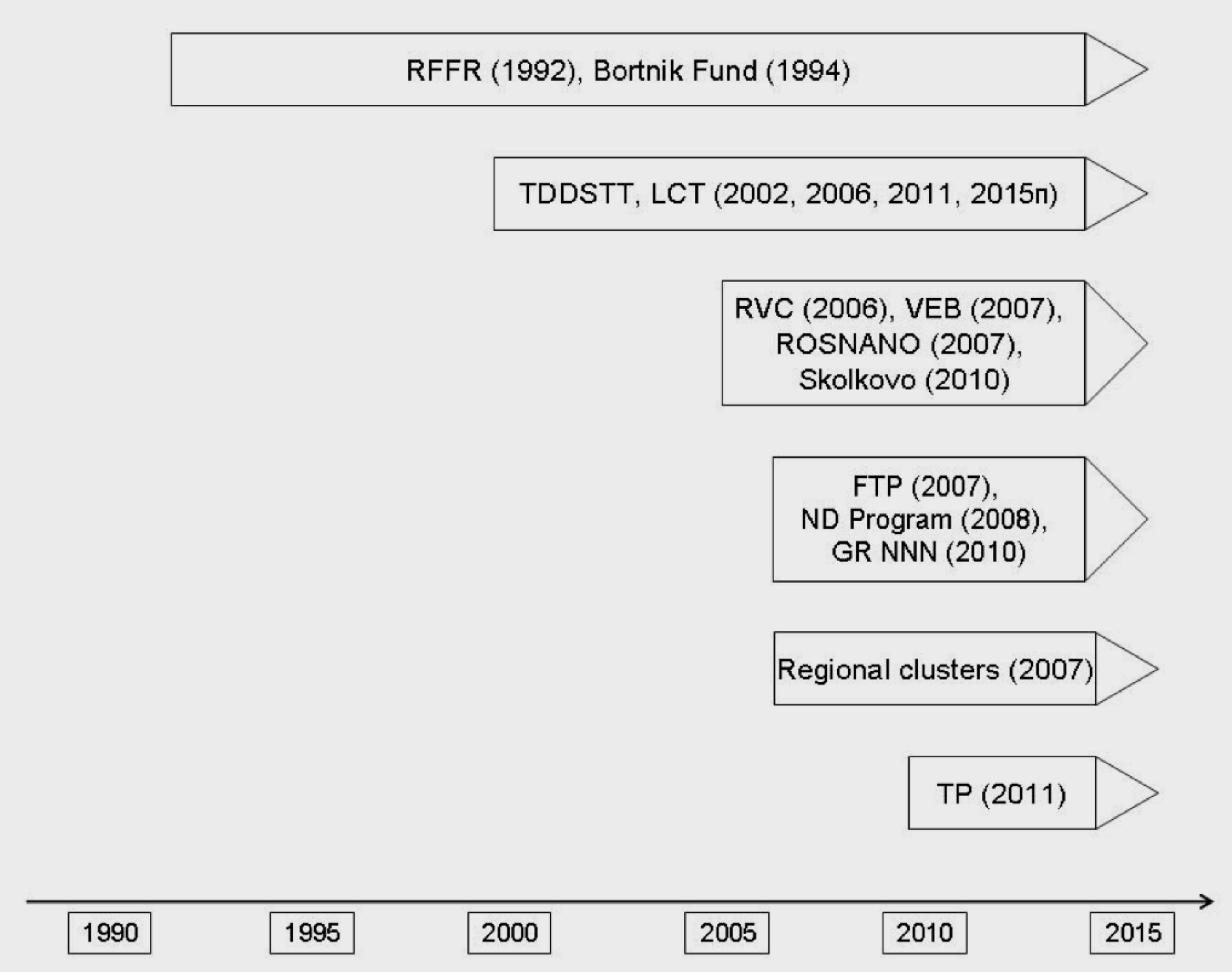
Indicators	**2008**	**2009**	**2010**	**2012**	**2013**
Number of organizations which conducted R&D related to nanotechnologies	463	465	480	489	486
Number of researchers who conducted R&D related to nanotechnologies	14,873	14,500	17,928	19,865	17,893
Internal expenditures for R&D, related to nanotechnologies, RUB million	11,026.2	15,113.1	21,283.7	26,360.2	21,808.1

Source: complied by the authors on the basis of: Russian statistical yearbook 2014. P. 481; Russian statistical yearbook 2011. P. 547.

Nanoindustry of the RF is exposed to negative influence of the effect of path dependence due to overcoming nature of its development: while in the USA, National Nanotechnology Initiative was adopted in 1999, and in the EU, Japan, and many other countries, similar strategic acts were passed at the beginning of 2000's, the Russian presidential initiative "Strategy of nanoindustry development" appeared only in 2007. As a result, institutionalization of Russian nanoindustry takes place in a very quick regime, which causes high concentration, mutual interlocking, and strengthening of institutional anomalies 28. Thus, creation of infrastructural institutions and development institutions during short period of 2007-2011 led to their functional doubling, hypogenesis (underdevelopment), and distorted forms of realization in practice (Fig. 1). Priorities of institutional policy of the state in innovational sectors change quickly and inconsistently: from regional clusters (2007), the emphasis was shifted to technological platforms (2011), and the project of implementation of technological innovational platforms (analog of European ETIPs) is being viewed.

At that, lack of objective readiness for economic subjects for use of these transplanted institutes and short period, given for their adaptation, are ignored – which leads to atrophy and functional "degeneration".

Fig. 1
Dynamics of institutionalization of nanoindustry in the RF



Legend: TDDSTT – Top-priority directions of development of science, technologies, and technics in the RF; LCT – List of critical technologies of the RF; RVC – Russian venture company; VEB – Vneshekonombank; FTP – Federal targeted program "Development of infrastructure of nanoindustry in the Russian Federation in 2008-2011"; ND Program – Program of development of nanoindustry in the RF until 2015; GR NNN – Government Resolution "On national nanotechnological network" dated April 23, 2010 No. 282; TP – technological platforms.

Table 6 systematizes disfunctions of leading institutions of development of Russian nanoindustry. In most cases, they are the consequence of very high rates of institutionalization of nanoindustry together with high targeted landmarks of its development.

Table 6
Disfunctions of key development institutions of Russian nanoindustry

Development institutionsf	**Main disfunctions**
ROSNANO OJSC	Conservative investment policy, investing into current business instead of startups, manipulations with accounting and statistical data
R&D Center "Kurchatov Institute"	Eclecticism of mega-project of NBICS-convergence, monopolization of the market of nanotechnological R&D, "absorption" of academic institutes (Institute of theoretical and experimental physics, etc.)
Russian Venture Company	Narrow horizon of investing, deficit of competition between venture funds created with participation of RVC, small size of

	venture funds (up to RUB 1 billion)
Vneshekonombank	"Atomism" of technological and sectorial priorities, excessive multifunctionality
Skolkovo Fund	High level of bureaucracy (accounting), lack of nanotechnologies among priorities
Russian Scientific Fund	Lack of transparency of expertise
Russian Fund of Fundamental Researches	Lack of expertise transparency, advantages with experts (constantly receiving grants)
Fund of Support for Development of Small Enterprises in Scientific & Technical Sphere (Bortnik Fund)	Limited volume of financial resources, tough conditions of projects realization (limited time), limited financial & economic competences of experts

3. Conclusions

Opposition to anomalies of social, legal, and economic institutions which order the use of nanotechnologies can be realized with the range of directions in view of experience of institutionalization of other GPT.

Firstly, there is a need for concept, strategy, and road map of institutional changes in innovational sector on the basis of evolutionary approach which increases realistic time period of adaptation of new institutions and necessity for achievement of complementarity of their functions.

Secondly, there is a need for transition to a new quality of dialogue of various stakeholders of nanoindustry 29 – these discussions should have a certain "meso-nature", i.e., be inter-disciplinary, inter-sectorial, inter-departmental, and international at the same time. This requirement is caused by synthetic nature of nanotechnologies, the nature of which cannot be perceived within one scientific discipline or regarding one economic sphere 30. However, existing institutions and mechanisms of technological regulation, created mostly in the industrial age, are aimed at creation and support for tough interdisciplinary, inter-sectorial, and other barriers which limit various forms of public life from one another. That's why all these institutions are of anomalous nature as compared to nanotechnology as a new form of technological development.

Thirdly, it is necessary to strive for creation of nano-specific institutions and regulation systems 31, trying to avoid the use of universal approaches which are equally fit for any high technologies; this is related to unique width of the range of nanotechnologies use. At that, developed legal acts, standards, and regulations in the sphere of nanotechnologies should be maximally synchronized with rates of their development – i.e., they should be neither early nor late.

At that, it should be taken into consideration that theoretical and empirical information, on the basis of which regulatory rules and mechanisms are created, is still insufficient and instable. Scientific knowledge on nanotechnologies – especially, on related risks – is limited; there is a deficit of interdisciplinary and inter-sectorial expert in the sphere of nanoknowledge, as most of them are competent only in the sphere of their discipline or sphere 32. That's why a decisive role belongs to involvement into the process of creation of institutions and mechanisms of regulation of nanoindustry of maximal circle of stakeholders, including representatives of regulating bodies, natural and humanitarian scientific disciplines, various spheres of industrial business, service sphere, and structures and groups of civil society – as active members and observers – as various stakeholders are involved in nanoindustrialization to different extent.

Acknowledgments

This work was supported by Russian Foundation for Basic Research (project No. 18-010-00832).

Bibliography

Allhoff F. On the Autonomy and Justification of Nanoethics // *Nanoethics: The Ethics of Technologies that Converge at the Nanoscale. 2007. Vol.* 1. No. 3. P. 185-210.

Allhoff F. Risk, Precaution, and Emerging Technologies // *Studies in Ethics, Law, and Society.* 2009. Vol. 3. No. 2. P. 1-27.

Belousov D.R. Creation of long-term scientific & technological forecast for Russia with the “foresight” method / D.R. Belousov, O.G. Solntsev, M.Y. Khromov // Issues of Forecasting [Problemy Prognozirovaniya]. 2008. No. 1. P. 18-33.

Carr N.J. Does It Matter?: Information Technology and the Corrosion of Competitive Advantage. Boston, MA: Harvard Business School Press, 2004. 193 pp.

Christensen, C.M. The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Boston, MA: Harvard Business School Press, 1997. 225 pp.

Connolly R. State Industrial Policy in Russia: The Nanotechnology Industry // Post-Soviet Affairs. 2013. Vol. 29. No. 1. P. 1-30.

Eggertsson T. Knowledge and theory of institutional changes // Issues of Economics [Voprosy Ekonomiki]. 2011. No. 7. P. 4-16.

Falkner, R. Regulating Nanotechnologies: Risk, Uncertainty and the Global Governance Gap / R. Falkner, N. Jaspers // Global Environmental Politics. 2012. Vol. 12. No. 1. P. 30-55.

Grazhdankin A.I., Kara-Murza S.G. White book of Russia. Construction, reconstruction, and reforms: 1950-2013. Moscow: Nauchny ekspert, 2015. 728 pp.

Hulmann A. Economic development of nanotechnologies: review of indicators // Foresight. 2009. Vol. 3. No. 1. P. 30-47. P. 33.

International Handbook on Regulating Nanotechnologies / G.A. Hodge, D.M. Bowman, A.D. Maynard (eds.). Edward Elgar, 2010. 586 pp.

Lanier J. You Are Not a Gadget: A Manifesto. N.Y.: Alfred A. Knopf, 2010. 209 pp.

Levi-Faur D., Comaneshter H. The risks of regulation and the regulation of risks: the governance of nanotechnology // New Global Regulatory Frontiers in Regulation: The Age of Nanotechnology / G.A. Hodge, D.M. Bowman, K. Ludlow (eds.). Northampton, MA: Edward Elgar, 2007. P. 149-165.

Lyons K., Whelan J. Community engagement to facilitate, legitimize and accelerate the advancement of nanotechnologies in Australia // NanoEthics. 2010. Vol. 4. No. 1. P. 53-66.

Mau V.A. Economic reforms in Russia: result and perspectives // Where has Russia arrived?.. Results of societal transformation / Ed. by T.I. Zaslavskaya. Moscow: MVSSEN, 2003. P. 63-75.

Nano market: from nanotechnologies to nanoproducts / Ed. by G.L. Azoev. Moscow: BINOM. Knowledge laboratory, 2011. 319 pp.

Nanotechnology Research Directions for Societal Needs in 2020: Retrospective and Outlook / Ed. by M. Roco, C. Mirkin, M. Hersam. Springer, 2010. 690 pp.

Perez C. Technological Revolutions and Financial Capital. The Dynamics of Bubbles and Golden Ages. Cheltenham: Edward Elgar Publishing, 2002. 224 pp.

Polterovich V. Hypothesis of innovational pause and strategy of modernization // Issues of Economics [Voprosy Ekonomiki]. 2009. No. 6. P. 4-23.

Polterovich V.M. Where to go: twenty four theses // Economic Science of Modern Russia [Ekonomicheskaya Nauka Sovremennoy Rossii]. 2014. No. 3. P. 7-16.

Presidential initiative "Strategy of nanoindustry development" (Order of the President of the RF dated April 24, 2007, No. Pr-688). Moscow, 2007. 8 pp.

Roco M.C. Broader societal issues of nanotechnology // Journal of Nanoparticle Research. 2003. Vol. 5. No. 2. P. 181-189.

Sergienko Y. Regarding financial mechanism of long-wave technical and economic changes // Issues of Economics [Voprosy Ekonomiki]. 2004. No. 1. P. 66-73.

Zhe L., Lifeng G., Xinghua Z. Definitions, R&D Activities and Industrialization of Biotechnology in China // Asian Biotechnology and Development Review. 2009. Vol. 11. No. 2. P. 29-43.

---

1. Volgograd State University, Volgograd, Russian Federation. e-mail: marketech@volsu.ru , ecodev@mail.ru

2. Volgograd State University, Volgograd, Russian Federation. e-mail: marketech@volsu.ru

3. Volgograd State University, Volgograd, Russian Federation. e-mail: interec@volsu.ru

4. Belousov D.R. Creation of long-term scientific & technological forecast for Russia with the "foresight" method / D.R. Belousov, O.G. Solntsev, M.Y. Khromov // Issues of Forecasting [Problemy Prognozirovaniya]. 2008. No. 1. P. 18-33. P. 20.

5. Mau V.A. Economic reforms in Russia: result and perspectives // Where has Russia arrived?.. Results of societal transformation / Ed. by T.I. Zaslavskaya. Moscow: MVSSEN, 2003. P. 63-75. P. 74.

6. Zhe L., Lifeng G., Xinghua Z. Definitions, R&D Activities and Industrialization of Biotechnology in China // Asian Biotechnology and Development Review. 2009. Vol. 11. No. 2. P. 29-43. P. 32.

7. Nano market: from nanotechnologies to nanoproducts / Ed. by G.L. Azoev. Moscow: BINOM. Knowledge laboratory, 2011. 319 pp. P. 14.

8. Sergienko Y. Regarding financial mechanism of long-wave technical and economic changes // Issues of Economics [Voprosy Ekonomiki]. 2004. No. 1. P. 66-73.

9. Perez C. Technological Revolutions and Financial Capital. The Dynamics of Bubbles and Golden Ages. Edward Elgar Publishing, 2002. 224 pp. P. 151-166.

10. Polterovich V. Hypothesis of innovational pause and strategy of modernization // Issues of Economics [Voprosy Ekonomiki]. 2009. No. 6. P. 4-23. P. 9.

11. Christensen, C.M. The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Boston, MA: Harvard Business School Press, 1997. 225 pp.

12. Carr N.J. Does It Matter?: Information Technology and the Corrosion of Competitive Advantage. Boston, MA: Harvard Business School Press, 2004. 193 pp. P. 54.

13. Falkner, R. Regulating Nanotechnologies: Risk, Uncertainty and the Global Governance Gap / R. Falkner, N. Jaspers // Global Environmental Politics. 2012. Vol. 12. No. 1. P. 30-55.

14. Eggertsson T. Knowledge and theory of institutional changes // Issues of Economics [Voprosy Ekonomiki]. 2011. No. 7. P. 4-16. P. 12.

15. Lanier J. You Are Not a Gadget: A Manifesto. N.Y.: Alfred A. Knopf, 2010. 209 pp. P. 107.

16. Allhoff F. On the Autonomy and Justification of Nanoethics // *Nanoethics: The Ethics of Technologies that Converge at the Nanoscale. 2007. Vol.* 1. No. 3. P. 185-210; Allhoff F. Risk, Precaution, and Emerging Technologies // *Studies in Ethics, Law, and Society.* 2009. Vol. 3. No. 2. P. 1-27.

17. Hulmann A. Economic development of nanotechnologies: review of indicators // Foresight. 2009. V. 3. No. 1. P. 30-47. P. 33.

18. Perez C. Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages. Cheltenham: Edward Elgar, 2002. 224 pp. P. 76.

19. Grazhdankin A.I., Kara-Murza S.G. White book of Russia. Construction, reconstruction, and reforms: 1950-2013. Moscow: Nauchny ekspert, 2015. 728 pp. P. 264.

20. Presidential initiative "Strategy of nanoindustry development" (Order of the President of the RF dated April 24, 2007, No. Pr-688). Moscow, 2007. 8 pp. P. 5-6.

21. Decree of the President of the RF dated July 7, 2011 No. 899 "On adopting top-priority direction of development of science and technologies in the Russian Federation and of the list of critical technologies of the Russian Federation". – URL: http://graph.document.kremlin.ru/page.aspx?1;1563800.

22. Federal law of the Russian Federation dated July 19, 2007 No. 139-FZ "On Russian corporation of nanotechnologies" – URL: http://www.rg.ru/2007/07/25/nano-korporacia-dok.html.

23. Federal law of the Russian Federation dated July 20, 2011 No. 249-FZ "On implementing changes into the Federal Law

"On science and state scientific and technical policy" and the Article 251 of Part 2 of the Tax Code of the Russian Federation in part of specification of legal status of funds for support for scientific, scientific & technical, and innovational activities" – URL: http://www.rg.ru/2011/07/26/nauka-nalog-dok.html.

24. Glaziev S. On the strategy of modernization and development of Russian economy under the conditions of global depression. – URL: http://www.glazev.ru/econom_polit/269/

25. Strategy of innovational development of the Russian federation until 2020 / The Ministry of Economic Development and Trade of the Russian Federation. – URL: http://www.economy.gov.ru/minec/activity/sections/innovations/doc20120210_04.

26. Polterovich V.M. Where to go: twenty four theses // Economic Science of Modern Russia [Ekonomicheskaya Nauka Sovremennoy Rossii]. 2014. No. 3. P. 7-16.

27. Calculated on the basis of the portal "Russian national nanotechnological network". – URL: http://www.rusnanonet.ru/nns/.

28. Connolly R. State Industrial Policy in Russia: The Nanotechnology Industry // Post-Soviet Affairs. 2013. Vol. 29. No. 1. P. 1-30.

29. Lyons K., Whelan J. Community engagement to facilitate, legitimize and accelerate the advancement of nanotechnologies in Australia // NanoEthics. 2010. Vol. 4. No. 1. P. 53-66.

30. Roco M.C. Broader societal issues of nanotechnology // Journal of Nanoparticle Research. 2003. Vol. 5. No. 2. P. 181-189.

31. Levi-Faur D., Comaneshter H. The risks of regulation and the regulation of risks: the governance of nanotechnology // New Global Regulatory Frontiers in Regulation: The Age of Nanotechnology / G.A. Hodge, D.M. Bowman, K. Ludlow (eds.). Northampton, MA: Edward Elgar, 2007. P. 149-165.

32. International Handbook on Regulating Nanotechnologies / G.A. Hodge, D.M. Bowman, A.D. Maynard (eds.). Edward Elgar, 2010. 586 pp.; Nanotechnology Research Directions for Societal Needs in 2020: Retrospective and Outlook / Ed. by M. Roco, C. Mirkin, M. Hersam. Springer, 2010. 690 pp.
