System of interaction between universities, scientific organizations and industrial enterprises under conditions of digital economy in Russia

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Abstract. Science and education are playing an undoubtedly key role in shaping the innovation economy referred to as ‘knowledge-based economy’. Development of academic science is the basic condition of achieving the strategic goals of innovative transformations in the Russian Federation economy. Each link in the ‘fundamental triangle’ of national economy development (university — scientific organization — industrial enterprise) requires particular analysis, specific set of support tools and mechanism enabling proper interaction between ‘fundamental triangle’ parts. Purpose of activities performed by universities and scientific organizations is supplying real economy enterprises with high-end professionals and innovative developments. This article presents key findings of investigation of the Russian Federation higher school’s science-and-innovation resources development for the period 2006–2015/2016. The paper is addressing the matters related to planned key indicators of Federal targeted program entitled ‘Research and development works in the priority areas of RF science-and-technology complex for 2014–2020’ acting in capacity of key mechanism intended to stimulate interactions within the ‘fundamental triangle’.

1. General formulation and correlation of the problem with crucial scientific and practical tasks

President of Russia in his recent annual state-of-the-nation address declared that Russia must not only settle down in top five world economies but increase the gross domestic product one-and-a-half times by 2025 [1]. Russia needs economic growth rate exceeding the global level and, according to Russian leader, this is the basic condition for economic breakthrough. The highest value, in this respect, is placed on social sphere which covers education and science.

Namely these spheres are expected to move forward the ‘innovation locomotive’ of Russian economy supplying enterprises with high-end professionals, innovative developments, new commercially viable technologies top requested not only in Russian but in the global market as well [2]. National economy depends on universities and research centers successfulness and modernization processes productivity [3, 4]. Apart from supplying high-end professionals and scientific developments, these spheres constitute the basis for public stability and social well-being.

Science and education are playing an undoubtedly key role in shaping the innovation economy referred to as ‘knowledge-based economy’ [5]. Development of academic science is the basic condition of achieving the strategic goals of innovative transformations in the Russian Federation (RF)
economy [6, 7]. Specialist training and research-and-development functions are traditionally identified by specialists as two basic functions of the higher school in the innovative process and this fact is reflecting linear model of educational institutions innovation-driven growth [8].

Table 1 represents indices characterizing the status of education, science and innovations in Russia based on statistic data disclosing scientific research-and-development financing in 2006–2015/2016 [9, 10] which show the state competitiveness level.

Table 1. Basic indices characterizing the status of education, science and innovations in Russia.

| Education | Science and innovations |
|-----------|-------------------------|
| Quantity of academic staff in higher professional education (hereafter — HPE) reduced by 13.16% over the past decade. | Proportion of technological innovations maintaining companies in the totality of companies reduced from 9.6% in 2006 to 8.3% in 2015. |
| Quantity of HPE students reduced by 32.53% over the past decade. | RF proportion in the global number of publications for the period 2005–2015 remained almost the same 2.45% in 2005 and 2.38% in 2015. For reference: USA — 25.2%, China — 19.07% in 2015. |
| Quantity of HPE institutions reduced by 16.1% over the past decade. | RF share in the market of high-technology products — around 0.4%. |
| Schooling quality in Russia, 2015: 33rd place out of 72 countries covered by PISA (Program for International Student Assessment)). | |

Analysis of represented indices shows the tendency of students’ number decrease, at that, the students more frequently take intramural form of study and prefer parent institutions to affiliates. Besides, it is necessary to underline that status of the Russian Federation in the sphere of science and innovation indices research is rather low if compared with world-class achievements. According to authors, dynamics of indices under consideration shows rather low Russia's competitive performance which may impair its future rating.

Government's perception of necessity to change economic policy so as to comply with global technological trajectory caused the requirement for all participants of this process, namely, state, universities, science and industrial enterprises to elaborate a consolidated viewpoint in respect of today's and future innovative development of Russia which will inevitably affect macroeconomic management [11].

2. Work target formation
Main target of investigation is to make analysis of interaction between universities, scientific organizations and industrial enterprises under conditions of digital economy in Russia.

Interaction between universities, scientific organizations and real economy enterprises may be represented in the form of ‘fundamental triangle’ of national economy development (figure 1).
Figure 1. ‘Fundamental triangle’ of national economy development.

Well-developed innovative systems are characterized by more complicated models which are defining, on one hand, higher educational institutions contribution to all stages of innovative cycle — from development and distribution up to diffusion and, on the other hand, interaction with all innovative process participants so as to achieve synergetic effect [12, 13].

Mission of ‘scientific organization-university-enterprise’ structure is training of engineering personnel and development of most advanced innovative technologies aiming to create world-class industrial enterprises intended for backbone branches of industry on the basis of organizational, managerial and economic technologies.

Each ‘fundamental triangle’ link requires particular analysis, specific set of support tools and mechanism enabling proper interaction between ‘fundamental triangle’ parts.

Global experience shows that most important role in solving the aforesaid issues may be assigned to specially maintained mechanism enabling cooperation between academic and scientific institutions and industry [14, 15]. Constituent components of such cooperation are quite numerous and may include:

— common projects jointly implemented by enterprise, university and scientific center financed by various national and international funds;
— special training programs fulfilled by universities and scientific centers for the enterprises (mainly in advanced and rapidly developed directions);
— wide range of activities fulfilled within the framework of complex agreements executed between universities and enterprises. This way of cooperation enables simultaneous solving of (i) tasks associated with target training of specialists for particular enterprise and (ii) scientific-and-research problems by parties’ joint efforts;
— wide range of consulting services rendered by university and scientific center experts for industrial enterprises;
— works performed for industrial enterprises through the mediation of university incubators and techno parks.
3. Statement of basic material

State sector plays a significant and more often a defining role in cooperation fulfilled within ‘fundamental triangle’ of economy development. Internal costs borne by the state for scientific research and development inside the country (including projects financed from abroad, however, excluding payments performed abroad) during financial year under report may serve as a roundup statistical indicator of national scientific research and development scope [16]. Distribution of research and development costs with reference to financing sources is reflecting practical implementation of principle where there multiple sources of financing exist with public funds predominance [17].

Scope of internal costs for research and development increased more than thrice during recent decade (table 2). Structural constituent of finance sources has not changed drastically in regard of funds of higher education institutions and funds owned by private non-commercial organizations. Share of costs related to public budget demonstrates a tendency of growth by 7.42%, while that of private entrepreneurship sector decreased by 3.22% showing low demand for the results of scientific-research activities on the part of various national economy enterprises. Scope of scientific enterprises’ own budgets has grown by 3.16%; this could be explained by increase of financing of scientific organizations activities at the cost of internal reserves.

Table 2. Structure of research and development costs with reference to financing sources for the period 2000–2016 in Russia (million rubles).

|                      | 2006 | 2008 | 2010 | 2012 | 2014 | 2015 |
|----------------------|------|------|------|------|------|------|
| Internal costs for   |      |      |      |      |      |      |
| research and         | 288.8| 431.1| 523.4| 699.9| 847.5| 914.7|
| development, total : |      |      |      |      |      |      |
| public budget funds  | 173.5| 272.1| 360.3| 462.2| 569.1| 617.3|
| funds owned by       |      |      |      |      |      |      |
| scientific          | 25.6 | 35.9 | 47.4 | 78.5 | 99.7 | 109.9|
| organizations       |      |      |      |      |      |      |
| extra-budgetary      | 4.8  | 6.3  | 10.1 | 11.7 | 9.1  | 8.8  |
| funds owned by       |      |      |      |      |      |      |
| organizations        | 56.9 | 90.0 | 85.9 | 118.2| 145.8| 150.9|
| belonging to         |      |      |      |      |      |      |
| private entrepreneurship |    |      |      |      |      |      |
| funds of             | 0.6  | 0.5  | 0.5  | 0.9  | 1.8  | 2.3  |
| higher education     |      |      |      |      |      |      |
| institutions         |      |      |      |      |      |      |
| funds of private     | 0.2  | 0.7  | 0.6  | 0.6  | 1.0  | 1.3  |
| non-commercial       |      |      |      |      |      |      |
| organizations        |      |      |      |      |      |      |
| funds of foreign     | 27.2 | 25.6 | 18.6 | 27.8 | 21.0 | 24.2 |
| sources              |      |      |      |      |      |      |

Public sector is using the following mechanisms to stimulate interactions in the ‘fundamental triangle’:

— Establishment of National research universities, Federal universities
— Federal special purpose program (FSPP) entitled ‘Research and development in top priority directions of the RF scientific-technological development for the period 2014–2020’ [18];
— RF Government Decree No. 218 dated April 9, 2010 ‘Concerning state support for cooperation between the RF higher education institutions and public scientific organizations and institutions fulfilling complex projects aiming to establish high-technology production facilities...’ [19];
— RF Government Decree No. 220 dated April 9, 2010 ‘Concerning leading RF scientists’ involvement into higher education institutions and scientific organizations...’ [20].
Thus, FSPP entitled ‘Investigations and developments in top priority directions of RF scientific-technological complex development for the period 2014–2020’ is one of basic regulatory tools enabling implementation of state-backed scientific-technical and research support policy in those spheres of science and technology which were recognized as priority-oriented issues improving RF economy competitiveness as a whole [21].

Figure 2 shows essential target indicators and indices foreseen by FSPP entitled ‘Investigations and developments in top priority directions of RF scientific-technological complex development for the period 2014–2020’.

![Essential target indicators and indices foreseen by FSPP entitled ‘Investigations and developments in top priority directions of RF scientific-technological complex development for the period 2014–2020’](image)

Federal budget financing — **126.4 billion rubles**, extra-budgetary financing — **41.4 billion rubles**

Increment of publications issued by leading academic periodicals in virtue of investigations and developments — **24.8 thousand**

Increment of patent applications submitted in virtue of research and developments — **3 thousand units**

Increment of new jobs — **900 units**

Program participants' mean age decrease by 2020 — **to 43 years**

Increment of share of researchers' under **39 years age** in total amount of up to **35%**

*Figure 2. Essential target indicators and indices foreseen by FSPP entitled ‘Investigations and developments in top priority directions of RF scientific-technological complex development for the period 2014–2020’.*

Implementation of stimulating mechanisms within the ‘fundamental triangle’ is causing (I) higher education institutions participation in the programs of innovative development maintained by large corporations, (II) formation and development of clusters and technological platforms. However, orientation of organizations belonging to higher education sector to research and development deliverables commercialization is still not sufficient; this is connected with incompletely established mechanism of inventions integrating into industrial sector.

Economy digitization and international cooperation constitute an important correction factor for integration of higher education institutions, scientific organizations and industrial enterprises [22, 23]:

— acceleration of scientific-technical growth, hardware and technologies renovation;
— fiercer international competition in the sphere of scientific-technical development;
growth in significance of intellectual capital within the structure of technical and technological developments;
extension of territorial capacities of integration (establishment of: international scientific-educational unions, affiliates of RF universities in foreign scientific institutions, laboratories of foreign scientific institutions in RF universities);
— reduction of engineering works lead time;
invention of advanced technologies.

4. Conclusions
Global scientific-technical progress is transforming today's society into a digital society which is fundamentally changing the system of interaction between universities, scientific organizations and real economy enterprises and putting forward new global issues: assignment of economy growth vector at the expense of new knowledge creation, integrating of smart technologies into production process and training of creative personnel capable to think and work in brand new world.

Role of the state acting in capacity of main stimulator within the ‘fundamental triangle’ is considered to be crucial in our case. Outcome of educational program acquisition shall be represented by full-fledged product designed by the student. The following innovation sites are becoming most actively functioning university units: spin-outs, spin-offs, start-ups, MIPs, techno parks, business incubators, specialized departments promoting commercialization of developments, involvement of teaching staff and students and into innovative activities, cooperation with scientific centers and industrial enterprises. Mechanisms providing efficient ‘fundamental triangle’ functioning represented, for instance, by (FSPP) entitled ‘Research and development in top priority directions of RF scientific-technological development for the period 2014−2020’ allow to solve issues put forward by RF industry.

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