About One Approach for Comparing Regions of Different Countries According to the Technical Efficiency of Innovation Space

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INTRODUCTION

In the paper (Ayvazyan et al., 2017), quantitative characteristics of the influence of science and business on the results of innovative activity of the subjects of the Russian Federation were obtained. In accordance such results, patents, international patent applications and developed new production technologies are considered. As a result of testing a number of hypotheses, it was established that there is a correlation between the result of innovation activity in the region and

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the number of potential connections between organizations creating new knowledge and innovative active enterprises. The totality of such ties is characterized as the innovative space of the region. It is shown that the dependence of the result of innovation activity on the size of the innovation space is described by the model

$$\ln Q_i = c + \delta \ln V_i + v_i - u_i .$$  \hspace{2cm} (1)

Here $Q_i$ - The result of innovation activity in the region $i$ (Options were considered: $Q_i = teh_i$ - Number of developed new production technologies in the region $i$; $Q_i = pat_i$ - Number of issued patents; $Q_i = ipat_i$ Number of international patent applications); $V_i = S_i * B_i$, where $S_i$ - Number of organizations creating new knowledge (options were considered: $S_i = vuz_i$ - Number of higher education institutions, $S_i = ror_i$ - Number of organizations performing scientific research); $B_i = buz_i$ - Number of enterprises in the region, $c, \delta, \gamma$ - options.

Value $V_i = S_i * B_i$ - The number of potential twinning relationships between organizations that create new knowledge and enterprises, which characterizes the size of the region's innovation space. The random component $v_i - u_i$ Reflects the results of the impact on the innovation process of the region of uncertainty factors and efficiency factors.

To simulate the effects of uncertainty factors, a normally distributed random variable $v_i$ is used with zero mathematical expectation $v_i \in N(0, \sigma_v^2)$. To simulate the effects of efficiency factors, it is used independent of $v_i$ nonnegative random variable $u_i$, having a truncated at zero normal distribution with zero mathematical expectation $u_i \in N^{+}(0, \sigma_u^2)$.

Models of the form (1) are constructed according to the data presented in Table 1 for the subjects of the Russian Federation, the US states (2001, 2006, 2009, 2012) and the prefectures of Japan (2001, 2006).

### Table 1. Initial data on subjects RF, US states, and Prefectures of Japan

| Designation | Designation Indicators | Country | Source, years |
|-------------|------------------------|---------|---------------|
| $pat_i$     | Number of international patent applications | RF      | (PCT patent applications, 2014) 2001, 2006, 2009, 2012 |
| $ror_i$     | Number of organizations performing scientific research | RF      | (Organizations performing scientific research, 2013) 2001, 2006, 2009, 2012 |
| $vuz_i$     | Number of higher education institutions | RF      | (Higher educational institutions, 2013) 2001, 2006, 2009, 2012 |
| $buz_i$     | Number of enterprises | RF      | (Number of enterprises..., 2013) 2001, 2006, 2009, 2012 |
| $pat_i$     | Number of international patent applications | USA     | (PCT patent applications, 2014) 2001, 2006, 2009, 2012 |
| $vuz_i$     | Number of higher education institutions | USA     | (Number of institutions, 2010) 2001, 2006, 2009, 2012 |
| $buz_i$     | Number of enterprises | USA     | (All business establishments, 2014) 2001, 2006, 2009, 2012 |
It was concluded that the set of parameters $(\delta, c, t)$, where $\delta$ and $c$ - The parameters of the model (1), $a$ is the time, can be used for a parametric description of the national innovation system of the Russian Federation when it creates regions of a certain result of innovation activity. Similarly, using a model of the form (1), a parametric description of other national innovation systems can be obtained. Moreover, it is possible to compare their parametric descriptions.

**Figure 1.** Parametric description of the innovation systems of the Russian Federation, the United States and Japan on international patent applications for the period 2001-2012, the abscissa is the constant estimate, the y-axis is the elasticity estimate, the figure is the year.

In fig. 1 is a parametric description $(\delta, c, t)$ innovation systems of the Russian Federation, the United States and Japan on international patent applications for a number of years of the period 2001-2012. The size of the innovation space of the subjects of the Russian Federation is estimated by the number of organizations performing scientific research and enterprises. The size of the innovative space of US states and prefectures in Japan is estimated by the number of higher education institutions and companies. The abscissa indicates the constant $c$, on the y-axis - the elasticity estimate $\delta$, obtained from a model of the form (1). For each point is the year. Growth in time as a constant $c$, and elasticity $\delta$, testifies to the development of the national innovation system. It is easy to see that in Fig. 1, the points characterizing the innovation systems of Japan and the USA possess the property of Pareto optimality. The points characterizing the parametric description of the innovation system of the Russian Federation are not pareto-optimal. At the same time, it should be noted that the number of international patent applications filed has increased...
significantly in terms of the size of the innovation space for both the constituent entities of the Russian Federation and the US states.

Table 2. Estimates of the parameters of the model (1) for the subjects of the Russian Federation, the US states, the prefectures of Japan and the general model according to 2006 data.

| Model | Subjects of the RF | US states | Prefectures of Japan | general model |
|-------|-------------------|-----------|----------------------|--------------|
|       | (1)               | (2)       | (3)                  | (4)          |
| $V$   | 0.722***          | 0.676***  | 0.848***             | 1.126***     |
|       | (0.000)           | (0.000)   | (0.000)              | (0.000)      |
| const | -8.102***         | -4.504*** | -5.949***            | -12.242***   |
|       | (0.000)           | (0.004)   | (0.003)              | (0.000)      |
| Log likely | -112.531   | -65.566   | -75.151              | -357.390     |
| $\sigma_v$ | 0.255     | 0.875     | 0.903                | 1.801        |
| $\sigma_u$ | 1.759     | 0.010     | 1.322                | 0.0706       |

Note. In this table and below, the symbols "***", "**", "*" denote estimates at 10-, 5-, and 1% significance levels, respectively.

Table 2 presents estimates of the parameters of a model of the form (1) constructed from the data of 2006. For 80 subjects of the Russian Federation (column 1), 51 states of the USA (column 2), 47 prefectures of Japan (column 3) and a general model for 178 regions (column 4). The size of the innovative space of the subjects of the Russian Federation is estimated by the number of higher educational institutions and enterprises. The size of the innovative space of US states and prefectures in Japan is estimated by the number of higher education institutions and companies.

1. PROBLEMS OF COMPARISON OF INNOVATIVE ACTIVITY OF REGIONS DIFFERENT COUNTRIES

With the estimated parameters $\sigma_v^2, \sigma_u^2$ Models (1) can be calculated (Battese, Coelli, 1988)

Mathematical expectation $TE_i = E(e^{-u_i} \mid v_i-u_i) = \Phi(\hat{\mu}_i / \sigma_v - \sigma_u) \exp \left\{ \frac{1}{2} \sigma_u^2 - \hat{\mu}_i \right\}$,

rAE $\hat{\mu}_i = -(v_i - u_i) \sigma_u^2 / \sigma_v^2$, $\sigma_v^2 = \sigma_u^2 \sigma_v^2 / \sigma_u^2$, $\sigma_u^2 = \sigma_v^2 + \sigma_u^2$.

In accordance with the concept of the stochastic boundary (Kumbhakar, Lovell, 2004), the value characterizes the expected value of the technical efficiency of the innovation space of the region as a ratio of the actual result of innovation activity in the region $\exp \{c + \delta \ln V_i + v_i - u_i \}$ to the potential $\exp \{c + \delta \ln V_i \}$. That is, $TE_i = E(e^{-u_i} \mid v_i - u_i)$. Set of four parameters $(\delta, c, t, TE_i)$ Can be used to describe a regional innovation system. The latter parameter is of particular interest, since the evaluation of technical efficiency can be considered as a characteristic of the quality of management of a regional innovation system. At the same time, a direct comparison of different regional innovation systems functioning within the framework of a common national
innovation system for a fixed time is allowed, since in this case the technical efficiency estimates obtained on the basis of one model are comparable.

For a parametric description of regional innovation systems of different countries, it is appropriate to use different models of the form (1). Each such model allows to obtain estimates of the parameters of the national innovation system and comparable estimated of the technical efficiency of innovation space in different regions of the same country. These economic entities have the property of homogeneity in the sense that they create innovative products in the general institutional environment formed by the state. Estimates of technical efficiency of regions of different countries, obtained using different models of the form (1), are not comparable, since they are relative. Therefore, comparing the estimates obtained for different models of the form (1), each of which characterizes the set of regions of a particular national innovation system, is generally not permissible.

In column 6 of Table A1 of the appendix, it is presented the technical efficiency estimates obtained for the model of form (1) independently for regions of the Russian Federation, US states and prefectures of Japan according to the data concerning international patent applications of 2006 year. The first 80 values of the technical efficiency estimates in the column 6 are obtained using the model $M_1$ estimated only for the regions of the Russian Federation, the following 51 – using the model $M_2$ estimated only for the US states, the following 47 – using the model $M_3$ estimated only for the prefectures of Japan. Each value of the technical efficiency estimates in column 6 corresponds to the region whose name is indicated in column 2 of this table. Column 1 shows the region's ordinal number in the list of regions of the country. In column 7, the rank of the technical efficiency rating in the sequence of estimates for the regions of the given country (the value of the rank increases with the decrease of technical efficiency). For example, the estimate of the technical efficiency of the innovative space for Bryansk region (the regional serial number in the total 80 regions of the Russian Federation is 2) when creating international patent applications, obtained from the model $M_1$ estimated for the Russian Federation regions using the data for 2006 year, is 0.41713. The rank of this estimate in the ranking for 80 regions of the Russian Federation is 36. The evaluation of the technical efficiency of the innovation space for the US state Alabama (the serial number of the region in the total 51 US states is 1) when creating international patent applications, obtained by the model $M_2$ estimated for US states using the data for 2006 year, is 0.99171. The rank of this estimate in the US state ranking is 18.
Figure 3. Assessing the technical efficiency of the innovation space of US states. The states are ordered in ascending order of their ordinal numbers (the abscissa axis).

In total, column 6 of Table P1 contains 178 (80 + 51 + 47) technical efficiency ratings. They are taught in three different models of the form (1) and their direct comparison is not correlated. Looking at Fig. 2 we can assume that the technical efficiency of the innovation space of any US state is higher than that of any prefecture in Japan and any region of the Russian Federation, but this is not true, since estimates obtained by different models are not comparable.

Another mistake may be the assumption that all US states are equally effective. However, an analysis of estimates with a higher level of accuracy of their values, as shown in Fig. 3, allows you to rank the regions in terms of efficiency level. In the works of the authors (Aivazyan et al., 2016, Aivazyan, Afanasiev, 2015, 2016) it was shown that the specification of model (1) and residual distribution functions can have a significant effect on the values of technical efficiency estimates. In this case, the ranks of these estimates have the property of resistance to the specification of the mode. It is quite natural to be able to compare the regions of different countries on the basis of technical efficiency estimates obtained from a common model for the whole region of the model $M_0$ of the form (1). The technical efficiency estimates obtained in this way are shown in Fig. 4.

Figure 4. Technical efficiency assessments obtained from the general model for the regions of the Russian Federation (left), the US states (in the middle), and the prefectures of Japan (right). Regions of each country are ordered by increasing their serial numbers (the same as in Figure 2).
Such assessments of technical efficiency are comparable and can be used to compare regions. But the general model $M_0$ does not have a satisfactory economic interpretation, because it unites economic entities that actually operate under different institutional conditions. At the same time, the grades of the region's estimates of any country, obtained in two ways: by the general model and the "national" model, can differ substantially. In column 3 of Table P1, technical efficiency estimates are presented for all 178 regions of the three countries, obtained from the general model $M_0$. In column 4, the ranks of these ratings are in the ranking of the entire aggregate of 178 regions. In column 5, the ranks of these estimates are in the ranking of the regions of each country. For example, an assessment of the technical efficiency of the innovation space of the Bryansk region in the general model $M_0$, Estimated for 178 regions of the three countries according to 2006, is equal to 0.94571. The rank in the rating of 178 regions of the Russian Federation, the United States and Japan is equal to 114. The rank of this rating in the rating of 80 regions of the Russian Federation is 25. Evaluation of the technical efficiency of the innovation space of the US state Alabama by the general model $M_0$ is equal to 0.94651. The rank in the rating of 178 regions of the Russian Federation, the United States and Japan is 58. The rank of this rating in the rating of the US states is equal to 22. The technical efficiency estimates obtained by the general model differ from the estimates of technical efficiency. Obtained by "national" models. The grades of these grades differ, moreover, the difference in ranks can be significant.

| Subjects of the RF | US states | Prefectures of Japan |
|-------------------|-----------|----------------------|
| Number of regions | 80        | 51                   | 47                   |
| Coefficient of Spearman's rank Correlation | 0.7206 | 0.5846 | 0.9528 |

In Table 3, for each country, Spearman's rank correlation coefficients of the regional technical efficiency estimates are presented for the general and "national" model. For Japan prefectures, grades of assessments vary slightly, for US states, changes in grades are significant. It can be concluded that the transition from "national" models of the form (1) to the general model $M_0$ allows to ensure comparability of estimates, but leads to a distortion of their ranks. The task is to ensure comparability of technical efficiency estimates for regions of different countries in such a way that the ranks of these estimates are equal to the ranks of the estimates obtained from the "national" models. To solve this problem, the method of adjusting the technical efficiency estimates obtained from the general model described in the next section can be used.

2. METHOD OF ADJUSTING THE TECHNICAL EFFICIENCY ESTIMATES TO COMPARABLE FORM.

In this section, it is presented a description of the method which is capable to bring the estimates of the technical efficiency of the innovative space of regions from several countries to a comparable type. We proceed from the premise that a "national" model can be built for each country separately, which makes it possible to obtain estimates of the technical efficiency of the innovation space of the regions from given country. However, the efficiency estimates obtained by the "national" models are not comparable. We get the comparable efficiency estimates from the mod-
el, which is common to the whole set of considered regions from different countries. The method described below makes it possible to adjust these comparable estimates so that the inferred ratings of regions from each country coincides with the rating of regions constructed according to the "national" model.

The proposed approach provides with the adjusted estimates of technical efficiency using the solution of the optimization problem. We compare the regions from the \( n \) countries. For each country \( s, s = 1, \ldots, n \) \((n \geq 2)\) it is available the information on the results of innovation activity, the characteristics of science and business for the assessing the size of the innovation space in each region \( i_s, i = 1, \ldots, m_s \) from the country \( s \). The comparable estimates of technical efficiency \( x^{s}_{i_s} \), \( i_s = 1, \ldots, m_s \), \( s = 1, \ldots, n \) could be obtained as a result of solving the optimization problem on maximizing the Spearman rank correlation coefficient of the sought corrected technical efficiency estimates \( x^{s}_{i_s} \), \( i_s = 1, \ldots, m_s \), \( s = 1, \ldots, n \) and the technical efficiency estimates \( \{ (TE^{s}_{i_s})_{M_0} \}_{i_s=1}^{m_s} \), obtained from the general model \( M_0 \) under the conditions that for each country \( s, s = 1, \ldots, n \) Spearman's rank correlation coefficient of the sought technical efficiency estimates \( x^{s}_{i_s} \), \( i_s = 1, \ldots, m_s \) and technical efficiency estimates \( \{ (TE^{s}_{i_s})_{M_s} \}_{i_s=1}^{m_s} \), obtained from the “national” model \( M_s \), equals to 1. The corresponding optimization problem is formalized as follows:

\[
spcor(\{x^{s}_{i_s}\}^s_{i=1}, \{ (TE^{s}_{i_s})_{M_0} \}^s_{i=1}) \rightarrow \max \quad (2)
\]

\[
spcor(\{x^{s}_{i_s}\}^s_{i=1}, \{ (TE^{s}_{i_s})_{M_s} \}^s_{i=1}) = 1, \ s = 1, \ldots, n, \quad (3)
\]

where \( spcor(\psi, \zeta) \) - the Spearman rank correlation coefficient for the series \( \psi \) and \( \zeta \) (comparable quantitative indicators).

The conditions in the above optimization problem ensure that the grades of the sought corrected technical efficiency estimates coincide with the ranks of the technical efficiency estimates obtained from the "national" models \( M_s \). The objective function makes it possible to bring the ranks of the scaled-up estimations to the maximum correspondence with the ranks of the technical efficiency estimates obtained by the general model \( M_0 \). Despite the simple form and compactness (the number of restrictions is equal to the number of countries) of the optimization problem (2-3), the use of unknown quantities as arguments of the Spearman rank correlation coefficient lead to computational difficulties. In the following it is presented an approach, which allows to transform the problem (2-3) to the optimization model of a quadratic objective function with linear constraints.

3. DESCRIPTION OF THE APPROACH

1. For each country \( s \) it is estimated the model \( M_s \) which has the form (1) and determines the dependence structure of the result of innovation activity on the size of the innovation space for
all $m_s$ regions of the considered country $s$. We get the parameters of the model $M_s$.

2. For each region $i_s, i = 1, ..., m_s$, from the country $s$ it is estimated the innovative space efficiency $(TE^s_{i_s})_{M_s}$.

3. The estimates $(TE^s_{i_s})_{M_s}$ are sorted in descending order in the set $\{(TE^s_{i_s})_{M_s}\}_{i_s=1}^{m_s}$. We get the rank $(R^s_{i_s})_{M_s}$ of the technical efficiency $(TE^s_{i_s})_{M_s}, 1 \leq (R^s_{i_s})_{M_s} \leq m_s$. In the following we will denote each rank $r_s, 1 \leq r_s \leq m_s$, together with its correspondent region number as follows: $i_s(r_s)$, which means that the region $i_s$ has rank $r_s$ in the sequence $(TE^s_{i_s})_{M_s}$.

4. A common model $M_0$ of the form (1) for the regions from all countries is estimated, which determines the dependence of the result of innovation activity on the size of the innovation space for all $m, m = \sum_{s=1}^{n} m_s$ regions. We get the parameters of the model $M_0$.

5. For each region $i_s, i_s = 1, ..., m_s, s = 1, ..., n$, from the model $M_0$ it is inferred the technical efficiency of the innovative space for each region $(TE^s_{i_s})_{M_0}$.

6. The estimations $(TE^s_{i_s})_{M_0}$ are sorted in descending order in the set $\{(TE^s_{i_s})_{M_0}\}_{i_s=1}^{m_s,n}$. We get the rank $(R^0_{i_s})_{M_0}$ of the technical efficiency $(TE^s_{i_s})_{M_0}, 1 \leq (R^0_{i_s})_{M_0} \leq m$.

7. For each $s, s = 1, ..., n$ the estimations $(TE^s_{i_s})_{M_0}$ are sorted in descending order in the set $\{(TE^s_{i_s})_{M_0}\}_{i_s=1}^{m_s}$. We get the rank $(R^s_{i_s})_{M_0}$ of the technical efficiency $(TE^s_{i_s})_{M_0}$,

$1 \leq (R^s_{i_s})_{M_0} \leq m_s$.

8. The required comparable and corrected technical efficiency estimates $(x^s_{i_s})_{M_0}, i_s = 1, ..., m_s, s = 1, ..., n$ can be obtained from the following optimization problem $M_x$:

$$\text{Problem } M_x:$$

$$\text{target function}$$

$$\sum_{s=1}^{n} \sum_{i_s=1}^{m_s} (x^s_{i_s} - (TE^s_{i_s})_{M_0})^2 \rightarrow \min,$$

$$\text{constraints}$$

$^1$ $M_x$ is a minimization problem with a strictly convex objective function and linear constraints. The model has $m$ parameters ($m$ - the total number of regions) and $m - n$ constraints ($n$ - the number of countries). The set of admissible solutions is not empty, there is a unique optimum.
\[ x_{i_r, (r)}^s \geq x_{i_{r+1}}^s + \varepsilon s, \quad r = 1, \ldots, m_s - 1, s = 1, \ldots, n. \]

9. We get the solution \( \left\{ \left( \hat{x}_{i_s}^s \right)_{M_s} \right\}_{i_s=1, s=1}^{m_s, n} \) of the problem \( M_x \).

10. The estimates \( \left( \hat{x}_{i_s}^s \right)_{M_s} \) are sorted in descending order in the set \( \left\{ \left( \hat{x}_{i_s}^s \right)_{M_s} \right\}_{i_s=1, s=1}^{m_s, n} \). For each region \( i_s, i_s = 1, \ldots, m_s, s = 1, \ldots, n \), we get the rank \( \left( R_{i_s}^{0s} \right)_{M_s} \leq \left( R_{i_s}^{0s} \right)_{M_s} \leq m \) of the \( \left( \hat{x}_{i_s}^s \right)_{M_s} \).

The ranks \( \left( R_{i_s}^{0s} \right)_{M_s}, 1 \leq \left( R_{i_s}^{0s} \right)_{M_s} \leq m \) are used for comparison of the regions from different countries in terms of the technical efficiency of the innovation space.

4. THE PROPERTY OF THE ADJUSTED TECHNICAL EFFICIENCY ESTIMATES.

For each country \( s \) we order the estimates \( \left( \hat{x}_{i_s}^s \right)_{M_s} \) in descending order in the set \( \left\{ \left( \hat{x}_{i_s}^s \right)_{M_s} \right\}_{i_s=1}^{m_s} \). For each region \( i_s, i_s = 1, \ldots, m_s \), we find a rank \( \left( R_{i_s}^s \right)_{M_s}, 1 \leq \left( R_{i_s}^s \right)_{M_s} \leq m_s \) in the sequence \( \left\{ \left( \hat{x}_{i_s}^s \right)_{M_s} \right\}_{i_s=1}^{m_s} \). For any positive \( \varepsilon s \) from the condition \( x_{i_r, (r)}^s \geq x_{i_{r+1}}^s + \varepsilon s, \quad r = 1, \ldots, m_s \) it follows: \( \left( R_{i_s}^s \right)_{M_s} = \left( R_{i_s}^s \right)_{M_s} \). That is, the rank \( \left( R_{i_s}^s \right)_{M_s} \) of the estimate \( \left( \hat{x}_{i_s}^s \right)_{M_s} \) equals to the rank \( \left( R_{i_s}^s \right)_{M_s} \) of the estimate \( \left( TEs_{i_s}^s \right)_{M_s} \). The estimates \( \left( \hat{x}_{i_s}^s \right)_{M_s} \) have the same order in the set of the estimates for only one country as the estimates \( \left( TEs_{i_s}^s \right)_{M_s} \), obtained from the model \( M_s \). So that, for \( \varepsilon s > 0 \) from the condition \( x_{i_r, (r)}^s \geq x_{i_{r+1}}^s + \varepsilon s, \quad r = 1, \ldots, m_s \) it follows \( spcor \left( \left\{ \left( \hat{x}_{i_s}^s \right)_{M_s} \right\}_{i_s}, \left\{ \left( TEs_{i_s}^s \right)_{M_s} \right\}_{i_s} \right) = 1 \).

If \( \varepsilon s = 0 \), some estimates \( \left( \hat{x}_{i_s}^s \right)_{M_s} \) may coincide. In this case when all constraints of the problem \( M_x \) are fulfilled, it isn’t necessarily that the following equality \( spcor \left( \left\{ \left( \hat{x}_{i_s}^s \right)_{M_s} \right\}_{i_s}, \left\{ \left( TEs_{i_s}^s \right)_{M_s} \right\}_{i_s} \right) = 1 \) fulfills. That’s why in the problem \( M_x \) we require that \( \varepsilon s > 0 \).

However, with the growth of \( \varepsilon s \) the value of the target function (2) \( spcor \left( \left\{ \left( \hat{x}_{i_s}^s \right)_{M_s} \right\}_{i_s}, \left\{ \left( TEs_{i_s}^s \right)_{M_s} \right\}_{i_s} \right) \) doesn’t increase.
Table 4. Spearman's correlation matrix for the ranks of technical efficiency estimates.

|                | \( (R_i^s)_{M_0} \), \( \text{eps}=0 \) | \( (R_i^s)_{M_0} \), \( \text{eps}=10^{-6} \) | \( (R_i^s)_{M_0} \), \( \text{eps}=10^{-7} \) | \( (R_i^s)_{M_0} \), \( \text{eps}=10^{-8} \) | \( (R_i^s)_{M_0} \), \( \text{eps}=10^{-9} \) |
|----------------|------------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|
| \( (R_i^s)_{M_0} \), \( \text{eps}=0 \) | 1                                       | 0.9984148                               | 0.998191                                | 0.784786                               | 0.602593                               | 0.908225                              |
| \( (R_i^s)_{M_0} \), \( \text{eps}=10^{-6} \) | 0.998414                               | 1                                       | 0.99993                                | 0.788331                               | 0.605083                               | 0.905693                              |
| \( (R_i^s)_{M_0} \), \( \text{eps}=10^{-7} \) | 0.998191                               | 0.999929                               | 1                                       | 0.789761                               | 0.606683                               | 0.904778                              |
| \( (R_i^s)_{M_0} \), \( \text{eps}=10^{-8} \) | 0.784785                               | 0.788330                               | 0.789761                               | 1                                       | 0.959239                               | 0.677618                              |
| \( (R_i^s)_{M_0} \), \( \text{eps}=10^{-9} \) | 0.602593                               | 0.605082                               | 0.606683                               | 0.959239                               | 1                                       | 0.505578                              |
| \( (R_i^s)_{M_0} \), \( \text{eps}=10^{-10} \) | 0.908224                               | 0.905692                               | 0.904778                               | 0.677618                               | 0.505578                               | 1                                       |

As it is shown in the last line of Table 4, the Spearman coefficient for the ranks of estimates obtained from the model \( M_0 \) and estimates obtained from the problem \( M_i \) decreases from the value 0.905692 with \( \text{eps}=10^{-6} \) to the value 0.505578 with \( \text{eps}=10^{-10} \). The ranks of the estimates, obtained with \( \text{eps}=10^{-6} \), are reported in the column 10 Table A1 (see Appendix). For the values \( \text{eps} \) from the interval \((0,10^{-5})\) the Spearman's coefficient differs from its maximal value 0.908224 by less than one percent. Therefore, taking \( \text{eps} \) as sufficiently small value, we get the ranks of the estimates, obtained from the model \( M_i \), for which the Spearman's correlation with the estimates from the model \( M_0 \), as closely as necessary to the maximum value.

**CONCLUSION**

In this paper it is presented a method for obtaining comparable estimates of the technical efficiency of the innovation space in the regions from several countries. These estimates are obtained as a result of adjusting the technical efficiency estimates obtained on the basis of a model common to the whole set of regions, which determines the dependence of the innovation activity result of the region on the size of its innovation space. The construction of a general model for obtaining comparable estimates of technical efficiency is entirely natural. However, the ranks of the estimates of the regions of a particular country obtained by it do not necessarily correspond to the ranks of the estimates obtained from the "national" model used to compare the regions of that country separately. In addition, the general model, as a rule, does not have a satisfactory economic interpretation, since the innovative activity of the regions of different countries is conditioned by different institutional conditions. These drawbacks of the estimates obtained by the general model require their correction.

The proposed method of adjusting allows, solving the problem \( M_s \), and taking any positive values for the parameter \( \text{eps} \), to obtain comparable estimates \( (\hat{x}_{i_j}^s)_{M_s} \), the ranks of which \( (R_i^s)_{M_s} \) correspond to the ranks \( (R_i^s)_{M_s} \) of estimates obtained by "national" models \( M_s \). With a sufficiently small positive value of the parameter \( \text{eps} \), the ranks \( (R_i^s)_{M_s} \) correspond at the maximal extent to the ranks \( (R_i^{0s})_{M_0} \) of the technical efficiency estimates obtained from a common model \( M_0 \) estimated from the data for the whole set of regions. The ranks \( (R_i^s)_{M_s} \) of the esti-
mates, corrected with the use of the above mentioned optimization problem $M_x$, allow comparing regions of different countries according to the technical efficiency of innovation space.

This approach can be used in a wide variety of problems of assessing technical efficiency and constructing ratings of economic entities operating under different institutional conditions. On its basis it is possible to rank objects belonging to different groups of generality in the case when theoretically justified comparison of them can be performed only within each group. To rank the entire set of objects, we need estimates obtained from a common model for all objects. These estimates, like the general model, do not need to have a rigorous theoretical justification. However, they must conform to the general principle of comparison used for objects within groups. When ranking the entire set of objects using the proposed optimization problem with a quadratic objective function and linear constraints, corrections are made to estimates obtained by the general model to ensure that their ranks correspond to the ranking results of objects obtained from group models.

REFERENCES

Aivazyan, S., Afanasyev, M. (2015), Assessment of Innovative Activity of Regions in the Russian Federation, Montenegrin Journal of Economics, Vol. 11, No. 1, 7-21. URL: http://www.gks.ru/bgd/regl/b14_14p/IssWWW.exe/Stg/ d02/12-01.htm (дата обращения: июнь 2015).

Aivazyan, S. A., Afanas’ev, M. Yu., Lysenkova M. A. (2016), “Otsenka rezul’tatov innovatsi-onnoy aktivnosti regiona s uchetom razmera prostranstva innovatsiy. Analiz i mode-lirovaniye ekonomicheskikh i sotsial’nykh protsessov”, Matematika. Komp’yuter. Obro-zovaniye: Sb. nauchn. Trudov, vypusk 23, No. 4, M., Izhevsk: NITS «Regulyarnaya i khaoti-cheskaya dinami-ka», s. 94-115.

Aivazyan, S., Afanasyev, M. (2016), “The Size of Innovation Space as a Factor of Innovation Activity in Regions”, Montenegrin Journal of Economics, Vol. 12, No. 2, pp. 7-27. DOI:10.14254/1800-5845.2016/12-2/11

Aivazyan, S. A., Afanas’ev, M. Yu., Kudrov A. V., Lysenkova M. A. (2017), “To the question about parameterization of national innovation system”, Applied Econometrics, Vol. 45, pp. 29-49.

All business establishments: Census Bureau, the Business Information Tracking Series (2014): Science and Engineering Indicators 2014. Table 8-53. High-technology establishments as a percentage of all business establishments, by state: 2003-2010 URL: http://www.nsf.gov/statistics/seind14/index.cfm/state-data/download.htm (дата обращения: январь 2016).

Battese, Coelli (1988): Prediction of Firm-level Technical Efficiencies with a Generalized Frontier Production Function and Panel Data// Journal of Econometrics. Vol. 38. P. 387-399.

Chislo predpriyatiy regiona (2013), RegionyRossii. Cotsial’no-ekonomicheskii pokazateli, 2013г. URL: http://www.gks.ru/bgd/regl/b14_14p/IssWWW.exe/Stg/d02/12-01.htm (data obrashcheniya: iyun' 2016).

Organizatsii, vypolnyayushchiye nauchnye issledovaniya (2010), U.S. National Center for Education Statistics, Digest of Education Statistics, annual. URL: http://www.nces.ed.gov/programs/digest (дата обращения: январь 2016).

Number of universities. Statistical abstract (2012): MEXT Japan. URL: http://www.mext.go.jp/english/statistics/index.htm

PCT patent applications – count. Dataset (2014): Innovation Indicators, OECD.
Table A1. Estimates of technical efficiency and their ranks for the regions of Russia, the US states and prefectures of Japan

| \( i \) | Name of the region of the Russian Federation | \( (TE^1_{t_i})_{M_0} \) | \( (R_{t_{i}}^{01})_{M_0} \) | \( (R_{t_{i}}^{1})_{M_0} \) | \( (TE^2)_{M} \) | \( (R_{t_{i}})_{M} \) | \( (R_{t_{i}}^{01})_{M} \) |
|---|---|---|---|---|---|---|---|
| 1 | Belgorodskaya oblast' | 0.9445 | 170 | 72 | 0.0782 | 74 | 172 |
| 2 | Bryanskaya oblast' | 0.9457 | 114 | 25 | 0.4171 | 36 | 132 |
| 3 | Vladimir'skaya oblast' | 0.9456 | 126 | 32 | 0.4617 | 30 | 126 |
| 4 | Voronezhskaya oblast' | 0.9450 | 151 | 53 | 0.3481 | 43 | 139 |
| 5 | Ivanovskaya oblast' | 0.9456 | 129 | 35 | 0.4630 | 29 | 125 |
| 6 | Kaluzhskaya oblast' | 0.9464 | 68 | 6 | 0.6938 | 6 | 55 |
| 7 | Kostromskaya oblast' | 0.9461 | 83 | 8 | 0.5343 | 22 | 118 |
| 8 | Kurskaya oblast' | 0.9439 | 178 | 80 | 0.0342 | 80 | 178 |
| 9 | Lipetskaya oblast' | 0.9457 | 112 | 24 | 0.4489 | 32 | 128 |
| 10 | Moskovskaya oblast' | 0.9456 | 127 | 33 | 0.7517 | 2 | 42 |
| 11 | Orel'skaya oblast' | 0.9457 | 118 | 27 | 0.4064 | 40 | 136 |
| 12 | Ryazanska oblast' | 0.9459 | 99 | 16 | 0.6116 | 16 | 112 |
| 13 | Smolenskaya oblast' | 0.9442 | 173 | 75 | 0.0465 | 77 | 175 |
| 14 | Tambovskaya oblast' | 0.9453 | 141 | 45 | 0.2404 | 51 | 147 |
| 15 | Tverskaya oblast' | 0.9460 | 93 | 13 | 0.6780 | 11 | 104 |
| 16 | Tol'jatskaya oblast' | 0.9456 | 123 | 30 | 0.5011 | 26 | 122 |
| 17 | Yaroslavskaya oblast' | 0.9454 | 136 | 41 | 0.4168 | 37 | 133 |
| 18 | g. Moskva | 0.9441 | 176 | 78 | 0.5511 | 19 | 115 |
| 19 | Respublika Kareliya | 0.9448 | 159 | 61 | 0.0834 | 70 | 168 |
| 20 | Respublika Komi | 0.9458 | 108 | 21 | 0.4518 | 31 | 127 |
| 21 | Arkhangelskaya oblast' | 0.9459 | 101 | 17 | 0.5354 | 21 | 117 |
| 22 | Vologodskaya oblast' | 0.9461 | 89 | 11 | 0.6512 | 13 | 109 |
| 23 | Kaliningradskaya oblast' | 0.9457 | 120 | 28 | 0.5450 | 20 | 116 |
| 24 | Leningradskaya oblast' | 0.9463 | 73 | 7 | 0.6827 | 10 | 86 |
| 25 | Murmanska oblast' | 0.9464 | 66 | 5 | 0.6874 | 9 | 85 |
| 26 | Novgorodskaya oblast' | 0.9469 | 34 | 3 | 0.7042 | 5 | 54 |
| 27 | Pskovskaya oblast' | 0.9446 | 166 | 68 | 0.0667 | 76 | 174 |
|   | Region                          | G, Sankt-Peterburg | Respublika Adygeya | Respublika Kalmkya | Krasnodarskiy kray | Astrakhanskaya oblast' | Volgogradskaya oblast' | Rostovskaya oblast' | Respublika Dagastan | Respublika Ingushetiya | Krasnodarskiy kray | Astrakhanskaya oblast' | Volgogradskaya oblast' | Rostovskaya oblast' | Respublika Dagastan | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika Ingushetiya | Respublika 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|   | Respublika Tyva | 0.9478 | 5   | 2   | 0.7315 | 3   | 43 |
|---|----------------|--------|-----|-----|--------|-----|----|
| 63| Respublika Khakasiya | 0.9455 | 131 | 37  | 0.1670 | 61  | 159|
| 64| Altayskiy kray | 0.9445 | 168 | 70  | 0.1255 | 64  | 162|
| 65| Zabaykalskiy kray | 0.9448 | 162 | 64  | 0.0816 | 73  | 171|
| 66| Krasnoyarskiy kray | 0.9453 | 142 | 46  | 0.4368 | 34  | 130|
| 67| Irkutskaya oblast' | 0.9450 | 153 | 55  | 0.3136 | 44  | 140|
| 68| Kemerovskaya oblast' | 0.9449 | 156 | 58  | 0.2458 | 49  | 145|
| 69| Novosibirskaya oblast' | 0.9454 | 135 | 40  | 0.6533 | 12  | 108|
| 70| Omskaya oblast' | 0.9455 | 130 | 36  | 0.5936 | 17  | 113|
| 71| Tomskaya oblast' | 0.9461 | 87  | 10  | 0.6901 | 8   | 84 |
| 72| Respublika Sakha (Yakutia) | 0.9440 | 177 | 79  | 0.0384 | 79  | 177|
| 73| Kamchatskiy kray | 0.9455 | 133 | 38  | 0.2076 | 57  | 155|
| 74| Primorskiy kray | 0.9452 | 143 | 47  | 0.4253 | 35  | 131|
| 75| Khabarovsky kray | 0.9442 | 174 | 76  | 0.0828 | 71  | 169|
| 76| Amurskaya oblast' | 0.9448 | 161 | 63  | 0.0919 | 72  | 170|
| 77| Magadanskaya oblast' | 0.9460 | 91  | 12  | 0.2761 | 46  | 142|
| 78| Sakhalinskaya oblast' | 0.9452 | 144 | 48  | 0.1239 | 65  | 163|
| 79| Yevreyskaya avtonomnaya oblast' | 0.9465 | 57  | 4   | 0.4115 | 38  | 134|
| 80| Chukotskiy avtonomnyy okrug | 0.9482 | 2   | 1   | 0.7813 | 1   | 1  |

| i | US State     | \((TE^2_{i1})_{M_0}\) | \((R^{02}_{i1})_{M_0}\) | \((R^2_{i1})_{M_0}\) | \((TE^2_{i1})_{M_5}\) | \((R^2_{i1})_{M_5}\) | \((R^{02}_{i1})_{M_5}\) |
|---|--------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| 1 | Alabama      | 0.9465                 | 58                     | 22                     | 0.9917                 | 18                     | 60                     |
| 2 | Alaska       | 0.9467                 | 44                     | 13                     | 0.9916                 | 49                     | 101                    |
| 3 | Arizona      | 0.9464                 | 69                     | 27                     | 0.9917                 | 20                     | 62                     |
| 4 | Arkansas     | 0.9462                 | 75                     | 32                     | 0.9917                 | 39                     | 81                     |
| 5 | California   | 0.9457                 | 115                    | 46                     | 0.9917                 | 14                     | 56                     |
| 6 | Colorado     | 0.9464                 | 67                     | 26                     | 0.9917                 | 19                     | 61                     |
| 7 | Connecticut  | 0.9473                 | 15                     | 5                      | 0.9918                 | 3                      | 8                      |
| 8 | Delaware     | 0.9482                 | 1                      | 1                      | 0.9918                 | 2                      | 3                      |
| 9 | District of Columbia | 0.9478             | 6                      | 3                      | 0.9918                 | 4                      | 9                      |
| 10| Florida      | 0.9453                 | 138                    | 51                     | 0.9917                 | 43                     | 95                     |
| 11| Georgia      | 0.9456                 | 124                    | 49                     | 0.9917                 | 45                     | 97                     |
| 12| Hawaii       | 0.9467                 | 46                     | 14                     | 0.9917                 | 36                     | 78                     |
| 13| Idaho        | 0.9473                 | 14                     | 4                      | 0.9917                 | 9                      | 25                     |
| 14| Illinois     | 0.9457                 | 116                    | 47                     | 0.9917                 | 33                     | 75                     |
| 15| Indiana      | 0.9466                 | 53                     | 19                     | 0.9917                 | 11                     | 47                     |
| 16| Iowa         | 0.9462                 | 79                     | 35                     | 0.9917                 | 37                     | 79                     |
| Prefecture     | TE | RH03 | RH1 | TE | RH03 |
|---------------|----|------|-----|----|------|
| Kansas        | 0.9461 | 81 | 37 | 0.9917 | 41 |
| Kentucky      | 0.9463 | 74 | 31 | 0.9917 | 28 |
| Louisiana     | 0.9460 | 95 | 40 | 0.9917 | 44 |
| Maine         | 0.9466 | 50 | 16 | 0.9917 | 32 |
| Maryland      | 0.9465 | 56 | 21 | 0.9917 | 16 |
| Massachusetts | 0.9465 | 63 | 23 | 0.9917 | 13 |
| Michigan      | 0.9463 | 71 | 29 | 0.9917 | 15 |
| Minnesota     | 0.9464 | 70 | 28 | 0.9917 | 17 |
| Mississippi   | 0.9464 | 65 | 25 | 0.9917 | 35 |
| Missouri      | 0.9456 | 122 | 48 | 0.9916 | 48 |
| Montana (US)  | 0.9465 | 55 | 20 | 0.9917 | 40 |
| Nebraska      | 0.9462 | 76 | 33 | 0.9917 | 46 |
| New Hampshire | 0.9481 | 3 | 2 | 0.9918 | 1 |
| New Jersey    | 0.9466 | 52 | 18 | 0.9917 | 12 |
| New Mexico    | 0.9466 | 51 | 17 | 0.9917 | 27 |
| New York      | 0.9455 | 132 | 50 | 0.9917 | 30 |
| North Carolina| 0.9461 | 90 | 39 | 0.9917 | 21 |
| North Dakota  | 0.9466 | 48 | 15 | 0.9917 | 47 |
| Ohio          | 0.9458 | 111 | 44 | 0.9917 | 29 |
| Oklahoma      | 0.9461 | 80 | 36 | 0.9917 | 38 |
| Oregon        | 0.9464 | 64 | 24 | 0.9917 | 23 |
| Pennsylvania  | 0.9458 | 106 | 43 | 0.9917 | 22 |
| Rhode Island  | 0.9461 | 86 | 38 | 0.9916 | 51 |
| South Carolina| 0.9463 | 72 | 30 | 0.9917 | 26 |
| South Dakota  | 0.9462 | 78 | 34 | 0.9916 | 50 |
| Tennessee     | 0.9459 | 104 | 42 | 0.9917 | 42 |
| Texas         | 0.9457 | 113 | 45 | 0.9917 | 24 |
| Utah          | 0.9470 | 26 | 8 | 0.9917 | 8 |
| Vermont       | 0.9470 | 30 | 11 | 0.9917 | 25 |
| Virginia      | 0.9459 | 97 | 41 | 0.9917 | 31 |
| Washington    | 0.9467 | 43 | 12 | 0.9918 | 6 |
| West Virginia | 0.9471 | 24 | 7 | 0.9917 | 10 |
| Wisconsin     | 0.9470 | 29 | 10 | 0.9918 | 5 |
| Wyoming       | 0.9470 | 28 | 9 | 0.9917 | 34 |

| Prefecture     | TE | RH03 | RH1 | TE | RH03 |
|---------------|----|------|-----|----|------|
| Hokkaido      | 0.9452 | 146 | 47 | 0.1224 | 46 |
| Aomori        | 0.9459 | 98 | 42 | 0.1686 | 45 |
| Iwate         | 0.9461 | 82 | 38 | 0.2404 | 39 |
|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
|   | Miyagi | 0.9460 | 92 | 41 | 0.2649 | 37 | 88 |
| 5 | Akita  | 0.9465 | 59 | 33 | 0.3154 | 36 | 52 |
| 6 | Yamagata | 0.9468 | 37 | 23 | 0.4245 | 29 | 40 |
| 7 | Fukushima | 0.9457 | 119 | 45 | 0.1912 | 43 | 105 |
| 8 | Ibaraki | 0.9476 | 10 | 5  | 0.6649 | 6  | 11 |
| 9 | Tochigi | 0.9468 | 38 | 24 | 0.4892 | 20 | 31 |
| 10 | Gumma | 0.9468 | 41 | 27 | 0.4790 | 22 | 33 |
| 11 | Saitama | 0.9469 | 32 | 19 | 0.5638 | 13 | 20 |
| 12 | Chiba | 0.9467 | 47 | 30 | 0.5038 | 18 | 29 |
| 13 | Tokyo | 0.9469 | 33 | 20 | 0.6132 | 9  | 14 |
| 14 | Kanagawa | 0.9478 | 8  | 3  | 0.7173 | 1  | 4  |
| 15 | Yamanashi | 0.9466 | 49 | 31 | 0.4172 | 31 | 44 |
| 16 | Nagano | 0.9475 | 11 | 6  | 0.6264 | 8  | 13 |
| 17 | Shizuoka | 0.9466 | 54 | 32 | 0.4628 | 25 | 36 |
| 18 | Niigata | 0.9465 | 61 | 35 | 0.3745 | 34 | 49 |
| 19 | Toyama | 0.9472 | 19 | 11 | 0.5311 | 14 | 22 |
| 20 | Ishikawa | 0.9469 | 36 | 22 | 0.4429 | 27 | 38 |
| 21 | Fuku | 0.9469 | 31 | 18 | 0.4632 | 24 | 35 |
| 22 | Gifu | 0.9467 | 45 | 29 | 0.4356 | 28 | 39 |
| 23 | Aichi | 0.9478 | 9  | 4  | 0.7098 | 2  | 5  |
| 24 | Mie | 0.9470 | 27 | 17 | 0.5269 | 15 | 24 |
| 25 | Shiga | 0.9478 | 7  | 2  | 0.6827 | 4  | 7  |
| 26 | Kyoto | 0.9475 | 12 | 7  | 0.6513 | 7  | 12 |
| 27 | Osaka | 0.9474 | 13 | 8  | 0.6692 | 5  | 10 |
| 28 | Hyogo | 0.9470 | 25 | 16 | 0.5727 | 12 | 18 |
| 29 | Nara | 0.9469 | 35 | 21 | 0.4771 | 23 | 34 |
| 30 | Wakayama | 0.9471 | 20 | 12 | 0.5251 | 16 | 26 |
| 31 | Tottori | 0.9461 | 88 | 40 | 0.2157 | 42 | 93 |
| 32 | Shimane | 0.9462 | 77 | 37 | 0.2401 | 40 | 91 |
| 33 | Okayama | 0.9459 | 102 | 44 | 0.2483 | 38 | 89 |
| 34 | Hiroshima | 0.9473 | 16 | 9  | 0.5847 | 11 | 16 |
| 35 | Yamaguchi | 0.9465 | 62 | 36 | 0.3896 | 32 | 45 |
| 36 | Tokushima | 0.9471 | 22 | 14 | 0.5165 | 17 | 27 |
| 37 | Kagawa | 0.9480 | 4  | 1  | 0.6840 | 3  | 6  |
| 38 | Ehime | 0.9468 | 39 | 25 | 0.4519 | 26 | 37 |
| 39 | Kochi | 0.9461 | 84 | 39 | 0.2200 | 41 | 92 |
| 40 | Fukuoka | 0.9473 | 17 | 10 | 0.5918 | 10 | 15 |
| 41 | Saga | 0.9452 | 145 | 46 | 0.1055 | 47 | 150 |
| 42 | Nagasaki | 0.9471 | 21 | 13 | 0.4835 | 21 | 32 |
| 43 | Kumamoto | 0.9468 | 40 | 26 | 0.4232 | 30 | 41 |
| 44 | Oita | 0.9468 | 42 | 28 | 0.3840 | 33 | 46 |
| 45 | Miyazaki | 0.9471 | 23 | 15 | 0.5016 | 19 | 30 |
|   | Kagoshima |   |   |   |   |   |
|---|-----------|---|---|---|---|---|
| 46| 0.9465    | 60| 34| 0.3618| 35| 50|
| 47| 0.9459    | 100| 43| 0.1723| 44| 106|