Impact of Resource Provision for Regional Research and Innovation on Labor Productivity Growth

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Abstract. The study analyzes the impact of resource provision for regional research and innovation on labor productivity growth in Russian regions.

The dataset covers the data on 85 Russian Regions for the 2010–2017 years. Panel regression with fixed effects was employed to fulfil research aim. We use blocks of indicators characterizing financial, intellectual/human, information, entrepreneurial, and material and technical resources.

The regression analysis showed that the following indicators of resource provision for research and innovation have a significant positive impact on labor productivity growth: domestic current costs for applied research, domestic current costs for development, domestic current labor costs for employees engaged in R&D, share of researchers with advanced degrees. The indicators characterizing the resource base of the regions that were included in our study are all significant. The capital-labor ratio and the number of personal computers per 100 workers provide the most positive effect on labor productivity growth in Russian regions.

The study results can find practical implications in development of suggestions for adjusting Regional Development Strategies.

Keywords: Resourcing · Resource availability · Supply · Labor productivity · Regression model · R&D · Regional development

JEL Code: J24 · O30 · R1

1 Introduction

Analysis of labor productivity today is an important topic of research, since labor productivity is one of the crucial indicators that reflect the performance of national and regional economies. In particular, it describes the availability and possibilities of attracting various economic resources for these purposes, including financial resources, human capital, material and technical, business, information and other types of resources. The Decree of the President of the Russian Federation (of 7 May 2018) No. 204 “On National Goals and Strategic Objectives for the Development of the Russian Federation for the Period up to 2024” considers the growth of labor productivity as a priority goal of the state. This is also reflected in the National Project “Labor Productivity and Employment Support”.

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Today, the growth of labor productivity is possible to a greater extent due to the introduction of innovations in enterprises: raw materials, technological, organizational and managerial. However, the resource provision for research and innovation in the region significantly influences the effectiveness of these measures. It reflects the possibility of creating promising innovative products in terms of the funds’ availability for these purposes, the necessary potential in the form of human resources of appropriate “quality”, the provision of ICT infrastructure, the state of fixed assets, as well as entrepreneurial resources, without which the generation of new ideas is impossible.

A large number of studies by foreign and domestic authors are devoted to the influence of various factors on labor productivity: Aboal and Tacsir (2018), Arvanitis (2005), Baharin et al. (2020), Edquist and Henrekson (2017), Ekimova (2019), Gunina (2015), Kurt and Kurt (2015), Mirolyubova (2016), Panshin et al. (2019), Relich (2017), Samargandi (2018), Seropov (2015) etc. However, the issue of assessing the impact of resource provision for regional research and innovation on labor productivity growth remains insufficiently studied.

In this regard, the aim of the study is to analyze the influence of the main factors reflecting the resource provision for research and innovation on labor productivity growth in the regions of the Russian Federation.

2 Methodology

Labor productivity is a dynamic indicator that constantly changes under the influence of many factors, determined by both objective and subjective reasons. The study of labor productivity originates in the 17th century in works of such scholars as Smith A., Petty W., Ricardo D., Quesnay F., Marx K. and Engels F. The concept of one-factor productivity has been dominant for several decades. Solow R.M., Sink D.S., Kendrick J.W., Birman A.M. developed the concept of multi-factor labor productivity.

Modern researchers continue to study the issues of labor productivity analysis and its growth factors. Samargandi (2018) showed that employment and wages are negatively linked to productivity, while human capital and fixed capital are positively linked to it; the price of oil, financial development, trade openness, and value added in industry play an important role in increasing productivity; innovation is an important factor in productivity growth. Arvanitis (2005) noted that labor productivity depends on physical and human capital along with the availability of knowledge and innovation. Innovative activities of organizations, in particular, the number of product innovations, can contribute to the growth of labor productivity. Kurt and Kurt (2015) showed that patent applications and Internet users increase productivity in BRICS countries. Samargandi (2018), Arvanitis (2005), Kurt and Kurt (2015) showed in their studies the importance of innovation and research in improving labor productivity, however, these works do not answer the question which resources are most essential for increasing innovative activity.

Baharin et al. (2020) examined the impact of human capital, namely education and health, on labor productivity in Indonesia using the ARDL model. The results of the analysis showed that investment in primary and secondary education positively affects labor productivity, while investment in higher education has a significant negative
impact. Indeed, higher education in itself is not so important as its application in innovation and research. Only then it should contribute to the growth of labor productivity. Therefore, it is necessary to consider the “quality” of human resources, when analyzing the impact of the resource provision for research and innovation on labor productivity growth.

Quite a large number of papers are devoted to the impact of information and communications technology (ICT) on labor productivity. For example, Edquist and Henrekson (2017) concluded that research and development (R&D) affect overall productivity growth much more than ICT-investment. Relich’s (2017) study showed the positive and significant impact of individual ICT components on labor productivity in EU countries. Aboal and Tacsir (2018) assessed the relative importance of ICT-investment and all other innovative activities for labor productivity. In some way these researchers also analyzed the importance of providing financial resources in addition to the importance of providing ICT resources. Mirolyubova (2016) found a strong positive relationship between GRP per employee and the number of personal computers that had access to the Internet.

As for Russian scholars, for example, Seropov (2015) suggests dividing all the factors that affect labor productivity into internal and external ones. Internal factors include monetary factors (salary level), non-monetary factors (free food, comfortable office, parking, corporate discounts, health insurance, employer characteristics, employee characteristics). External factors include political, economic, social, technological, and legislative factors. Gunina (2015) identified the following factors of labor productivity growth: fixed assets factors – the level of technology, materials used; socio-economic factors – the labor potential and working conditions; organizational factors – the level of labor organization, production and management. Ekimova (2019) came to conclusion that the contribution of technological factors to the total increase in labor productivity over the past 25 years was 66.7%, while all other indicators (institutional, organizational, structural, natural, and human capital development factors) accounted for only 33.3%.

Thus, labor productivity depends not only on the quality of labor resources and motivation of employees to work intensively, but also on the technologies used in the enterprise, the level of automation and robotization of production, the novelty and frequency of the equipment and tools updating.

Analysis of the recent studies showed that they cover a really wide range of factors affecting labor productivity. Many scholars emphasize the importance of research and innovation level in the context of productivity growth, but they do not answer the question: What resources should be provided for research and innovation in the region in order to have significant impact on labor productivity growth?

We will not consider labor productivity as an indicator of efficiency, but as a private indicator of resource productivity. Below is the formula for multifactor resource productivity:

$$\text{Resource productivity} = \frac{\text{Income}}{F_1 + F_2 + \ldots + F_n} \quad (1)$$
\[ F_1 + F_2 + \ldots + F_n \] – factors of production, such as labor, scientific and technological progress, etc.

In the framework of this study, we assess the influence of scientific and technological progress factor, which is characterized by the level of research and innovation in the region, on the return on the use of labor resources, i.e. labor productivity, however, we assess the level of research and innovation not directly, but through the resource base.

We selected 19 indicators characterizing the availability of various resources to assess the level of research and innovation in the region (Table 1). 11 indicators of them reflect the level of resource provision for research and innovation in the region, such as:

- share of domestic costs for R&D, as % of gross regional product (GRP);
- share of technological innovation costs in the total volume of goods shipped, work and services performed, %;
- domestic current costs for basic research, mln. rubles;
- domestic current costs for applied research, mln. rubles;
- domestic current costs for development, mln. rubles;
- domestic current labor costs for employees engaged in R&D, mln. rubles;
- domestic current costs for the purchase of equipment for R&D, mln. rubles;
- the number of researchers performing R&D per 10,000 employed in the economy;
- share of researchers with advanced degrees, %;
- the number of advanced technologies used, pcs.;
- share of organizations engaged in innovative activities in the total number of organizations (innovative activity of organizations), %.

Table 1. Indicators for assessing the resource base of research and innovation in the region

| Resource type          | Variable | Name of estimated indicators                                      | Brief description                                                                 |
|-----------------------|----------|---------------------------------------------------------------------|----------------------------------------------------------------------------------|
| 1. Financial resources| X11      | Share of domestic costs for R&D, as % GRP                           | Financial resources are needed both at the stage of generating ideas and developing innovations |
|                       | X12      | Share of technological innovation costs in the total volume of goods shipped, work and services performed, % |                                                                                  |
|                       | X13      | Costs for ICT, mln. rubles                                         |                                                                                  |
|                       | X14      | Domestic current costs for basic research, mln. rubles              |                                                                                  |
|                       | X15      | Domestic current costs for applied research, mln. rubles            |                                                                                  |
|                       | X16      | Domestic current costs for development, mln. rubles                 |                                                                                  |
|                       | X17      | Domestic current labor costs for employees engaged in R&D, mln. rubles |                                                                                  |
|                       | X18      | Domestic current costs for the purchase of equipment for R&D, mln. rubles |                                                                                  |

(continued)
The remaining 8 indicators presented in the Table 1 characterize other factors that influence the overall development of the economy in the region (GRP), including the level of research and innovation.

3 Results

The study was based on the data from Unified Interdepartmental Information and Statistical System (EMISS) of the Russian Federation. The sample includes the data on 85 Russian regions for the 2013–2017 years.

We applied regression analysis in order to check the relationship between the resource provision for research and innovation in the regions and labor productivity. The following hypothesis was to be tested:

H0: The greater is resource provision for research and innovation in the region the higher is labor productivity.
The different types of resources that support research and innovation are the independent variables (explanatory variables). Labor productivity (LP) is the dependent variable (response variable). We calculated the labor productivity at the regional level as the ratio of the gross regional product to the average annual number of employees.

Descriptive statistics for the above indicators are presented in Table 2 below.

The analyzed variables are presented in different units of measurement. Therefore, it will be more correct to present the results of the study in the form of a percentage change or elasticities. For this, we found the logarithms of the source data.

All variables were tested with Levin, Lin & Chu unit root test for panel data. All variables are stationary at 5% level of statistical significance. Fixed effects model was tested for redundancy of fixed effects. Fixed effects approach is appropriate according to Hausman test. Estimated econometric model is presented in Table 3.

Since the source data for analysis is panel data, panel regressions with fixed effects or random effects are applicable. Fixed effects regression model is more suitable for testing the hypothesis, since it allows for individual heterogeneity of the sample to be taken into account.

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| Variable                      | Mean    | Median  | Maximum | Minimum | Std. Dev. | Observations |
|-------------------------------|---------|---------|---------|---------|-----------|--------------|
| LP, thous. rubles per person  | 803.2047| 578.0667| 8455.202| 212.9503| 846.6887  | 670          |
| X11, %                        | 0.75714 | 0.455   | 6.7     | 0       | 0.94033   | 680          |
| X12, %                        | 1.827219| 1.337418| 16.7    | 0       | 1.788268  | 669          |
| X13, mln. rubles              | 12829.07| 3400.385| 781271.6| 25.6762 | 49813.53  | 672          |
| X14, mln. rubles              | 1406.641| 295.75  | 55572   | 0       | 5262.743  | 680          |
| X15, mln. rubles              | 1684.724| 251.95  | 78880.1 | 0       | 7360.175  | 680          |
| X16, mln. rubles              | 5607.849| 463.3   | 210328.2| 0       | 19656.8   | 679          |
| X17, mln. rubles              | 4090.24 | 624.5   | 161780.1| 0       | 15383.66  | 680          |
| X18, mln. rubles              | 276.31  | 24.85   | 8212    | 0       | 993.1458  | 680          |
| X21, persons                  | 27.08293| 16.2    | 211.9774| 0       | 31.82314  | 679          |
| X22, %                        | 19.64125| 17.13293| 70.89202| 0       | 13.45464  | 672          |
| X31, pcs                      | 41.70735| 42      | 80      | 0       | 8.688926  | 680          |
| X32, %                        | 86.34521| 88.35   | 100     | 0       | 11.7741   | 680          |
| X33, %                        | 30.35159| 24.5    | 83.7    | 0       | 16.51574  | 678          |
| X41, %                        | 49.32814| 49.87604| 92.79438| 10.9459 | 11.89094  | 672          |
| X42, pcs                      | 2529.175| 1518.5  | 20649   | 0       | 3237.469  | 680          |
| X43, %                        | 9.019643| 8.3     | 34.3    | 0       | 4.740774  | 672          |
| X51, mln. rubles              | 1884949 | 850455.5| 36604923| 0       | 3830241   | 680          |
| X52, %                        | 45.24015| 45.6    | 73.3    | 0       | 10.47235  | 680          |
| X53, thous. rubles per person | 2242.761| 1441.235| 27138.26| 240.6214| 3034.957  | 670          |
| Variable/dependent variable | Ln(LP)       |
|-----------------------------|-------------|
| Ln (X11)                    | −0.25435*** |
|                             | (0.020634)  |
| Ln (X12)                    | 0.001826    |
|                             | (0.004269)  |
| Ln (X13)                    | 0.012508**  |
|                             | (0.006908)  |
| Ln (X14)                    | 0.012429    |
|                             | (0.008203)  |
| Ln (X15)                    | 0.024617*** |
|                             | (0.007531)  |
| Ln (X16)                    | 0.025006*** |
|                             | (0.006559)  |
| Ln (X17)                    | 0.286945*** |
|                             | (0.027575)  |
| Ln (X18)                    | 0.005523    |
|                             | (0.003405)  |
| Ln (X21)                    | −0.069952***|
|                             | (0.01824)   |
| Ln (X22)                    | 0.097371*** |
|                             | (0.018839)  |
| Ln (X31)                    | 0.436801*** |
|                             | (0.044839)  |
| Ln (X32)                    | 0.094082**  |
|                             | (0.053856)  |
| Ln (X33)                    | 0.021081**  |
|                             | (0.008743)  |
| Ln (X41)                    | 0.089009*** |
|                             | (0.01864)   |
| Ln (X42)                    | −0.011225   |
|                             | (0.011321)  |
| Ln (X43)                    | 0.016115    |
|                             | (0.010801)  |
| Ln (X51)                    | −0.697671***|
|                             | (0.066618)  |
| Ln (X52)                    | −0.109895***|
|                             | (0.034797)  |
| Ln (X53)                    | 0.996821*** |
|                             | (0.065336)  |
| Constant                    | 3.200529*** |
|                             | (0.544468)  |

R-squared 0.988400
Adjusted R-squared 0.986098
F-statistic 429.3940
Observations 661

Note: Standard Errors are in parentheses. *** stat. significance on 1%, ** stat. significance on 5%, * stat. significance on 10%
Model is significant at 1% significance level. Thus, the model confirms the statistically significant relationship between the resource provision for research and innovation in the region and labor productivity.

However, in the framework of our study first of all it is necessary to assess the impact of 11 indicators, reflecting the level of resource provision for research and innovation in the region. Among them, only 6 indicators have a statistically significant effect (Fig. 1).

![Fig. 1. Indicators of resource provision for research and innovation in the regions of the Russian Federation, which have statistically significant impact on labor productivity](image)

X11 – Share of domestic costs for R&D, as % GRP
X15 – Domestic current costs for applied research, mln. rubles
X16 – Domestic current costs for development, mln. rubles
X17 – Domestic current labor costs for employees engaged in R&D, mln. rubles
X21 – Number of researchers performing R&D per 10,000 employed in the economy
X22 – Share of researchers with advanced degrees, %

Such indicators as domestic current costs for applied research, domestic current costs for development, domestic current labor costs for employees engaged in R&D, that characterize the financial resources of research and innovation, have a significant positive impact on labor productivity. The higher is the salary, the more qualified, experienced and promising specialists can be attracted. However, it is necessary to consider, that the labor costs for employees engaged in R&D should grow at a lower rate than the volume of industrial production. During the study period this condition was met in the Russian Federation only in 2015 and 2016.

The share of domestic costs for R&D, as % of GRP, has a negative effect on labor productivity. The growth of certain costs contributes to the increase in the denominator in the multifactor resource productivity model (1). And as a result, it reduces the final indicator if the numerator grows more slowly.

Human resources indicators have a multidirectional impact on labor productivity. In particular, a large number of researchers performing R&D reduces labor productivity. At the same time, the higher is the share of researchers with academic degrees, the higher is the labor productivity. Therefore, it is not the quantity of intellectual resources that is important, but their quality.
Remaining 8 indicators characterizing the resource base of the regions, and indirectly affecting the resource provision for research and innovation, turned out to be significant. The capital-labor ratio and the number of personal computers per 100 workers provide the biggest positive effect on labor productivity. It should be noted that digitalization of labor becomes more and more sufficient factor of labor productivity in the context of restrictive measures introduced by governments of various countries in 2020 related to preventing the spread of coronavirus infection (COVID-19).

The elasticity of labor productivity for most resource indicators is less than one, which means that the increase in resource expenditures occurs in larger volumes than the increase in labor productivity. However, the low elasticity can be explained by the big delay in introducing research results into production.

4 Conclusions

The results of the analysis show that there is a significant positive impact of 4 indicators that characterize the resource base of research and innovation in the region on labor productivity, such as domestic current costs for applied research, domestic current costs for development, domestic current labor costs for employees engaged in R&D, share of researchers with advanced degrees.

Such indicators as the share of domestic costs for R&D, as % GRP and the number of researchers performing R&D per 10,000 employed in the economy have a negative impact on labor productivity.

Labor productivity turned out to be inelastic for most indicators of the resource provision for research and innovation in the Russian regions. However, the low elasticity of influence can be explained by the big delay in introducing research results into production.

In conclusion, it should be noted that the sphere of research and innovation can have an impact on labor productivity by increasing the competence of the entire working population. In other words, the growth in the number of highly qualified personnel contributes to overall productivity growth in all areas of society. Most R&D is carried out on the basis of universities (for example, National Research University Higher School of Economics), which train future personnel for the country. Therefore, we consider it appropriate to include in future studies of labor productivity dynamics such indicator as the level of education of the population.

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