THE METHODOLOGICAL BASES OF COMPARATIVE EVALUATION OF SCIENTIFIC AND TECHNOLOGICAL POTENTIAL OF RUSSIA AND THE EU: REGIONAL AND INTERNATIONAL ASPECTS

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This article analyses approaches to the definition of such categories as "scientific and technological potential" and "innovative potential" in view of their resource, structural, procedural and resultant components. The author gives a more accurate definition of the scientific and technological potential through identifying its resources and orientation towards transforming abilities. On the basis of the existing methods of comparative analysis used in Russia and abroad, the author proposes a methodology for evaluating scientific and technological potential in the context of regional and international comparison. The integral index is calculated on the basis of a customised information and statistical database of normalised indicators through the identification and convolution of subindices that characterise individual components of potential. These subindices include specific indicators applied in different statistical systems, in particular, those used in Russia and the EU, which made it possible to compare the data.

The article presents the result of the application of this methodology based on a comparative evaluation of the scientific and technological potential of Russia (Northwestern federal district) and EU states of the Baltic region. The experimental check suggests that the methodology be further improved for future clustering of Russian and EU regions according to the level of their innovative development.

Key words: scientific and technological potential; comparative evaluation; human resources, infrastructural and research components; transforming abilities, index method

At the moment, an important condition and, at the same time, foundation for the development of principles, forms and methods of international cooperation in the field of innovations in Russia and the EU, is the assessment of scientific, technological and innovative potential, its qualitative composition, characteristics and their main compo-

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Submitted on August 12, 2012.

doi: 10.5922/2079-8555-2012-4-2

nents. At the same time, the problem of comparing scientific and technological potential in view of its complex character and the mediated impact on the development of a certain territory has both international and regional aspects. This is determined by the features of the comparative analysis and the developing research and technological potential. Of significance are the borders of concentrations of its components, as well as the implementation of its transformation capacities, which is manifested within territories of different levels (country, region, or city) and makes it possible to juxtapose different objects. Thus, in case of Russia and the EU, it is reasonable to choose such territorial systems as "country — country", "region — region", or "country — region" as objects of comparison. However, it impedes the comparability of data, in particular, in terms of requirements for their representativeness, invariance, transitivity, and conformity.

The current situation is characterised by the multicriterion approaches to scientific, technological and innovative development aimed at the formation of innovation-driven economy at the regional level, which results in the diversity of assessment of terminological essence and correlations of such concepts as "scientific and technological potential" and "innovative potential". An analysis of individual definitions makes it possible to apply the following types of compatibility of the mentioned categories: equivalence (identity), intersection, and subordination.

The compatibility of the "equivalence (identity)" type is emphasised by such authors as Yu. V. Budavei [5], M. S. Danko [8], V. A. Kalashnikov [23], A. I. Nikolaev [21], B. A. Raizberget al. [22], E. A. Utkin [25], etc. The authors predominantly emphasise the significance of economic growth potential, the development of new products, knowledge and technologies without focusing on research, technological and innovative components, or the levels, to which a certain concept should relate.

The most widespread types of compatibility are "intersection" and "subordination". The "intersection" type of compatibility is often found in the approaches of authors focusing on the resource component of potential, since, from the methodological point of view, it is quite difficult to identify, which part of resources and factors comprises the research, technological or innovative potential. Among the advocates of the "intersection" type of compatibility one can mention O. F. Balatsky [29], D. M. Gvishiani [4], P. N. Zavlin et al. [10], V. I. Kushlin and A. M. Folomyev [19], B. K. Lisin and V. N. Fridlyanov [14], etc.

The "subordination" type of compatibility emerges as a result of analysing innovative activity and opportunities for using the productive force of the existing potential including a certain set of resources and factors. The notion 'potential' characterises the ability of different systems to transform into a qualitatively new state, which is closely connected with both potencies and innovations. In the framework of this approach, one can quote the category definitions given by such authors as V. N. Gunin [7], G. I. Zhits [9], S. I. Kravchenko and I. S. Kladchenko [12], V. G. Matveikin et al. [11], Ye. A. Monastyrny [16], V. I. Suslov [24], I. V. Shlyakhto [27], etc.

The multicriterion approaches to the study as well as the absence of a common understanding of processes related to the functioning of the research, technology and innovation sector, give rise to numerous definitions of generic and specific concepts. The observed diversity of categories being applied when describing different aspects of research, technology and innovation and often supplemented by various interpretations, presents not only a problem of the correct understanding, but also that of terminological clarity, which is a necessary condition for any methodological choice within a study into the phenomenon. Of interest is the list of such related concepts as "scientific and technological", "innovative and technological", "technological", "innovative", etc. used in combination with such categories as "development", "cooperation", or "potential" in such contexts as territory (country or region) development, economic model formation, external ties, or development of potential.

It seems logical — without conducting a detailed analysis of the multitude of existing categories and definitions related to research, technology and innovaions — to establish correspondence in relation to scientific and technological and innovative potential.

The understanding of "potency" as an aggregate of opportunities, which can be used for solving certain problems or attain certain objectives can serve as a starting point for examining the notion of potential[1].

Such an objective, which determines further tasks of defining scientific/technological and scientific/technical potential, is the acquisition of new knowledge and the development of technology on the basis of research. At the same time, potential is comprised of resource factors and process factors (according to A. N. Folomyev), required for the development based on technology. The interconnection and interdependence is determined by the features of functioning of the scientific/technological and scientific/technical spheres, which, in essence, comprise a unified system of science — technology — technical equipment in view of the needs of public production.

For the purpose of further research in view of the existing approaches and definitions of the categories mentioned, the author suggests considering "scientific and technological potential" and "scientific and technical potential" as identical concepts: *scientific and technological potential is a system of resource factors, process factors, and conditions designed and necessary for achieving the objectives of scientific and technological development aimed at ensuring an increase in economic competitiveness, as well as national economic — and scientific and technological — security.*

An exception is the conditions of applying these concepts — if there is a need to emphasise the significance of the technological component for development, one may use the notion of "scientific and technological potential"; the term "scientific and technical potential" may be used in other cases.

At the same time, the author believes that the concept "innovative potential", when the context does not concern the structure of potential, is broader than the concept "research and technological potential". When defining innovative potential, most researchers emphasise the resource component and the industrial opportunities of innovative potential, which is considered a

[1] Potency (from Latin *potentia*) is the ability or capacity to achieve or bring about a particular result (Merriam-Webster Online Dictionary).

necessary condition for innovative activity at different levels — an interpretation that brings its close to scientific and technological potential.

However, the principal difference stems from the orientation of the transforming abilities of potentials. If, within the scientific and technological potential, the transforming ability is aimed at the sphere of research and technological progress, where achievements can have direct and indirect impact on the socioeconomic sphere, the abilities of innovative potential are aimed predominantly at its transformation, renewal, and development. Moreover, the innovative potential — as a resource for conducting innovative activity — suggests an obligatory orientation towards the commercialisation of results: new product, services, or technologies should generate profit creating conditions for the reproduction of research complex and further innovative development.

Thus, the concept of "innovative potential" is of greater practical and applied significance; it ensures the reproduction of the existing scientific and technological potential, which emphasises the prominent role of the resource component. In the interest of further research, one can consider the innovative potential as an aggregate of resources, processes, and conditions required and sufficient for conducting innovative activity and achieving the objective of innovative and technological development.

The structure of the scientific and innovative potentials is represented by the combination of the following components: 1) the personnel component — the number of researchers and people involved in hi-tech production; 2) the infrastructure component — the equipment of scientific, technological and innovative activity; 3) the research component — the intensity of creation and application of R&D and innovations; 4) the transforming abilities of potential — an increase in system opportunities (technological, information, qualification, intellectual, managerial, and other ones).

The formulation of the methodological framework for a comparative assessment of the scientific and technological potential in the context of Russia-EU cooperation requires taking into account both the existing practices of comparison and the whole body of applied instruments. Among the most influential studies into the problems of innovative, scientific and technological potential assessment, one can mention:

— approaches of the World Bank, the US National Science Foundation, the World Economic Forum, the Organisation for Economic Cooperation and Development (OECD), the Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT — the Netherlands) and the Commission of the European Communities (CEC), the Institute of Economics of the Russian Academy of Sciences, the Independent Institute of Social Policy of the Russian Federation, the North-West centre for strategic research, and the Expert RA rating agency;

— methodologies of international authors: H. Bruijn, M. Fischer, J. Fröhlich, C. Freeman, F. Geels, B. Lundvall, C. Nauwelaers, R. Wintjes, R. Nelson, etc. [31—37];

— methodologies of Russian authors: V. I. Akopov, E. P. Amosenok, O. F. Balartsky, V. A. Bazhanov, A. Ye. Varshavsky, Yu. A. Gadzhiev, A. B. Gusev, S. I. Dvoretsky, K. A. Zadumkin, D. V. Kolechkov, I. A. Kondakov, S. V. Kortov, V. I. Kushlin, O. I. Letunova, V. G. Matveikin,

L. V. Minko, S. I. Orlenko, M. M. Styrov, V. P. Tarov, V. V. Tikhomirov, V. V. Fauzer, A. N. Folomyev, L. N. Chainikova, T. A. Shtertser, etc. [see, for example: 1—6; 15; 17; 18; 20; 26; 28; 30].

These approaches to the assessment of scientific, technological and innovative potentials exhibit, to a certain degree, such characteristics as availability and objectivity of source data, clarity of results obtained, opportunities for calculating and modelling in relation to other objects, possibility of assessing potential from the perspective of its structure and composition, functioning, content, and organisation. The methodologies can be applied to studying and assessing the scientific and technological potential of a country, or a certain region; however, they are poorly developed as regards the study of Russian and international regions. Thus, the development of a methodological framework for a comparative assessment of scientific and technological potential requires taking into account a number of considerations.

Firstly, there is a need to ensure the comparability of results of international and regional comparisons. Secondly, one must pay special attention to the use of official statistical sources, excluding expert assessments and survey results. Thirdly, there is a need to ensure the adequacy and sufficiency of the selected system of indicators for describing the condition of the scientific and technological potential. These requirements determine the directions of formation and the content of the compared information and statistical databases. At the same time, one should not overlook the fact that, as of today, the Russian and EU statistical systems — Rosstat and Eurostat (EIS) exhibit significant discrepancies. Moreover, there is the problem of disproportions between the objects of statistical studies in the sphere of scientific, technological and innovation development by Eurostat (EIS), since the applied system of EU territorial units (NUTS 2)[2] considers some territories (for instance, Latvia and Estonia) without taking into account individual administrative and territorial divisions.

The mentioned discrepancy can be overcome by including into the system of potential indicators the comparative assessment only of those indicators that can be expressed in specific terms. It makes it possible to make a comparison both at the level of countries (regions) and when studying interaction between Russia or Russian regions with EU regions and countries, for example, the Northwestern federal district of Russia with EU member states.

A comparative analysis of indicators according to the Rosstat and Eurostat methodology made it possible to identify a group of indicators that can be included into the information and statistical database for an assessment and further comparative study of the scientific and technological potential against the background of the requirements of consistency, sufficiency, and relevance.

1. The personnel component:

— the number of researchers within the economically active population (EAP),%;

[2] The EU nomenclature of territorial units for statistics (Regulation No 1059/2003) distinguishes three types of NUTS regions, which regularly coincide with national networks of administrative and territorial units. URL: http://epp.eurostat.ec.europa.eu/portal/page/portal/ nuts_nomenclature/ introduction (accessed on 13.04.2012).

— the number of researchers within the mean annual number of employed population,%;

— the share of population with higher education,%.

2. The research component:

— national/regional expenditure on research and development,% of GDP (GRP);

— the share of people employed within hi-tech industries,%;

— the share of innovative businesses (technological, managerial, marketing and other innovations),%.

3. The infrastructure component:

— intensity of expenditure on technological innovations,%;

— Internet coverage,%;

— expenditure on information and communication technologies and objects,% of GDP/GRP.

4. The transforming ability of the scientific and technological potential:

— the number of patent applications per 1 mln residents,

— the share of new products in the total turnover,%;

— the share of hi-tech export,%.

The calculation of a composite index of the scientific and technological potential can be performed with the help of the modified methodology of Saint Petersburg State Faculty of Engineering and Economics (A. K. Kazantsev, S. N. Leora, I. A. Nikitina, D. A. Rubvalter, S. A. Firsova) [12] according to the following scheme.

The first stage focuses on the analysis of the structure of the indicators according to the groups of scientific and technological potential and the selection of the initial data in accordance with the identified structure and components.

The second stage is dedicated to the formation of a database according to the groups of indicators that are to be calculated as components of the potential, as well as their measurement.

The normalising of indicators of scientific and technological potential can be carried out on the basis of the traditional linear scaling used by the majority of researchers when assessing scientific, technological and innovative potential. The procedure of linear transformation brings the data to a common scale. All magnitudes are found within the interval [0; 1]; where 0 corresponds to the minimum value of the property and 1 is the maximum one. Such data can be easily interpreted [12, c. 42]. The normalising of indicators on the basis of linear scaling is performed for each year under consideration, whereas the maximum and minimum values of each variable are registered for the whole period studied. Otherwise, the values obtained would be dynamically incomparable: it would be impossible to compare the scaled values for different years. Then, the composite indices of groups of indicators are calculated on the basis of the simple arithmetic mean. The calculation of the composite index of scientific and technological potential within regional comparisons at an inter-country level is conducted through obtaining the mean value from composite indices calculated in groups in the structure of scientific and technological potential.

The experimental validation of the methodology was performed through a comparative assessment of the scientific and technological potential of the Northwestern federal district of Russia and EU states of the Baltic region (Denmark, Sweden, Finland, Lithuania, Latvia, and Estonia) in 2008—2010. It is worth noting that a customised information and statistical base of specific indicators, as well as the assumption about the limits of formation of the scientific and technological potential made it possible to obtain objective data on the condition of the scientific and technological potential. However, there is a need to meet such obligatory conditions of the comparative analysis method as the unity of recording methodologies and comparability of indicator calculation, the congruity of time periods, the comparability of structure and conditions of the functioning of the object compared (scientific and technological potential).

During the development of information and statistical database containing the data on the scientific and technological potential in the selected regions, it was established that certain statistical data characterising the scientific and technological development of countries in 2008—2010 are missing. It relates to the fact that their accumulation is carried out on the basis of regular sampling surveys, for example in EU-27 countries — the Community Innovation Survey (CIS). Moreover, statistical information accumulation helped identify discrepancies between the data published in different sources. For example, the data of Central Statistical Offices (Lithuania, Latvia, and Estonia) contradict those of Eurostat; there are also discrepancies between the annual OECD reports. A similar situation is observed in the Northwestern federal district of Russia.

Difficulties related to the measurement and comparative analysis of the scientific and technological potential are resolved with the help of the following assumptions. First of all, the lacking data were replaced with the obtained values: in cases when more recent data were unavailable, they were replaced with the previous year's data; if the missing data relate to the middle of the period under consideration, they are replaced with the previous year's data on; if the missing data relate to the beginning of the period analysed, they are replaced with the next year's data. Secondly, there have been adjustments to the qualitative composition of indicators: the number of indicators that are not fully taken into account by statistical studies has been reduced; additional indicators characterising the condition of science and technology have been included. Thirdly, there has been a qualitative improvement in the indicators of scientific and technological potential; they have been replaced by generalising indicators, since composite indicators are the most easily available data in innovation statistics at a regional level. In case of certain indicators, the results of sampling surveys and expert assessment published in official sources were also taken into account.

The normalising of indicators helped calculate the mean values for each of the four groups of indicators, perform the convolution of individual values by groups, and calculate composite indices for each region under consideration. As a result of the analysis of the Northwestern federal district, the Nordic countries, and the Baltics in 2008—2010, the following integral estimations were obtained (table).

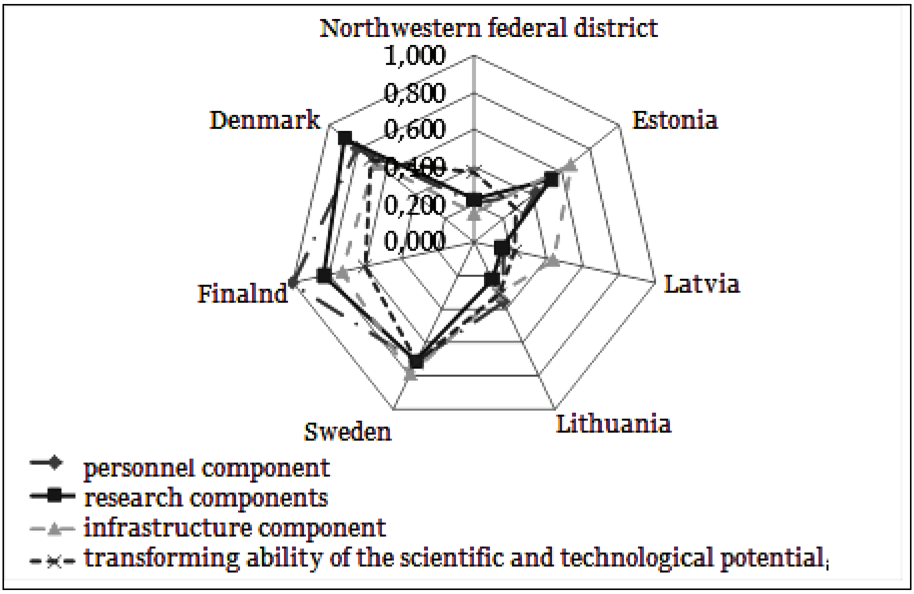
An integral estimation of the scientific and technological potential of the Northwestern federal district, the Nordic countries, and the Baltics for 2008—2010

Country/region	2008	2009	2010	Increase rate in 2008—2010,%
NW federal district	0.180	0.178	0.242	34.1
Latvia	0.196	0.216	0.244	24.9
Lithuania	0.295	0.304	0.302	2.2
Estonia	0.454	0.501	0.478	5.3
Sweden	0.781	0.810	0.734	– 6.0
Denmark	0.742	0.757	0.769	3.6
Finland	0.850	0.862	0.788	– 7.2

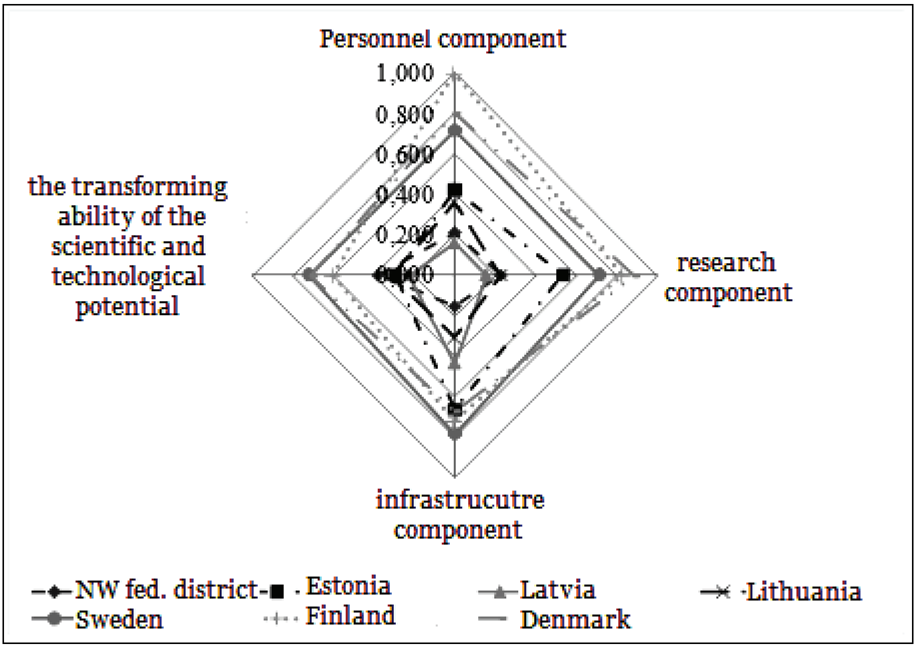
A high level of potential is characteristic of the Nordic countries. Whereas the potential is increasing in Denmark, in Sweden and Finland the situation is opposite — there is a trend towards a decrease in the concentration of scientific and technological potential (for reference only: in 2010, in comparison to 2008, the potential of the countries reduced by 6.0 % and 7.2 % respectively).

As to the scientific and technological potential of the Baltics — despite the positive dynamics in comparison to innovatively developed regions — the concentration is still low, which is manifested in the integral indicator that has not exceeded 0.5 over the last three years. In the Northwestern federal district, in comparison to the Nordic countries and the Baltic, the indicators are the lowest due to the persistent scientific, technological and innovative underdevelopment of the region. Throughout the whole period (2008—2010), the indicators of the NW federal district were three times as low as those of the leading countries of the Baltic region in terms of research and technological development, despite a considerable increase in the integral indicator (34 % over the last three years).

Changes in the composite index are determined by the condition of its structural components. The integral estimate of the scientific and technological development of the NW federal district underwent most significant structural changes in 2008—2010. These three years saw positive change related to the increase in the personnel and infrastructure potential of the region, predominantly through increasing expenditure on communication and information technologies and an increase in the Internet coverage. The index characterising the transforming ability of the scientific and technological potential increased by 4.5 %. The positive dynamics relates to the growth in hi-tech production and export. However, it is important to pay attention to the existing problems in connection to the low innovative activity of economic entities in comparison to the other countries of the Baltic region, insufficient financing of the R&D field, and the decreasing number of researchers. All these factors have an adverse effect on the opportunities for further improvement of the standing of the NW federal district within the scientific and technological and innovative space of the Baltic region and require the development of an effective mechanism of their solution (fig.).



a



b

Fig. A comparison of the structure of the scientific and technological potential of the NWFD, the Nordic countries, and the Baltics in 2010:
a — a comparison of the country's position according to structural components;
b — a comparison of structural components by countries

Based on the data of Rosstat, Eurostat (Eurostat regional yearbook, 2011), and the European Cluster Observatory (URL: http://www. clusterobservatory. eu/ (accessed on 10.07.2012)).

A comparative analysis of the structure of the scientific and technological potential of the countries studied emphasised significance difference both in the level of concentration and the lines of development of the potential. Despite the different features of increase, the closest to the NWFD value of scientific and technological potential is characteristic of Latvia and Lithuania. Latvia places emphasis on the infrastructure component, Lithuania on the personnel one. As to the NWFD, the focal point is the transforming ability of the potential, which largely stems from the high patent activity in the region.

The research and personnel components served as the basis for the increase in the scientific and technological potential of the Nordic countries.

The results of experimental calculations of integral estimation of the scientific and technological potential not only proved the possibility of a comparative analysis in the "region-country" cross-section, but also revealed a number of disadvantages.

One of the most important remarks concerns the selected period of study, which imparts certain subjectivism and affects the representativeness of the statistical data. The identification of parameters of scientific and technological potential and their comparative analysis should be performed over a longer period. Moreover, there is a problem of the comprehensive coverage of indicators characterising the components of the scientific and technological potential. A limited number of analysed indicators in the structure of personnel, research and infrastructure groups, and transforming components of the scientific and technological potential do not make it possible to fully assess the quality and direction of the current innovative, scientific and technological processes, or identify their objective influence on the condition of both regional economy and international markets. This is also true speaking about a similar assessment of the common research, technological, and innovative space of the Baltic region. It results in the need — despite the initial elimination of expert assessment and sampling survey data from the indicators system — to include these data in order to meet the following obligatory conditions — those of representativeness, invariance, external and internal consistency.

Firstly, there is a need to expand the quantitative and qualitative composition of indicators in order to eliminate considerable discrepancies between indicators of the scientific and technological development, as it was established in relation to the transforming ability of potential. Secondly, one should bring all the indicators to a unified form for using only official statistical sources; expert assessment and sampling surveys at a level of the studied countries (regions) should be taken into account in case of certain indicators. Thirdly, the analysis results fail to be informative in case of comparing several countries or regions, thus the application of the methodology requires a more comprehensive coverage of regions and countries.

The exclusion of these shortcomings and the objectives formulated is the next step of study aimed to develop a methodology for a comparative analysis of the scientific and technological potential within interregional comparisons. The proposed approach can be further improved for clustering regions according to the level of innovative development, which may serve as a basis for formulating the lines of innovative, research, and technological development between Russia and the EU.

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