Construction of Efficiency Indicators for Innovative Activity in Russia's Regions

Review of Integrative Business & Economics Research

Irina Rudskaia*
Peter the Great Saint-Petersburg Polytechnic University

Dmitry Rodionov
Peter the Great Saint-Petersburg Polytechnic University

ABSTRACT

This paper analyzes the literature dedicated to regional innovation systems and various approaches to how regional specifics can be considered when evaluating the efficiency of innovative activity in regions. This paper is aimed at developing an approach to assessing the efficiency of regional innovation systems in Russia. Since the regions are quite different in terms of the internal and external conditions for innovative activities, a problem arises related to various regions' innovative capacity rankings, which are based on compilation of integral average weight indicators. It is that they virtually represent a range of values in relation to the average indicator (region) for a selection. In case the conditions for operation in the country are changing, both the average value and the ranking values of all regions change too, but the position of regions in relation to this average value remains fairly stable. Therefore, it is impossible to identify the direction for improvement of innovative activities in a region. To avoid this problem, this research uses an approach based on data envelopment analysis (DEA). The authors used a non-parametric approach and DEA. Practical implications: The weaknesses and strengths of this method have been identified. In the analysis, the data of statistical reporting of Russia's regions for 2014 were used (the data were acquired in 2015). As a result of the research study, calculations have been made for the common indicator of efficiency of the Russian regions and for the efficient frontier and deviations from it for the most innovatively active regions. The obtained results have been analyzed and the relevant conclusions have been made.

Keywords: Data Envelopment Analysis, region, innovation system, efficiency.

Received 15 November 2016 | Revised 4 August 2017 | Accepted 25 August 2017.

1. INTRODUCTION

The aim of this research is to develop an approach that provides regional authorities with clear vision of factors of comparative efficiency of Russian regional innovation systems.

Regional innovation systems are being one of the most discussed issues of the modern innovation policy due to the diffused character of knowledge, resources and proactive interaction of the actors involved in innovation activities. Interaction creates new capacities, possibilities and competences for all the members of the system.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Innovations are based on the new knowledge that is generated and distributed by different people, organizations, institutes, and by their multi-level interaction (Edquist, 1997).

Innovation systems consist of participants (enterprises, their consumers, suppliers, contractors, universities and academic institutions, innovation infrastructure organizations etc.), their mutually acquired competences (various forms of the intellectual capital), and interrelations between them. Due to the active interaction of participants, the circle of operations extends, increasing opportunities and competences that allow them to perform better than at the level of a single firm. The understanding of the importance of innovation-connected actors' interaction at different levels, from a single company to global platforms, resulted in development and introduction to the practice of government regulation and supports of innovative activities such concepts as national innovation system (NIS) and regional innovation system (RIS).

National innovation system involves the networks of organizations that generate and commercialize new scientific results, knowledge and technologies within national borders (Rodionov, Guzikova, Rudskaya, 2014). It also includes financial, legal and social institutes, supporting innovations in different countries, with their national routines, political and cultural specifics, and social and economic relations between economic agents and institutes, that promote generation, diffusion and practical implementation of innovations (Ivanova, 2001). The effective interaction of all NIS components, providing conditions for interactive mutual learning, joint creation of knowledge by producers and consumers of innovations and management of the intellectual capital, has a crucial value for national competitiveness strengthening and maintenance (Chung, 2002).

Also, there may appear new centers of knowledge and technologies development. Concentration of the centers of generation of knowledge and creation of advanced technologies in different regions of the country and an exchange of knowledge and technologies flows between these regions caused the attention to the regional aspect of innovation activities and to regional innovation systems (Nikolova, Rodionov, Mokeeva, 2014).

Interest to an RIS is especially high in the countries with the federal state system where the innovation policy is determined by the federal government, but its implementation depends heavily on the specific conditions of innovation activities, that differ strongly from one region to another (Holbrook, Salazar, 2004). Russia is a federation with substantial diversity of innovation resources and results. Alongside with traditionally "strong" regions as Moscow and St.-Petersburg and "weak" ones as Chechen Republic, there is a large group of regions that demonstrate controversial results. So their efficiency and performance evaluation requires a special methodology, different from usually performed on the base of statistic data evaluation of innovation potential.

The paper develops an approach to measurement of RIS efficiency. It is organized as follows. The second section determines the basis of the research, which derives from the academic literature. Then we discuss the theoretic model of an RIS efficiency based upon

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Russian indicators. We would explain the choice of a non-parametric approach to the evaluation of the relative efficiency of Russian RIS further.

2. LITERATURE REVIEW

The literature dedicated to regional innovation systems discusses various approaches to how regional specifics should be considered when the efficiency of innovative activity in regions is evaluated:

1. As a rule, innovatively-active enterprises and research institutes are concentrated in large agglomerations (Feldman M., Audretsch D. 1999).
2. Industrial and industrial-innovative clusters contribute to knowledge and new technology spreading and can be located fairly far away from big regional centers (Botazzi L., Peri G., 2003).
3. Generally, the regions located on the outskirts of the country are less innovatively active comparing to the ones which are close to the largest scientific and financial centers.

Differently from the concept of national innovation systems, where the terminology is rather clear, there is no stable comprehension among theorists and practitioners of what regional innovation systems (RISs) are, although most researchers recognize that it is regions which compete for innovation capital and in the innovative product market. Thus, R. Florida (Florida, R., 1998) notes it is thanks to understanding the importance of knowledge spread at regional level that trainable systems can be created and that regional policy must be aimed not only at formation of short-term economic advantages, but also long-term competitive innovation-based advantages. The main definitions of a regional innovation system are presented in Table 1.

Table 1. Definitions of a Regional Innovation System

Definition	Authors
A collective network, based on regional regulation, involving trust, reliability, data exchange and cooperative interaction	Cooke, P., Gomez Uranga M., Etxebarria, G. (1997)
Consists of knowledge creation and usage subsystems, which interact with each other and other regional, national and international knowledge creation systems	Cooke, P. et al. (2004)
A network of interacting state and private enterprises, institutions and other organizations, interacting on the basis of formal and informal cooperation agreements in the process when knowledge is created and utilized	Doloreux, D. (2004)
Institutional infrastructure, supporting innovations in the production system of a region	Asheim, B., Gertler M. (2006)

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

A wide network of organizations and institutions, supporting educational and innovative processes in a region	Asheim, B. (2009)

All in all, a regional innovation system is understood as a system of state, public and private organizations and relations between them in the field of creation, utilization and transfer of new knowledge and technologies (Doloreux D, 2003). Herewith, the system can exist only in case this interaction is sustainable and effective, i.e. it results in special forms of public relation, norms, values, i.e. intellectual capital (or, as it is called by Cooke et al. (1997), social capital of a region), on the one hand, and financial capital aimed at supporting innovative activities and improved competitiveness of a region, on the other hand (Gertler MS.,2003).

3. MEASURING THE INNOVATION POTENTIAL OF REGIONS

3.1. The foreign practice systems

In the foreign practice, several systems are used for measuring the innovation potential of regions. The best-known technique of the EU is Regional Innovation Scoreboard (Regional Innovation Scoreboard 2012) for Europe and Portfolio Innovation Index (Statsamerica, 2012) for the USA.

The methodology for constructing the index of innovative regions of the EU is represented in (Regional Innovation Scoreboard 2012). The index is built on three areas of innovative capacity: factors of innovative capacity; companies' activities; results of innovative activity. The groups of indicators used in this measurement system are shown in Fig. 1.

Several indicators are calculated for each group represented in Fig. 1. The value of this index is in the regular acquisition of information and, consequently, it can be used for benchmarking of regional innovative capacity. As a result of evaluation of regional innovative capacity, in the EU four types of regions are highlighted – leaders of innovative capacity; strong innovative regions, which follow the leaders; regions of moderate innovative capacity; and regions of modest innovative capacity. The US index of regional innovative capacity PII (Crossing the Next Regional Frontier, 2012) is based on evaluation of four groups of indicators, each of them having a certain weight: the level of human capital capacity (30%); the level of economic dynamics (30%); labor productivity and employment (30%) and economic well-being of a region (10%). It is notable that in the American ranking there are no specifically innovative groups of indicators, but within each group there are indicators characterizing innovative capacity.

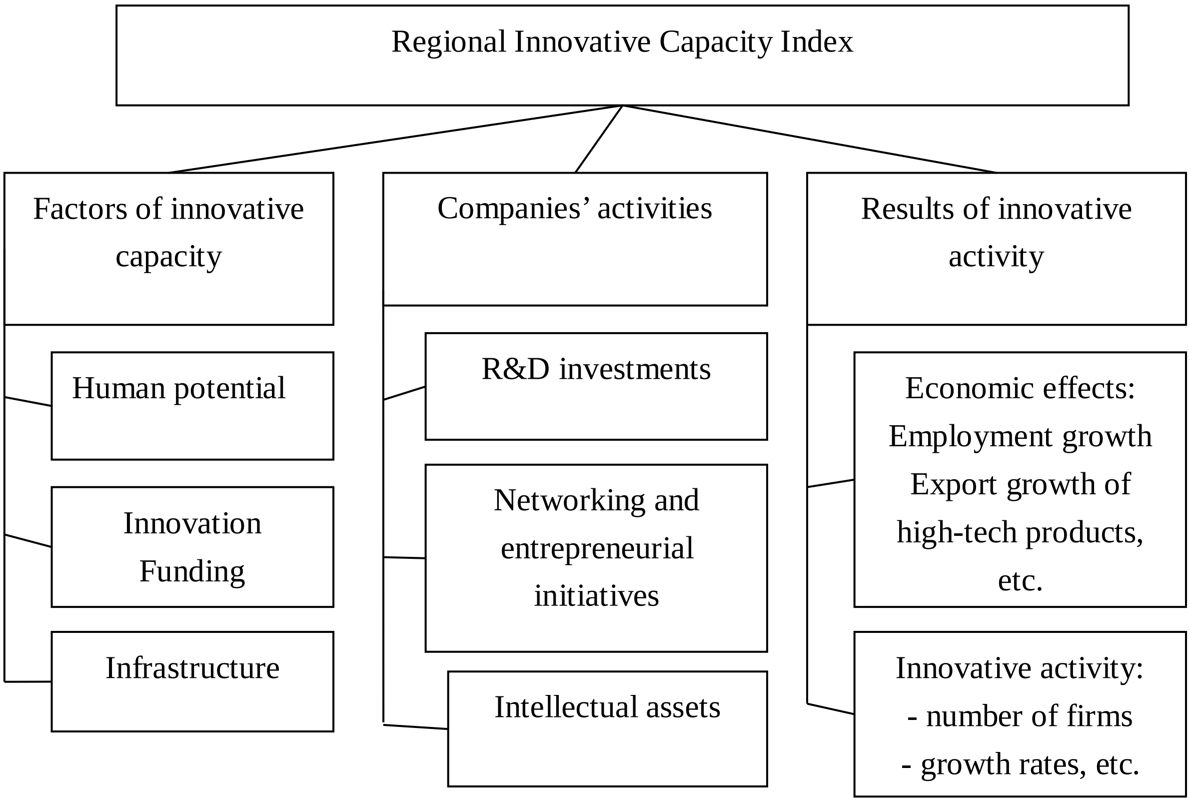
The innovative capacity index is calculated by formula:

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

$$PII_j = \sum_{s=1}^{4} A_s X_{sj} , \qquad (1)$$

where PIIj is an index of innovativeness for a region (county) j, As is the weight of an s component in the index of innovativeness, Xsj is the value of index by the s component for a j region.

Fig. 1. Groups of indicators used for measuring the innovativeness of a region



Depending on the value of the compound index, the following levels of regional development are identified (Table 2).

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Table 2. The US regions grouped by the level of their innovative capacity

Criterion	The value of innovative indicator in the region (percentagewise of the average level in the US as a whole)					
	Over 110%	From 100% to 110%	From 90% to 100%	From 80% to 90%	Less than 80%	No data
Number of regions	53	75	229	1001	1748	5

Source: Crossing the Next Regional Frontier: Information and Analytics Linking Regional Competitiveness to Investment in a Knowledge-Based Economy, p. 91

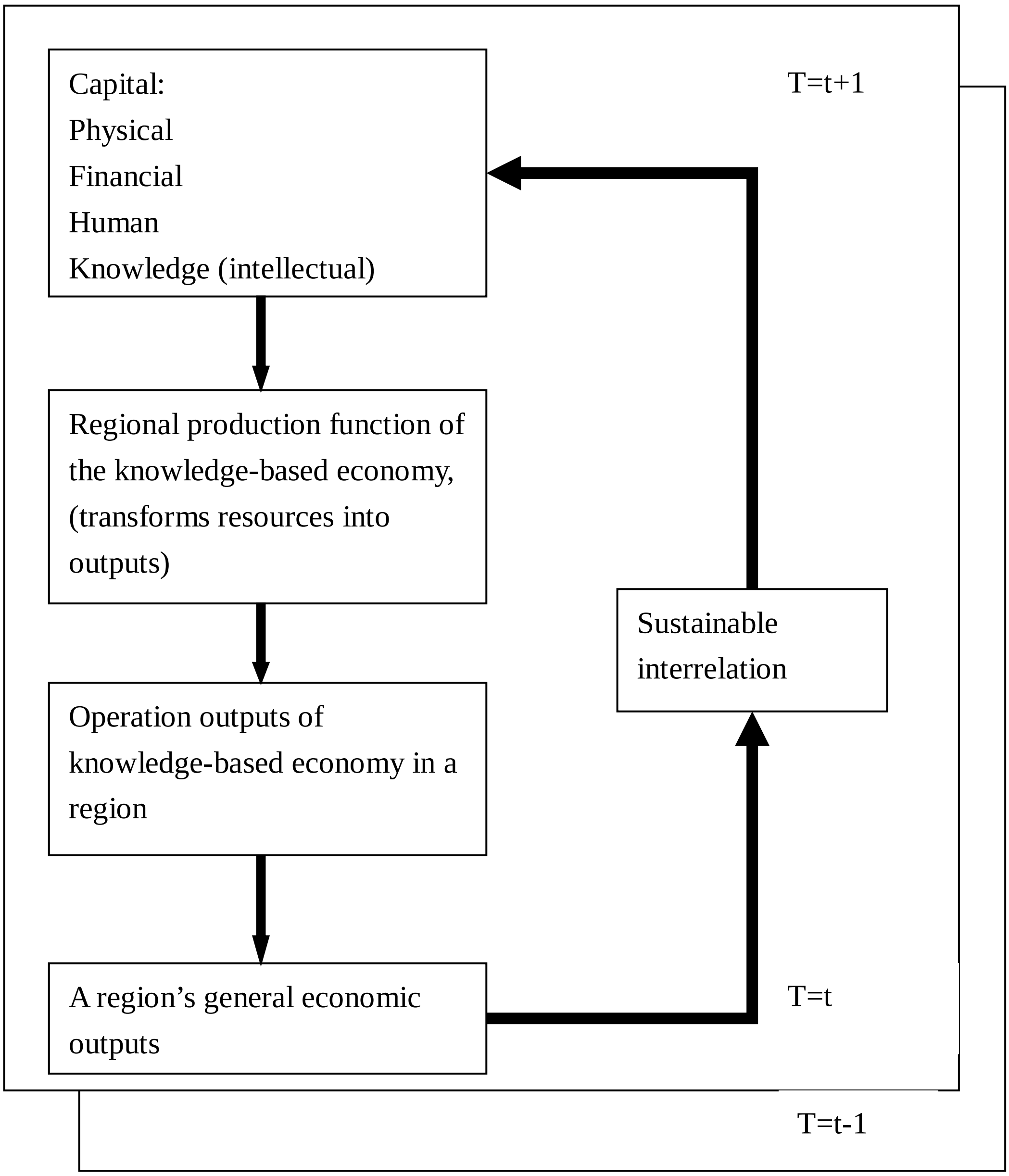
The structure of RIS and PII indices is such that they comprise of both the resources of innovative activity and its results. As a rule, the leading regions combine high scores for resource and performance components of the indices. However, in some cases this condition is not met. For instance, a region can have a high value for the resource element of the index and a low one for the performance element. This means that the created potential has not been implemented fully due to a delay effect. A reverse situation is observed when low scores for the resource element of the index are accompanied in regions with high values of performance. Most probably, high values of performance appear as a consequence of the impact of other factors, which are not considered by the innovative index (for example, presence of companies exploiting natural resources in a region).

Finally, one more technique should be mentioned. To a point, it has become the basis for this research – World Knowledge Competitiveness Index (WKCI), worked out by R. Huggins *et al.* (Huggins, R., Izuschi, H., Davies, W., Shougui, L., 2008). The authors' objective was to measure the contribution of the knowledge-based economy in the competitiveness of a region.

This technique is based on comparison of a region's performance outputs to the resources (capital) utilized in this region. I.e., in fact, the point is how efficiently the knowledge-based economy is in certain regions (Fig.2).

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Fig.2. A concept for construction of the regional competitiveness knowledge-based index



The regional production function of the knowledge-based economy implies transformation of four types of capital in the operation outputs of the knowledge-based economy. Then the contribution of this economy into the general operation outputs of a region is measured over a period of time. An important element of the concept is that a sustainable interrelation is formed between the outputs of the previous period and the outputs of the next period. If part of the achieved outputs is reinvested into resources, in particular, into immaterial ones (human capital and knowledge capital), in the future this

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

interrelation means a growth in the region's wellbeing thanks to the knowledge-based economy.

3.2. Russian practice

In Russia, quite a number of attempts have been made in order to compile a regional innovative capacity index.

The problem of the Russian regions' innovative potential measurement has been studied by various authors (Untura G.A., 2011; Kazantsev S.V., 2012; Khalimova S., 2015).

In the paper by N. Mikheeva and R. Semenova (2011) the methodology of the European Innovation Scoreboard was used and analogues indicators, available from the Russian statistics, were selected. In the end, complex assessment of the innovative capacity of the Russian regions was carried out on the basis of the values of 13 indicators, individually for each year within the period of 2000-2009.

This paper has been the basis for the Ranking of Russia's Innovative Regions, which is formed by the Association of Innovative Regions of Russia (AIRR) (Semenova R., 2015) and includes three sub-rankings:

1. Sub-ranking, characterizing the level of scientific research and development in a region (9 indicators).
2. Sub-ranking, characterizing innovative activity of enterprises in a region (9 indicators).
3. Sub-ranking, characterizing socioeconomic conditions for innovative activity in a region (5 indicators).

All the indicators are standardized and compared to the average level in the country, similarly to the methodology of the American PII index. The compilers of the ranking identify five groups of the regions: strong innovators (the integrated indicator is over 130% of the average Russian level); moderately strong innovators (the ranking is from 110 to 130% of the average Russian level); moderate innovators (the ranking is from 90% to 110%); moderately weak innovators (the ranking is from 60% to 90% of the average Russian level) and weak innovators with the ranking below 60%. The leader of the ranking is St. Petersburg with the indicator of 175.9% of the average Russian level (it should be noted that in previous years this indicator was higher – 181.3%, which is indirect evidence of some convergence of the regions in terms of their innovativeness). The ranking is closed by the Republic of Tyva with the indicator of 52.4 (in the previous ranking Chechen Republic was the last one, with the indicator of 36.5%).

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

The regions are distributed by groups in Figure 3. The leading group of regions include, apart from St. Petersburg, Moscow, the Republic of Tatarstan, Nizhny Novgorod Oblast, Moscow Oblast, Yaroslavl Oblast, Kaluga Oblast and Tomsk Oblast. The number of leading regions have diminished over the recent years – there used to be three more regions (Novosibirsk Oblast, Perm Kray and Sverdlovsk Oblast), which are now in the category of moderately strong innovators. The number of moderately strong and moderate innovators have somewhat increased over the past years, the number of weak regions have shrunk considerably (from 7 to 4 regions), the number of moderately weak regions (the most numerous group) has remained the same.

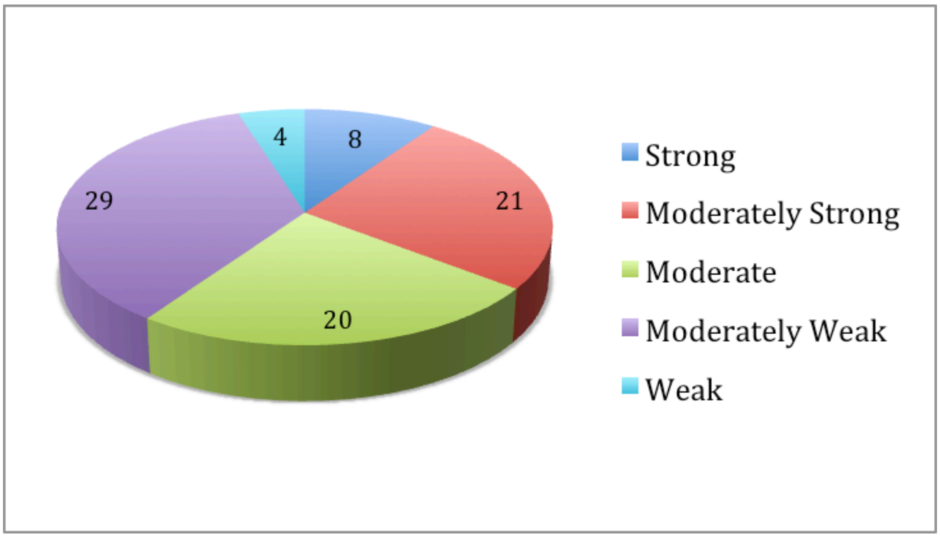


Fig. 3. Distribution of regions by groups in the AIRR ranking

In our opinion, the weak point of the AIRR ranking is the fact that it is based exceptionally on statistics. Thus, it provides for quantitative data that characterizes the results of innovative activity, rather than its conditions and it is impossible to deduct from the ranking why the results are what they are.

Finally, the Russian Regional Innovative Index (RRII) should be mentioned. It has been published by the Institute of Statistics and Knowledge Economics of the National Research University, Higher School of Economics (NRU HSE) (Gokhberg L.M., 2012, 2016). The ranking is based on the methodology used by the EU, but it has specifics, corresponding to the realities of innovative activity in Russia. 4 groups of indicators are considered: socioeconomic conditions for innovative activity in a region; scientific and technical potential of a region; characteristics of innovative activity in a region and quality of innovation policy in a region. Each of these groups includes indicators of the

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

higher and lower level. The value of the index by each subject of the Federation is calculated by the following formula:

$$RRII^{r} = \frac{8}{37} ISEC^{r} + \frac{11}{37} \mathrm{ISTP}^{r} + \frac{9}{37} IIA^{r} + \frac{9}{37} IQIP^{r} , \qquad (2)$$

where $RRII^r$ – is the value of regional innovation index for an r region; $ISEC^r$ – index of the r-th region by the indicators of the “Socioeconomic conditions of innovative activity” block; $ISTP^r$ – index of the r-th region by the indicators of the “Scientific and Technical Potential” block; IIA^r – index of the r-th region by the indicators of the “Innovative Activity” block; $IQIP^r$ – index of the r-th region by the indicators of the “Quality of Innovation Policy” block. The total number of indicators, N = 37 [1], p. 10.

Moreover, quite a large database is used – from statistic surveys to mass media monitoring. Differently from the AIRR, the RRII considers not only performance, but also conditions for innovative activity in one or another region in the sub-ranking “Index of Quality of Innovation Policy”. The same as in the previous ranking, four groups of regions are identified.

The authors of the ranking point out that for Russia’s regions a considerable inhomogeneity is common in the development of various aspects of innovative processes and factors which they are affected by. Even in the first and second groups, which include 32 regions, homogeneous development of all the components of the ranking is noticeable only in three regions (Moscow – 2nd position, Tomsk Oblast – 7th position, Krasnoyarsk Kray – 12th position). In the authors’ opinion, only three regions go into the first group – the Republic of Tatarstan, whose leadership is based on the quality of innovation policy, Moscow and St. Petersburg, where St. Petersburg takes only 23rd position in terms of the quality of innovation policy. In most cases, high values in some blocks combine with low ones in other blocks or there are significant fluctuations for one or several sub-indices in comparison with the value of the RRII. As a result, the final index becomes an average, smoothed assessment, which, to a point, counterbalances various components of innovative capacity, and, at the same time, hides them. In these terms, it is important that the ranking should be analyzed by individual sub-indices in order to define the reserves for further innovative capacity (Fig. 4).

[1] Ranking of Innovative Capacity of the Russian Federation Subjects: Issue 4 / editied by Gokhberg L.M.; National Research University “Higher School of Economics” – Moscow: NRU HSE, 2016. – 248 c.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Regions of the first and second group falling behind by the indicators of the "Scientific and Research Potential" block: Republic of Tatarstan – I group *Republic of Mordovia* – II group *Chuvash Republic* – II group *Altai Kray* – II group Stavropol Kray – II group Khabarovsk Kray – II group Belgorod Oblast – II group *Kursk Oblast* – II group *Lipetsk Oblast* – II group Penza Oblast – II group *Tambov Oblast* – II group *Yamalo-Nenets Autonomous Okrug* – II group	Regions of the first and second group falling behind by the indicators of the "Innovative Activity" block: Stavropol Kray – II group *Volgograd Oblast* – II group Voronezh Oblast – II group Kaluga Oblast – II group Moscow Oblast – II group Novosibirsk Oblast – II group *Tver Oblast* – II group Tyumen Oblast - II group *Ulyanovsk Oblast* - II group *Yamalo-Nenets Autonomous Okrug* – II group
Regions of the first and second group falling behind by the indicators of the "Quality of Innovation Policy" block: Republic of Bashkortostan Perm Kray – II group Nizhny Novgorod Oblast – II group Rostov Oblast – II group Samara Oblast – II group Sverdlovsk Oblast – II group *Ulyanovsk Oblast* - II group Yaroslavl Oblast – II group St. Petersburg – I group	Regions of the first and second group falling behind by the indicators of the "Socioeconomic Conditions for Innovative Activity" block: *Republic of Mordovia* – II group *Chuvash Republic* – II group *Altai Kray* – II group *Volgograd Oblast* – II group *Kursk Oblast* – II group *Lipetsk Oblast* – II group *Tambov Oblast* – II group *Tver Oblast* – II group *Ulyanovsk Oblast* - II group

Fig. 4. Regions with unbalanced capacity (the first and the second groups of the ranking)

As it is seen from Fig.4, falling behind by the group of indicators "Socioeconomic conditions for innovative activity" has the most serious impact on the positions of a

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

region. All the regions in this group also fall behind by other groups of indicators in the sub-indices of the ranking.

It should be noted that for a number of regions, belonging to the third and fourth group of the ranking, there is considerable overbalance of the consolidated index by individual sub-indices. In some cases, it may be preconditioned by the effect of low base, but the factors of growth are different. Analysis of the specifics of innovative capacity in nine regions, whose positions grew by 6-9 points in the ranking of 2013-2014, gives evidence that all the sub-indices are virtually equally significant in terms of their contribution to the dynamics of the integral index. Four regions used scientific and technical potential as a growth drive (the Republic of Buryatia, Perm Kray, Kirov and Lipetsk Oblasts), four more – the indicators of innovative activity (Udmurt Republic, Khabarovsk Kray, Kemerovo and Kirov Oblasts). For three regions, the growth in the ranking was preconditioned by improvements in innovation policy (the Republic of Sakha (Yakutia), Kemerovo and Lipetsk Oblasts) and for two regions (Udmurt Republic and Vladimir Oblast) improvement of socioeconomic conditions for innovative activity proved to be more important. Correspondingly, a rapid growth can be ensured with equal facility by any factor of innovative capacity.

The same is true in respect of the failures and lowering of the positions in the ranking. Some subjects of the Russian Federation rolled back in terms of the level of innovative capacity. In the first turn, it is Kurgan Oblast (-36 positions), Magadan Oblast (-34), Leningrad Oblast (-25), Kamchatka Kray (-18), Arkhangelsk Oblast (-17), Khanty-Mansiisk Autonomous District – Yugra (-15), Zabaykalsky Kray (-12) and Krasnodar Kray (-11). The weak points of the regions that lowered their positions in the ranking are, to an equal extent, socioeconomic conditions (Kamchatka and Krasnodar Krays, Kurgan, Leningrad and Magadan Oblasts), scientific and technical potential (Zabaykalsky Kray, Kamchatka Kray, Kurgan and Magadan Oblasts, Khanty-Mansiisk Autonomous District – Yugra) and quality of innovation policy (Zabaykalsky Kray, Kamchatka Kray, Krasnodar Kray, Kugran and Leningrad Oblasts). In Kurgan and Magadan Oblast decrease is registered by all indices. We should note that, on the whole, the movement of the regions up and down in the positions of the ranking is really unstable. Only about 30 regions are capable of keeping their positions stable, more or less.

The difference in the drives of innovative activity is also preconditioned by the nature of innovative activity in the regions. According to S.V. Kazantsev (2012), there are territories where innovations are developed, in others they are spread and applied, there are regions where they are actively created and used. I.e. when the level of

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

innovative capacity of regions is evaluated, their specifics must be considered in relation to the creation and use of innovations. An attempt to compile such indices is taken in the paper by S. Khalimova (2015), who has divided all the regions and identified the “index of innovation creation” and the “index of innovation use”.

The following ones are marked out as components of the index of innovation creation: the share of internal costs of R&D in the GRP; the share of organizations which performed R&D in the total number of organizations; the share of staff involved in R&D in the total number of the employed. The following ones are defined as indicators of innovation use: the quantity of innovative product percentagewise of the total amount of products, specific weight of the organizations which implemented technological innovations in the total number of organizations, the share of costs of technological innovations in the GRP. The specifics of the author’s approach is that it compares the obtained values of the indices by the regions with the average value of an index in the relevant period, which makes it possible to avoid rigid quantitative limitations and trace the dynamics of an index.

Breakdown of regions into groups by indicators of innovative activity is common for foreign research studies too. Thus, in “The evolution of technologies in time and space: from national and regional to spatial innovation systems” (Oinas, P. and Malecki, E., 2002) three groups of regions are defined – “true innovators” (regions, based on and generating advanced technologies, such as Silicon Valley), adaptive regions, which have a relatively high level of technology competence, such as Bangalore in India and borrowing regions, which develop competences oriented on production. However, differently from the abovementioned approaches, the authors investigate regional bases for emergence of new technologies, their spread and relations between technology creators and technology consumers. These regional bases are the foundations for both regional technological specialization in some regional systems and diversification in others.

3.3. Comparative analysis

The difference in the drives of innovative activity is also preconditioned by the nature of innovative activity in the regions. According to S.V. Kazantsev (2012), there are territories where innovations are developed, in others they are spread and applied, there are regions where they are actively created and used. I.e. when the level of innovative capacity of regions is evaluated, their specifics must be considered in relation to the creation and use of innovations. An attempt to compile such indices is taken in the paper by S. Khalimova (2015), who has divided all the regions and

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

identified the “index of innovation creation” and the “index of innovation use”.

The following ones are marked out as components of the index of innovation creation: the share of internal costs of R&D in the GRP; the share of organizations which performed R&D in the total number of organizations; the share of staff involved in R&D in the total number of the employed. The following ones are defined as indicators of innovation use: the quantity of innovative product percentagewise of the total amount of products, specific weight of the organizations which implemented technological innovations in the total number of organizations, the share of costs of technological innovations in the GRP. The specifics of the author’s approach is that it compares the obtained values of the indices by the regions with the average value of an index in the relevant period, which makes it possible to avoid rigid quantitative limitations and trace the dynamics of an index.

Breakdown of regions into groups by indicators of innovative activity is common for foreign research studies too. Thus, in “The evolution of technologies in time and space: from national and regional to spatial innovation systems” (Oinas, P. and Malecki, E., 2002). three groups of regions are defined – “true innovators” (regions, based on and generating advanced technologies, such as Silicon Valley), adaptive regions, which have a relatively high level of technology competence, such as Bangalore in India and borrowing regions, which develop competences oriented on production. However, differently from the abovementioned approaches, the authors investigate regional bases for emergence of new technologies, their spread and relations between technology creators and technology consumers. These regional bases are the foundations for both regional technological specialization in some regional systems and diversification in others.

Herewith, quite a large database is used - from statistic surveys to mass media monitoring. Differently from the AIRR, the RRII considers not only performance, but also the conditions for innovative activity in one or another region in the sub-ranking “Innovation Policy Quality Index”.

The examined methodologies have several weak points. First, it is formation of a single ranking based on average weight values according to the predetermined weights. Thus, there appears some uniformity in the assessments which makes it possible to compare regions with some average value, but does not show the direction of movement. In case the conditions for operation change, the average value of the ranking changes too, but the position of regional innovation systems in relation to it remains rather stable.

4. METHODOLGY

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

4.1. Efficiency of innovative activity of a region

In the attempts to evaluate the efficiency of innovative activity of a region, researchers unavoidably collide with a variety of conditions of this activity in different regions. The efficiency of innovative activity in a region can be affected by the time it is performed, historic and economic specifics of the region, random factors (Edquist, C. ed.,1997). Due to the openness of regional innovation systems it is not always possible to identify indicators of innovative activity specific to a certain region, which also makes the efficiency evaluation more problematic.

It should be also considered that there is time lag between innovations and outputs of innovative activity, which is defined, firstly, by the amounts of investment and, secondly, by the life cycle of the technologies, prevailing in a region.

The concept of efficiency is always based on the ratio of outputs and expenses. A producer is efficient if it achieves the maximal output with the available bundle of resources, or achieves the required output with the minimum resources involved[2]. It should be noted that the efficiency understood in such a way is only part of the notion about productivity of an economic system. In order to carry out complex analysis, it is also necessary to select efficiency measuring indicators and the degree to which the system corresponds to the chosen development goals (achieved outputs, possibility for achieving them, quality and acceptability as development goals) (Greene, W.H., 1997), as shown in Fig.5.

Two main types of efficiency are normally marked out in literature – technical one and allocative (price) one. Allocative (price) efficiency characterizes the efficiency degree of the allocated resources with the existing prices when purchases and distribution are managed.

Given the above considerations, we, first of all, look into the technical efficiency of innovative activity in a region. Technical efficiency is understood as an ability to generate an output with certain resources. According to the initial definition formulated by T.C. Koopmans in 1951, "a producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output" (Koopmans, T.C., 1951).

[2] Greene, W.H. (1997). Frontier production functions. In Pesaran, M.H. and Schmidt, P., editors, Handbook of Applied Econometrics, vol. II: Microeconometrics. Blackwell Publishers Ltd.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

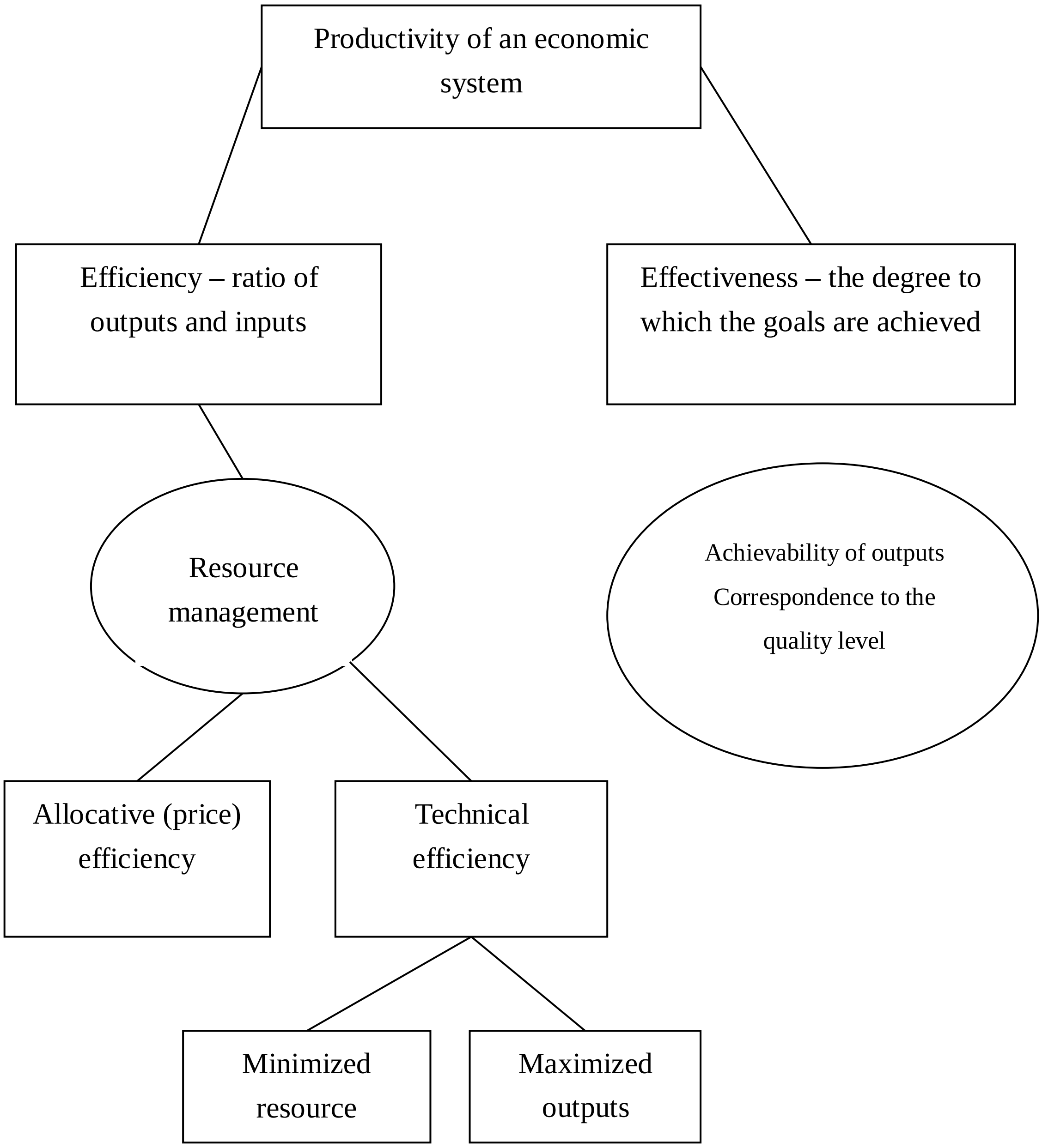


Fig.5. Contribution of efficiency and effectiveness in the productivity of an economic system

An economic system is recognized as inefficient if it incapable of generating the maximally achievable output based on a certain bundle of inputs (Farrell, M. J., 1957). In application to a regional innovation system it can be assumed that a region is technically efficient if it can produce the maximally achievable output of innovative activity per unit of innovative resources (Fritsch, M., Slavchev, V., 2006), i.e. maximally implement its innovative potential. Thus, technical efficiency shows the capability of a

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

region to transform investment into innovative resources and outputs of innovative activity (Chen, K., Guan, J., 2012). In fact, it is production function, where knowledge plays the key role.

4.2. Data Envelopment Analysis

Key approaches to assessing the technical efficiency of economic systems rely on the theory of production curves and specification of production function. Two groups of methods – parametrical and non-parametrical – are used for their construction. There are two main approaches to measuring technical efficiency: based on parametrical methods and non-parametrical methods. Their comparison applied to innovative activity is carried out in the paper (Bonaccorsi, A., Daraio, C., 2004).

Foreign literature describes differences of non-parametrical and parametrical methods for assessing these indicators. This paper uses a non-parametric approach and the method of (Data Envelopment Analysis; DEA) (Cooper, W. W., Seiford, L. M., Tone, K., 2006). This method is quite actively used in the analysis of national innovation systems (review of the conducted research studies is presented in the paper) (Kotsemir, M., 2013). However, it has not been applied to regional innovation systems. According to DEA, a region can be recognized as efficient in terms of innovative activity in case no other region (regions) can produce a better innovative output with the given amount of innovative resources (Charnes, A., Cooper, W., Rhodes, E., 1979). In the DEA approach, an organization, region or economic system whose efficiency is being analyzed is called a decision-making unit (DMU) (decision-making unit, DMU)[3]. This subject must transform resources into performance outputs.

A detailed formalized description of the model and its limitations are given by W. Cooper (2007). In fact, he marked out two independent models: an input oriented model and an output oriented model. Thus, all indicators, characterizing how successful a production (or any other economic) unit is, are divided into inputs and outputs.

The model is aimed at evaluation of technological parameters of economic agents in the “resources-outcomes” space. According to this method a firm can be considered efficient if there is no other firm or linear combination of firms which produce more (with fixed inputs) or whose inputs are smaller (with fixed output) (Charnes, A., W.W. Cooper and E. Rhodes , 1978). All in all, the model “minimizes” inputs and “maximizes” outputs. Given the desirable actions all parameters may be classified and

[3] Hereinafter we will use the term “economic unit”, which emphasizes the essence of this subject – transformation of resources into performance outputs.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

referred to either inputs or outputs. In certain cases, the same indicator can be referred both to inputs and outputs. Thus, in a regional innovation system the number of created advanced production technologies in a region, in terms of research and development effectiveness, is an output; but in terms of commercialization of innovative products they become an input on which basis these products can be made. Since the model is used in order to identify a direction for better performance of a region's government bodies, it is necessary to define clearly how these indicators must be classified. In a number of cases the so-called two-step process is used, when the outputs, maximized at the first stage, become the inputs, minimized at the second stage of optimization.

Thus, the model is aimed at maximizing the relation of "outputs" to "inputs". In the classical model, also called the model of Charnes, Cooper and Rhodes (Charnes, Cooper, Rhodes, 1979), there is a number of inputs (x_i) and outputs (y_r), which comes down to the general indicator by means of weights:

$$\begin{aligned} \text{Intput} &= v_1 x_{1_o} + \cdots + v_m x_{m_o} \\ \text{Output} &= u_1 y_{1_o} + \cdots + u_s y_{s_o} \end{aligned} , \qquad (3)$$

where v_i, i=[1, m]; u_r, r=[1, s] are weights of each input and output in the general indicator. The weights are set by means of linear programming so as to maximize the ratio:

$$\frac{\text{Output}}{\text{Input}}$$

Herewith, weights can vary from one DMU to another, since their values are not pre-set but taken from actual data, i.e. its own optimal range of weights appears for each unit. I.e. for each DMU_j we obtain input and output vectors with unique weights. Thus, input and output matrices are as follows:

$$X = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ . & . & \cdots & . \\ . & . & \cdots & . \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{pmatrix}$$

$$Y = \begin{pmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ . & . & \cdots & . \\ . & . & \cdots & . \\ y_{s1} & y_{s2} & \cdots & y_{sn} \end{pmatrix} , \qquad (4)$$

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

where X is a matrix with dimensions of ($m \times n$), Y is a matrix ($s \times n$).

Thus, the efficiency of each DMU is measured and then optimization is carried out for each DMU. I.e. according to the matrix size stipulated in the formula (4), n optimization problems are solved. If the evaluated DMU_j in each trial is designated as DMU_o (o = 1, 2, …, n). To obtain the optimal values of input weights (v_i) (i = 1, …, m) and output weights (u_r) (r = 1, …, s) the task of linear fractional programming is:

$$(FP_o) \qquad \max_{v,u} \theta = \frac{u_1 y_{1o} + u_2 y_{2o} + \cdots + u_s y_{so}}{v_1 x_{1o} + v_2 x_{2o} + \cdots + v_m x_{mo}}, \tag{5}$$

$$\text{with} \quad \frac{u_1 y_{1j} + \cdots + u_s y_{sj}}{v_1 x_{1j} + \cdots + v_m x_{mj}} \le 1 \;\; (j = 1, \ldots, n), \tag{6}$$

$$v_1, v_2, \ldots, v_m \ge 0, \tag{7}$$

$$u_1, u_2, \ldots, u_s \ge 0. \tag{8}$$

The limitations of the model mean that the ratio of inputs to outputs for every economic unit must not exceed 1 (in case the value of this ratio is equal to 1, a DMU is technically efficient). I.e. the greatest optimal solution θ* is equal to 1. One of the limitations of the approach suggested by this model is an assumption that all inputs and outputs are non-negative, i.e. they have a certain non-zero importance. This limitation can be inconsistent with reality and is removed when more advanced data envelopment analysis models are applied. However, from a managerial standpoint it seems justified.

For the convenience of presentation and optimization, the task of linear fractional programming (FP_o) is substituted with a linear programming task (LP_o):

$$(LP_o) \qquad \max_{\mu,u} \theta = \mu_1 y_{1o} + \cdots + \mu_s y_{so}, \tag{9}$$

$$\text{with} \quad \upsilon_1 x_{1o} + \cdots + \upsilon_m x_{mo} = 1, \tag{10}$$

$$\mu_1 y_{1j} + \cdots + \mu_s y_{sj} \le \upsilon_1 x_{1j} + \cdots + \upsilon_m x_{mj}, \; (j = 1, \ldots, n), \tag{11}$$

$$\upsilon_1, \upsilon_2, \ldots, \upsilon_m \ge 0, \tag{12}$$

$$\mu_1, \mu_2, \ldots, \mu_s \ge 0. \tag{13}$$

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

With an assumption about non-zero values of the weight vector (v_i) and a positive set of inputs $X > 0$, it is possible to prove the equivalency of linear fractional programming and linear programming. There is also proof that optimum values $\max\theta = \theta^*$ are independent on the parameters measuring inputs and outputs provided that these parameters are the same for every DMU.

Optimal solution of the linear programming task represents a solution (θ*, v*, u*)[4], where v* and u* correspond to the limitations (12) and (13). Then the technical efficiency of a DMU can be defined as follows:

DMU_o is efficient if $\theta^* = 1$, and there is a least one optimum set (v*, u*), c v*>0, u*>0. In case there is no such set, DMU_o is technically inefficient. I.e. either $\theta^* < 1$, or $\theta^* = 1$, and at least one element of the optimum set (v*, u*) is equal to 0 from every optimal solution (LP_o).

In case if $\theta^* < 1$, i.e. in case of technical inefficiency of DMU_o, there is at least one set (or DMU), wherein w при котором при весах (v*, u*) the inequation from the formula (9) turns into an equation (otherwise θ* may be increased). Let the set of such parameters from {j=1, …, n} represent E'_o:

$$E'_o = \left\{ j : \sum_{r=1}^{s} u_r^{*} y_{rj} = \sum_{i=1}^{m} v_i^{*} x_{ij} \right\}. \qquad (14)$$

Within this set there is set E_o, consisting of technically efficient units and called a referent group for DMU_o. They form an efficiency frontier.

The values of optimal weights should be addressed too. The set (v*, u*), obtained as an optimal solution to the linear programming task (LP_o), represents a set of optimal weights for DMU_o. Since we evaluate the ratio of outputs to inputs, it can be written as follows:

$$\theta^* = \frac{\sum_{r=1}^{s} u_r^{*} y_{ro}}{\sum_{i=1}^{m} v_i^{*} x_{io}}. \qquad (15)$$

It follows from the condition (10) that the denominator of the formula (15) is equal to 1, so:

[4] Instead of symbols υ and μ, utilized in the linear programming task, in the optimal solution v and u are used.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

$$\theta^* = \sum_{r=1}^{s} u_r^* . y_{ro} \, . \qquad (16)$$

As noted above, (v^*, u^*) represent a set of mostly preferred weights for DMU_o in terms of maximized ratio of outputs to inputs; v^* characterizes the optimal weight for the input i, and fluctuations of its values show how important this specific input is. The same is true in relation to outputs: u^*_r characterized the importance of the output r. If we analyze every input $v^*_i x_{io}$ in a set of inputs:

$$\sum_{i=1}^{m} v_i^* x_{io} = (1), \qquad (17)$$

Then we can evaluate the relative importance of every input in every $v^*_i x_{io}$. The same approach is true for the ratio of output weights, $u^*_r y_{ro}$, where u^*_r represents the evaluation of the relative contribution of every y_{ro} to the general ratio θ^*. I.e. the values of weights not only characterize how much is contributed to the general ratio by any given inputs or outputs, but also illustrate the possible scales of their change.

It should be noted that the above optimization by CCR model represents one of the simplest data envelopment analysis modelling variants. Development of this approach has resulted in emergence of other, more advanced models, mitigating the main assumptions of the classical model. Among them is the so-called "network model" (Lui, J.S., Lu, Y.Y.L., Lu, W.-M., 2016), which uses dynamic programming and allowing obtaining the best results when evaluating a DMU whose activity has a noticeably multi-stage nature with the inputs of one stage being the outputs for the next one. There are also other approaches to optimizing the ratio of outputs and inputs in the context of data envelopment analysis.

The DEA approach is quite universal so it is used for analysis of various branches of the economy. Research examples of internet companies (Ho, C., 2008), oil industry (Vygon, G.V., 2001) allow defining the methodology for such research studies. In literature, there are examples of efficiency and competitiveness analysis of commercial banks (Seiford, L., & Zhu, J., 1999; Shahwan, T. M. and Hassan, Y. M., 2013; Tahir, I. M., Bakar, N. M. A., 2009). Researchers select specific parameters given the market condition and economic situation in the country which is being studied.

One of the DEA advantages in assessing the innovative efficiency of regions is a capability to evaluate efficiency as a whole, as a result of many factors affecting inputs and outputs. Thus, this approach is different from the approach that is commonly used. It implies formation of an index on the basis of weighed indicators, characterizing the

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

input and output components of innovative activity individually.

One of the serious limitations of the data envelopment analysis approach is a strict prerequisite about the lack of random errors in data. It implies that data is free from measurement errors. If data integrity gets broken, DEA results cannot be interpreted with confidence, because they will affect the efficiency values and the efficient frontier will be displaced. That is why, the efficient frontier should be built on large samples of information.

Another limitation of the proposed approach is that a decision-making unit is efficient only in relation to other decision-making units in the same sample. In other words, it is more about relative, rather than absolute efficiency, which shows how successful innovative activity in a region is compared to other regions, but not in relation to a theoretically achievable maximum. However, this limitation is also true for other approaches to evaluation of the efficiency of innovative activity in regions.

The essence of a regional innovation system is determined by the interaction of its participants interested in gaining larger profits from innovative activity together with optimization and stabilization of inputs. Construction of this model makes it possible to bring this research study closer to these realities.

A decision-making unit is efficient if $DMU_j \theta^* = 1$, and there is at least one optimal combination (v*, u*), where v*>0 и u*>0. Otherwise, a decision-making unit is inefficient.

To achieve these goals, we used the CCR model with constant returns to scale. In fact, we tested two models - resource-oriented and results-oriented (table 3).

Table 3. Description of models

Input model (resource-oriented)		Output model (results-oriented)	
Target function	$\max \sum_{r=1}^{s} \mu_r y_{ro}$	Target function	$\min \sum_{i=1}^{m} \nu_i x_{io}$
Limitations	$\sum_{r=1}^{s} \mu_r y_{rj} \le \sum_{i=1}^{m} \nu_i x_{ij}$, $\sum_{i=1}^{m} \nu_i x_{io} = 1$, $\mu_r, \nu_i \ge 0(\varepsilon)$	Limitations	$\sum_{r=1}^{s} \mu_r y_{rj} \le \sum_{i=1}^{m} \nu_i x_{ij}$, $\sum_{i=1}^{m} \mu_r y_{ro} = 1$, $\mu_r, \nu_i \ge 0(\varepsilon)$

Note: x - resources, y - results, ν, μ - weights to be set for each DMU.

The following indicators have been referred to the resources of innovative activity:

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

- the number of staff involved in R&D in a region;
- the number of organizations involved in R&D;
- the spending of organizations on technological innovations (percentagewise of total costs);
- the spending of organizations on technology acquisition;
- the number of advanced production technologies used in a region;
- the amounts of direct foreign investments attracted to a region.

The following ones have been considered as the results of innovative activity:

- the share of innovative products and services in the gross regional product;
- the number of advanced production technologies developed in a region;
- the number of patents registered in a region.

The time lag between costs and results was considered through separate acquisition of information by cost indicators (data referred to 2012) and the results (data referred to 2014). “DEAFrontier Solver” package based on Microsoft Excel was used for calculation.

5. RESULTS

The data provided in Table 4 presents 28 regions, which, according to the results of modeling using the DEAFrontier Solver package, θ ^ * = 1, they are effective. Further, in the table were added the results of the ranking of the regions according to two existing ratings in Russia - the RSRI and the AIRR. Color was allocated to those regions that either belong to the same category on both rating scales, or the gap in positions between them does not exceed 10 points, regardless of the category.

Table 4. Technically effective regional innovation systems

№	Region	Group on RSRI	Group on AIRR[5]
1	Vladimir region	III (35)	Moderately strong innovators (23)
2	Kostroma region	IV (75)	Moderately strong innovators (64)
3	Lipetsk region	II (14)	Medium innovators (31)
4	Moscow region	II (17)	Strong innovators (6)
5	Tula region	III (42)	Moderately strong innovators (18)
6	Yaroslavl region	II (22)	Strong innovators (5)

[5] 2015 rating summing data for 2014.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

№	Region	Group on RSRI	Group on AIRR[5]
7	Moscow	I (2)	Strong innovators (2)
8	Nenets Autonomous Okrug	-[6]	Weak innovators (81)
9	Novgorod region	III (60)	Moderately strong innovators (24)
10	Saint- Petersburg	I (3)	Strong innovators (1)
11	Republic of Adygea	III (69)	Moderately weak innovators (65)
12	Republic of Bashkortostan	II (15)	Moderately strong innovators (15)
13	Mari El Republic	III (38)	Medium Innovators (37)
14	Republic of Mordovia	II (4)	Moderately strong innovators (20)
15	Udmurt republic	III (61)	Moderately strong innovators (29)
16	Chuvash Republic	II (8)	Moderately strong innovators (19)
17	Perm Region	II (19)	Moderately strong innovators (12)
18	Nizhny Novgorod Region	II (6)	Strong innovators (4)
19	Penza region	II (10)	Moderately strong innovators (10)
20	Samara Region	II (25)	Moderately strong innovators (14)
21	Sverdlovsk region	II (13)	Moderately strong innovators (9)
22	The Yamalo-Nenets Autonomous Area	II (26)	Moderately weak innovators (74)
23	Chelyabinsk region	II (18)	Moderately strong innovators (16)
24	Altai Republic	III (58)	Moderately weak innovators (75)
25	Republic of Buryatia	III (40)	Moderately weak innovators (51)
26	Tyva Republic	III (72)	Weak innovators (82)
27	Sakhalin Oblast	III (52)	Moderately weak innovators (50)
28	Chukotka Autonomous District	IV (73)	Moderately weak innovators (73)

The obtained results, to an extent, coincide with the results presented in the aforementioned ranking. The efficient regions include the Republic of Tatarstan (leader of the RRII ranking), St. Petersburg (leader of the AIRR ranking) and Tomsk Oblast, which is in both rankings. Some regions – leaders (Moscow, Moscow Oblast,

[6] As part of the Arkhangelsk region

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Krasnoyarsk Kray) have proven to be inefficient.

However, as can be seen from Table 4, technically efficient regions belong to different groups according to the levels of innovation development. There is also a discrepancy between the ratings between the two ratings.

As a result of the analysis, despite the difference in the methodologies for calculating ratings, among the technically efficient regions, strong ones predominate (their number is small, but representation among effective regions is significant) and medium-strong (second category), which indicates the overall effectiveness of the authorities' efforts to conduct Innovation policy and high susceptibility to it of the innovation environment. Attention is drawn to the absence among the effective regions of one of the leaders of both ratings - the Republic of Tatarstan. If you look at the applications that characterize the efficiency reserves, you can see that the region re-invests in research and development for results, that is, investments in research and development do not yield the desired results.

Among the technically efficient regions there are also those that do not belong to the leaders of innovative development. These are the Republic of Adygea, the Republic of Tyva, the Kostroma Region, the Yamalo-Nenets Autonomous District, and the Chukotka Autonomous District. Technical efficiency means that with an increase in the resource base these regions will be able to adequately increase the results of innovation activity.

Another interesting conclusion, which confirms the importance of research specifically the regional aspect of innovation, is the uneven distribution of technically efficient innovation regions across Russia. The highest density falls on the Volga Autonomous Okrug, which indicates the existence of effective interaction not only within regions, but also between them. At the same time, there is only one technically effective region in the Southern and North Caucasus Federal Districts - the Republic of Adygea.

REFERENCES

[1] Bonaccorsi, A., Daraio, C. (2004). Econometric Approaches to the Analysis of Productivity of R&D Systems: Production Functions and Production Frontiers. In: Moed, H.F. et al. (eds.) *Handbook of Quantitative Science and Technology Research*. Dordrecht: Kluwer Academic Publishers, 51-74.

[2] Botazzi L., Peri G. (2003). Innovation and spillovers in regions: Evidence from European patent data. *European economic review*. No. 47. 687 – 710.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

[3] Charnes, A., Cooper, W., Rhodes, E. (1979). Measuring the Efficiency of Decision-Making Units. *European Journal of Operational Research*, 3(4), 429-444.

[4] Chen, K., Guan, J. (2012). Measuring the Efficiency of China's Regional Innovation Systems: Application of Network Data Envelopment Analysis (DEA). *Regional Studies*, vol. 46, no. 3, 355-377.

[5] Cooke, P., Gomez Uranga, M., Etxebarria, G. (1997). Regional Innovation Systems: Institutional and Organizational Dimensions. *Research Policy*. 26. 475-491.

[6] Cooper, W. W., Seiford, L. M., Tone, K. (2006). *Introduction to Data Envelopment Analysis and Its Uses. With DEA-Solver Software and References*. New York: Springer.

[7] Crossing the Next Regional Frontier: Information and Analytics Linking Regional Competitiveness to Investment in a Knowledge-Based Economy. *Innovation in American Regions* [URL: http://www.statsamerica.org/innovation/data.html].

[8] Doloreux D. (2003). Regional Innovation Systems in the Periphery: The Case of the Beauce in Quebec (Canada). *International Journal of Innovation Management*, 7(1). 67–94.

[9] Edquist, C. (ed.) (1997). *Systems of Innovation: Technologies, Institutions and Organisations*. Pinter Publisher, London.

[10] Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistic Society*, 120, 253-282.

[11] Feldman M., Audretsch D. (1999). Innovation in cities: science-based diversity, specialization and localized competition. *European Economic Review*. No. 43. 409 – 429.

[12] Florida, R., (1998). Calibrating the learning region. In: De La Mothe, Paquet, G. (Eds.), *Local and Regional Systems of Innovation. Kluwer Academic*, Dortrecht, 19–28.

[13] Fritsch, M., Slavchev, V. (2006). Measuring the Efficiency of Regional Innovation Systems: An Empirical Assessment. Freiberg Working Papers, 2006-6.

[14] Gertler MS. (2003). Tacit Knowledge and the Economic Geography of Context, or the Undefinable Tacitness of Being (There). *Journal of Economic Geography*. 3(1). 75–99.

[15] Greene, W.H. (1997). Frontier production functions. In Pesaran, M.H. and Schmidt, P., editors, *Handbook of Applied Econometrics*, vol. II: Microeconometrics. Blackwell Publishers Ltd.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

[16] Ho, C. (2008). Measuring Profitability and Marketability in Internet Companies. *The Open Management Journal*. Vol. 1 (14). – P. 12-25.

[17] Kazantsev S.V. (2012). Dynamics of Innovative Activity in Russia's Regions. *Region: economics and sociology*, 1. 212-231.

[18] Khalimova S. (2015). Assessment of Regional Distinctions in the Capacity of Innovative Activity // XV April International Scientific Conference on the Issues of Economic and Social Development. In 4 vol. / edited by Yasin E.G.; National Research University – Higher School of Economics with the participation of the World Bank and IMF. - Moscow: Publishing House of HSE, Vol. 3. 301-326.

[19] Koopmans, T.C. (1951). Analysis of production as an efficient combination of activities. In: T.C. Koopmans (ed.). *Activity Analysis of Production and Allocation*. New York: John Wiley & Sons. 33–37.

[20] Kotsemir, M. (2013). Measuring National Innovation Systems Efficiency – a Review of DEA Approach. //HSE Basic Research Programme Working Papers. Series: Science, Technology and Innovation. WP BRP 16/STI/2013.

[21] Lui, J.S., Lu, Y.Y.L., Lu, W.-M. (2016). Research fronts in data envelopment analysis. *Omega*, vol. 58, pp. 33-45.

[22] Mikheeva N., Semenova R. Innovative Potential of Regions: Problems and Results of Measurement. – New Economics. Innovation Portrait of Russia. – Moscow: Center for Strategic Partnership, 2011 (URL: http://komitet2-8.km.duma.gov.ru/file.xp?idb=2216676&fn=IPR4-Book.pdf&size=28509852)

[23] Oinas, P. and Malecki, E. (2002). The evolution of technologies in time and space: from national and regional to spatial innovation systems. *International Regional Science Review*, vol. 25, no. 1, pp. 102-131.

[24] Porcelli, F., 2009. Measurement of Technical Efficiency. A brief survey on parametric and non-parametric techniques. University of Warwick. p. 1-27.

[25] Ranking of Innovative Capacity of the Russian Federation Subjects: Analytical Report / editied by Gokhberg L.M. – Moscow: National Research University "Higher School of Economics", 2012. P.104.

[26] Ranking of Innovative Capacity of the Russian Federation Subjects: Issue 4 / editied by Gokhberg L.M.; National Research University "Higher School of Economics" – Moscow: NRU HSE, 2016. P.248.

[27] Regional Innovation Scoreboard 2012. [URL: http://ec.europa.eu/enterprise/policies/innovation/files/ris-2012_en.pdf]

[28] Rodionov D.G., Nikolova L.V. (2017). Impact of globalization on innovation project risks estimation. *European Research Studies Journal*. T.20. № 2. 396-410.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

[29] Rudskaia I.A., Rodionov D.G., Guzikova L. A. (2014.) Innovation potential of regions as a factor of national economy competitiveness. *Actual problems of economics, sociology and law*. № 8. 215-233.

[30] Seiford, L., & Zhu, J. (1999). Profitability and Marketability of the Top 55 U.S. Commercial Banks. *Management Science*. Vol. 45(9). 1270-1288.

[31] Semenova R. Ranking of Innovative Regions for Monitoring and Management Purposes, 2015. Association of Innovative Regions of Russia, 2016 (URL: http://www.i-regions.org/files/file_103.pdf).

[32] Shahwan, T. M. and Hassan, Y. M. (2013). Efficiency analysis of UAE banks using data envelopment analysis. *Journal of Economic and Administrative Sciences*. Vol. 29 (1). 4-20.

[33] Tahir, I. M., Bakar, N. M. A. (2009). Estimating Technical and Scale Efficiency of Malaysian Commercial Banks: A Non-Parametric Approach. *International Review of Business Research Papers*. Vol. 5 (1). 113-123.

The data has been compiled on the basis of the website of Rosstat and regional bodies of public statistics.

[34] Untura G.A. (2011). About Compatibility of the Innovative Capacity of Russia and the Strategy of Development of the Regional Subjects *The Problems of Regional and Municipal Management: collection of scientific papers*. Edited by Novosyolov A.S. Novosibirsk : IEOPP SO RAS,. P. 35-56.

[35] Vygon, G.V. (2001). Appraisal Methods for Oil Companies in the Conditions of Uncertainty. *Audit and Financial Analysis*. No. 1. 158-177.

[36] World Knowledge Competitiveness Index 2008 /Huggins, R., Izuschi, H., Davies, W., Shougui, L. Centre for International Competitiveness, Cardiff School of Management, University of Wales Institute, Cardiff

[37] Zabala-Iturriagagoitia, J. M., Voigt, P., Gutiérrez-Gracia, A., Jiménez-Sáez, F. (2007). Regional innovation systems: How to assess performance. *Regional Studies*, 41 (5), 661-672.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)