# THE INFLUENCE OF GRADUATES OF PHD PROGRAMS ON THE LEVEL OF INNOVATION IN THE RUSSIAN ECONOMY

**Valery A. Gurtov[1,2], Liudmila V. Shchegoleva[1,2]**

[1] *Petrozavodsk State University (RUSSIAN FEDERATION)*
[2] *Saint-Petersburg Electrotechnical University "LETI" (RUSSIAN FEDERATION)*

## Abstract

The development of high-tech industries determines the status of each country in the world economy, the standard of living of its inhabitants, the prospects for business development. High-tech sectors in Russia include the aviation industry and engine building, the rocket and space industry, the shipbuilding industry, the radio electronic industry, the nuclear power industry complex, information and communication technologies.

High-tech sectors of the economy – this is the sphere of interests of the government, investors, entrepreneurs, as well as science and education. The creation of new knowledge and technologies directly depends on the scientific and technical potential and an important role here is played by the training of new personnel in postgraduate study.

The paper presents the results of the analysis of the correspondence between the numbers of graduated bachelors, graduated masters and graduated postgraduate students in the areas of training referred to high-tech sectors of the economy, and a comparison of these numbers with the share of high-tech sectors in the Russian economy in all federal districts.

As the analysis has shown, number of postgraduate students potentially covers these requirements, taking into account the requirements in staff number in the field of science and education. The paper provides a detailed analysis in the context of Russian regions and fields of science, in showing the deficit, balance and excess of postgraduate students to ensure the staffing requirements of the high-tech sectors of the economy.

Keywords: High-tech sectors of the economy, postgraduate students, highly qualified scientific personnel, PhD degree, innovation.

## 1 INTRODUCTION

The development of high-tech industries determines the status of each country in the world economy, the standard of living of its inhabitants, the prospects for business development [1].

High-tech sectors in Russia include the aviation industry and engine building, the rocket and space industry, the shipbuilding industry, the radio electronic industry, the nuclear power industry complex, information and communication technologies.

High-tech sectors of the economy (HTSE) – this is the sphere of interests of the government, investors, entrepreneurs, as well as science and education. The creation of new knowledge and technologies directly depends on the scientific and technical potential of a country. Therefore, an important task is to monitor and forecast the provision of high-tech sectors of the economy with graduates of higher professional education and personnel of highest scientific qualifications.

## 2 METHODOLOGY

For the analysis and forecasting of the provision of the HTSE of Russia with highly qualified scientific personnel, it is necessary to solve a number of problems:

- In the All-Russian Classifier of Economic Activities, there are no sections of economic activity that exactly correspond to the names of the HTSE profiles.
- The educational and scientific specialties (directions of training) corresponding the profiles of the HTSE are included to the various combined groups of specialties and branches of science.


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- Traditional approaches to forecasting the needs of the economy in personnel with different levels of education and analysis of the provision of these needs by the higher education system, including postgraduate study, do not take into account the specifics of the HTSE.

To solve the first two problems, conversion matrices have been formed that establish a correspondence between high-tech sectors of the economy and economic activities, between high-tech sectors of the economy and training specialties (directions of training), between high-tech sectors of the economy and scientific specialties.

For example, the following directions of training were assigned to the high-tech sector of the economy "Information and Communication Technologies": "Automation of technological processes and productions", "Information security of telecommunication systems", "Mathematical support and administration of information systems", "Applied Informatics" and others. And also the following scientific specialties: “Mathematical and software support of computers, complexes and computer networks”, “Mathematical modeling, numerical methods and program complexes”, “Methods and systems of information security, information security” and others.

The input data for the calculations were taken from the annual reports of the educational organizations and the annual reports of the dissertation councils.

The reports of educational organizations contain data by the directions of training. Conversion matrices allowed calculating the number of graduates of bachelor's, master's, specialist's and postgraduate courses, who were educated in the profiles of high-tech sectors of the economy.

To solve the third problem, an original method was developed, based on the calculation of the annual additional demand for candidates and doctors of science. The methodology uses statistical data on the number of candidates and doctors of science working in the industry at the present time. The methodology was tested using the example of Rosatom. The main problem for the calculation of the methodology is the lack of detailed statistical information on individual sectors of the economy. These data are approximately estimated, which, as a result, also gives an estimated result. To calculate the estimates, we used the methods presented in [2], [3].

## 3 RESULTS

Conversion tables allowed obtaining numerical data on the quantities of university students studying at different levels under programs corresponding to high-tech sectors of the economy (Table 1). The number of students at different levels of higher education is 350 thousand, and the number of graduate students - 30 thousand people. The distribution of these indicators between the six HTSE is uneven. More than half of the students belong to the high-tech sector of the economy "Information and Communication Technologies".

***Table 1.*** *The number of students in 2015 by the high-tech sectors of the economy.*

| High-tech sector of the economy | Students of Bachelor Programs | Students of Master Programs | Students of Specialist Programs | Postgraduate Students |
|---|---|---|---|---|
| Aviation industry and engine building | 3300 | 800 | 11750 | 5300 |
| Rocket and space industry | 1900 | 500 | 11750 | 4250 |
| Shipbuilding industry | 3950 | 400 | 1100 | 1750 |
| Radio electronic industry | 47150 | 10000 | 15600 | 4500 |
| Nuclear power industry complex | 2900 | 950 | 7350 | 3100 |
| Information and communication technologies | 181850 | 16850 | 34100 | 11600 |
| Total | 241050 | 29500 | 81650 | 30500 |

The peculiarity of the postgraduate study in Russia is the optional defense of the PhD thesis after graduation from the postgraduate school. Therefore, the number of candidates of science is much less than number of graduates of postgraduate programs (Table 2). At the same time, graduates of postgraduate programs can also defend their PhD thesis after some years since the graduation. And

graduates attached to a scientific organization to prepare a thesis without training in postgraduate programs can also defend their PhD thesis.

***Table 2.*** *Number of graduates from postgraduate studies and Number of defenses of PhD thesis in 2015 by the high-tech sectors of the economy.*

| High-tech sector of the economy | Number of graduates from postgraduate studies | Of them with the defense of the thesis | Number of defenses of PhD thesis |
|---|---|---|---|
| Aviation industry and engine building | 840 | 140 | 380 |
| Rocket and space industry | 860 | 140 | 400 |
| Shipbuilding industry | 570 | 80 | 230 |
| Radio electronic industry | 820 | 180 | 500 |
| Nuclear power industry complex | 550 | 110 | 360 |
| Information and communication technologies | 2730 | 440 | 930 |
| Total | 6370 | 1090 | 2800 |

Thus, the number of people who received a PhD degree is approximately half of the number of graduates from postgraduate programs.

The number of employees in the Russian High-tech sectors of the economy is approximately 2 million people. The proportion of employees of the HTSE enterprises is 6.3% of total number of employees. To reproduce the highest scientific qualifications staff at these enterprises, yearly an estimated 2.5 thousand specialists are required, who have completed postgraduate studies and/or obtained a PhD degree. As the analysis has shown, number of postgraduate students potentially covers these requirements, taking into account the requirements in staff number in the field of science and education.

For example, for HTSE "Nuclear power industry complex" the main enterprise is the State Corporation "Rosatom". The number of highly qualified scientific personnel in the structure of the staff of the State Corporation "Rosatom" is 3670 people (1.4% of the total number of employees). In this number doctors of sciences are 615 people, candidates of sciences – 3030 people. The annual additional demand of organizations / enterprises of "Rosatom" for highly qualified scientific personnel in all scientific fields for the medium term, taking into account the annual natural-age retirement, are 80 people for candidates of science.

In 2010-2013 on scientific specialties, corresponding to the sphere of activity of the State Corporation "Rosatom", on average, there were 147 defenses of candidate dissertations and 21 defenses of doctoral dissertations each year. It turns out that for candidates of sciences the annual additional need is completely closed by new candidates of sciences.

High-tech sectors of the economy are part of the country's innovative economy. There are different approaches to assessing the level of innovative development of the region. For Russia, one of the indicators of innovative development of its regions is the Rating of the investment attractiveness of Russian regions, compiled by the RAEX rating agency (Expert RA). This rating includes assessment of labor, financial, production and innovation potential of region [4].

The innovation potential of the territory is mainly determined by the highly qualified scientific personnel have job in the scientific organizations and industrial enterprises of the territory. In Fig. 1 the scattering diagram for 85 subjects of the federation of Russia shows relation between rank of region by the innovative component of the region's investment attractiveness and rank of region by the number of defenses of PhD thesis. In general, there is a direct correlation between these two indicators.

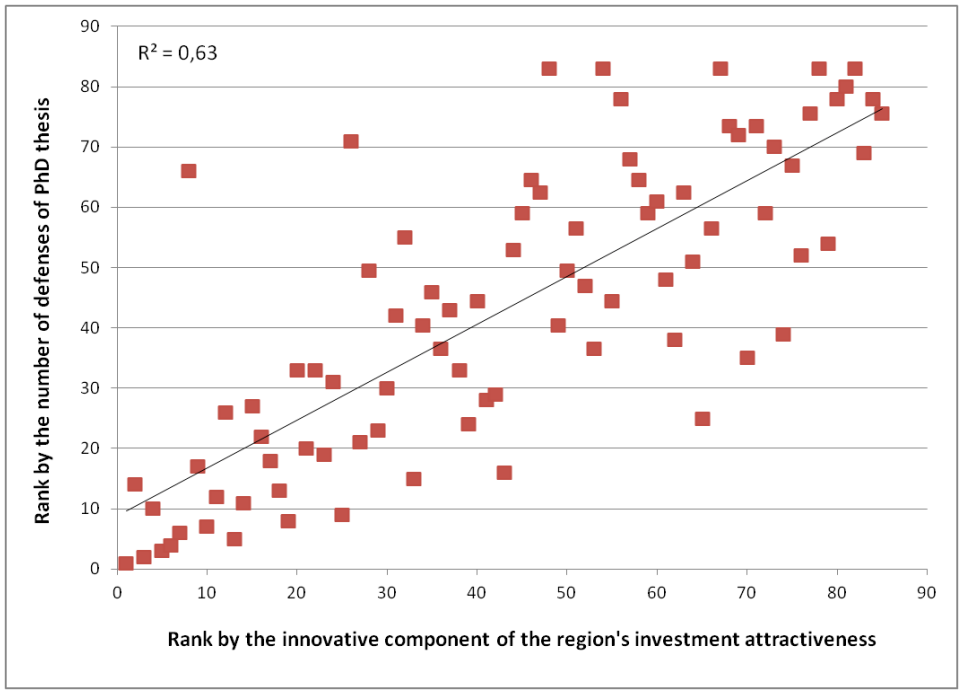


*Figure 1. Relation between rank of region by the innovative component of the region's investment attractiveness and rank of region by the number of defenses of PhD thesis.*

By the rank of region by the innovative component of the region's investment attractiveness in the top ten are in descending order of the indicator: Moscow, Moscow region, St. Petersburg, Nizhny Novgorod region, Republic of Tatarstan, Novosibirsk region, Sverdlovsk region, Kaluga region, Chelyabinsk region, Tomsk region.

Of these, Moscow Region (14th place in terms of number of defenses of PhD thesis), Chelyabinsk Region (66th place in terms of number of defenses of PhD thesis) and Tomsk Region (17th place in terms of number of defenses of PhD thesis) were not among the top ten in terms of rank of region by the number of defenses of PhD thesis. Instead of these regions, the top ten contains Rostov Region (the 13th place in terms of innovation), Republic of Bashkortostan (19th place in terms of innovation) and Saratov region (the 25th place in terms of innovations).

Another index of innovative development is the index "Scientific and Technical Potential", which is a composite assessment reflecting the development of the scientific and technical potential of innovation activities in the regions. The index is calculated by Higher School of Economics [5].

We estimated the relationship between the number of defenses of PhD thesis and the values of the index of the scientific and technical potential in 85 subjects of the federation of Russia (Fig. 2).

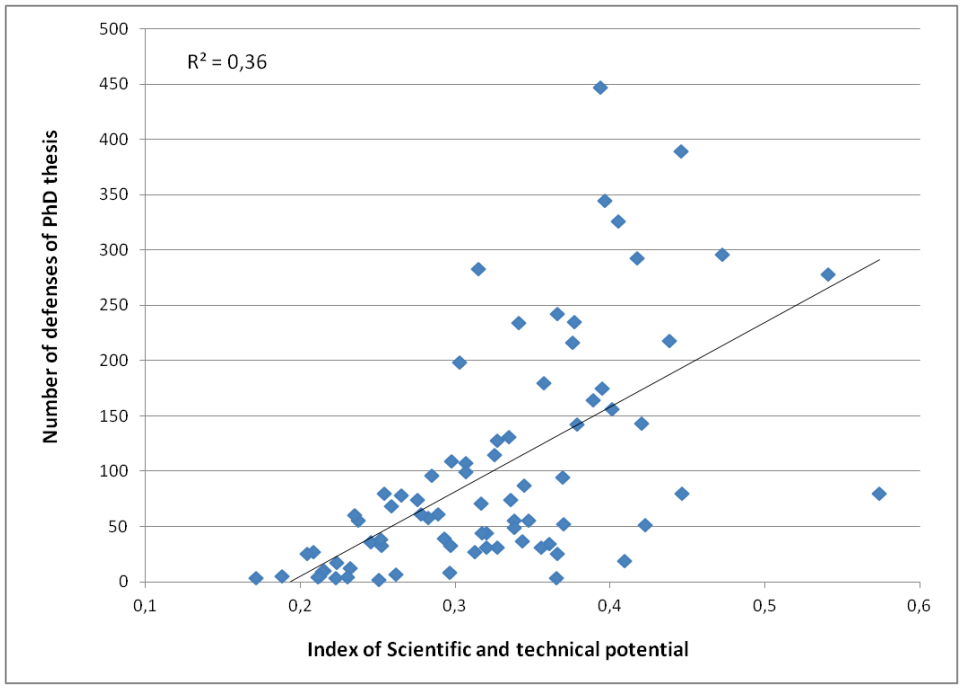


*Figure 2. The relationship between the number of defenses of PhD thesis and the values of the index of the scientific and technical potential.*

The first ten regions with the maximum value of the index of scientific and technical potential in the order of decreasing values of the index include Ulyanovsk Region, St. Petersburg, Nizhny Novgorod Region, Moscow, Tomsk Region, Yaroslavl Region, Novosibirsk Region, Moscow Region, Smolensk Region, Omsk Region.

The relationship between the number of defenses of PhD thesis and the values of the index of the scientific and technical potential is average (the correlation coefficient is 0.6). This indicates that the number of graduates of the graduate school corresponds to the level of scientific and technical potential in the region, which will support maintain and further develop the scientific base for obtaining innovative products.

## 4 CONCLUSIONS

Studies show that there is a direct correlation between the number of postgraduate graduates and the indicators of innovation potential in the regions of Russia. High-tech sectors of the economy form the core of Russia's innovative development. Providing these sectors with the graduates of PhD programs is the most important task for education in conditions of intense competition between states. And here Russia has a good potential in the training of the highly qualified scientific personnel and in the creating new technologies by these highly qualified scientific personnel.

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