

Scientific Communication of Russia in the Information Landscape of the Modern World

Petruk G.V.

Vladivostok State University Economics and Service, Vladivostok, Russia
e-mail: keeper@vvsu.ru

Peteraitis S.K.

Togliatti State University, Tolyatti, Russia

Sachko M.A.

Vladivostok State University Economics and Service, Vladivostok, Russia

Abstract—Formation of a new economy is directly linked to the creation and use of scientific knowledge. Such knowledge represents an inexhaustible economic resource, a driver of economic growth, and the foundation of the economy of knowledge. Scientific knowledge is first of all generated by the research institutes and universities of the leading economies. Russia is a great global scientific power, which has significantly contributed to the world civilization by enriching it with unique discoveries. The current role of the national science in the global scientific development can be determined by analyzing a number of citation indices. The authors hereof have analyzed the contribution of Russian scientists to the global science against the global scientific output. Data was sources from the statistics of Web of Science, an international citation database. The paper evaluates Russia's publication indicators against those of the leading countries for 2010 to 2017. The publication activity of Russian scientists is analyzed with breakdown by research fields, which allows us to find where Russian research is specialized. We have identified a positive trend in the knowledge growth and contribution of the Russian science to the international scientific dialog. The results of this study can be used for evaluating the developmental trends in various research fields, assessing the performance of research institutions, making general assessments of the country's and its regions' scientific potential; or they can be efficiently used to study the communication in professional communities, identifying the best-performing scientists in various fields, etc.

Keywords—Web of Science, citation indices, publication activity, level of citation, cross-country analysis.

I. ECONOMY AND SCIENCE

In the today's development of the Russian economy, the state considers transforming science and innovation into the most important resource of socioeconomic progress. Scientific knowledge represents an inexhaustible economic resource, a driver of economic growth, and the foundation of the economy of knowledge. Analysis of the global practices clearly shows that when the world is switching to a new, knowledge-based economic model, economic growth and competitiveness cannot be reasonably reached without efficient mechanisms for knowledge reproduction, dissemination, and transformation into innovative services and goods. Knowledge has always been fundamental to progress and the key enabler of development

and optimization in any area of human activity. However, the rapid technological progress of the modern world forces drastic changes in human life and bring about a new perspective of knowledge and its role in the economy. This is why using scientific accomplishments in the real sector of economy must be the national priority.

Russia's current role in the international scientific space can be analyzed by reference to some research indices, including the publication activity, the citation indices, the h-index, etc.

This research is aimed at analyzing Russia's contribution to the international scientific space from the standpoint of scientific indicators commonly accepted in Russia's and global science.

Various aspects of using citation indices for researchers and research institutions' performance have been studied by Russian scientists (A.V. Yurevich, I.P. Tsapenko, Ye.A. Ivanova, V.Ye. Polyakov, R.G. Kasimova, O.V. Kirillova, V.A. Markussova, V.V. Pislyakov et al) as well as their international colleagues (A. Annibaldi, A. Diem, L. Egghe, R. Tatavarti et al).

II. RESEARCH METHODS AND METHODOLOGY

The scientific performance of universities is evaluated by means of various citation indices that are calculated using the generally accepted scientometrics criteria.

As a rule, those include the following indicators:

- (1) relevance of research efforts, judged by the number of citations;
- (2) scale of research, including university's papers (in terms of publication numbers) and the h-index;
- (3) scientific potential judged by the number of citations.

Special literature describes various approaches to citation data analysis; however, most experts note there is no perfect indicator.

These indicators and bibliometric characteristics are determined by means of information systems based on citation databases. Those include: Scopus, Web of Knowledge (Web of

Science), Google Scholar, PubMed, Mathematics, Chemical Abstracts, Astrophysics, Springer, Agris, GeoRef, and many others.

Web of Science (WoS) is deemed the leading and most reputable specialized analytical and bibliographic information system. Statistical data contained therein enable the objective assessment of researchers' and research institutions' performance by means of scientometrics; they also enable probabilistic predictions of scientific development while being an efficient method for studying the communication in the scientific community.

Let us use the WoS database to evaluate institutional contribution to the knowledge economy.

III. FUNDAMENTAL RESEARCH MATERIAL

TABLE I. TOP 15 COUNTRIES IN TERMS OF WOS PUBLICATION NUMBERS

Rank	Country	Number of publications	Percentage of total publications	Development since 2010, %	h-index
1	USA	671,036	25.40	13	2,425
2	CHINA	412,682	15.62	89	731
3	ENGLAND	179,215	6.78	27	1,404
4	GERMANY	161,623	6.12	14	1,159
5	JAPAN	111,817	4.23	-1	1,004
6	INDIA	109,225	4.13	97	511
7	FRANCE	107,140	4.06	11	1,092
8	CANADA	105,803	4.01	21	1,132
9	ITALY	105,468	3.99	25	919
10	AUSTRALIA	98,301	3.72	57	904
11	SPAIN	92,713	3.51	33	772
12	SOUTH KOREA	76,136	2.88	38	548
13	BRAZIL	69,054	2.61	55	487
14	RUSSIA	65,247	2.47	88	509
15	NETHERLANDS	58,662	2.22	18	926

Notably, it is Asian countries form the bulk of the countries featuring skyrocketing growth of WoS publication numbers: Saudi Arabia (313%), Pakistan (179%), Malaysia (133%), Iran (112%) and China (89%). In Europe, the most significant growth is demonstrated by Croatia (104%) and Russia (88%).

The dynamic growth of the publication activity in emerging economies results in the lesser dominance of developed countries in terms of WoS publications when comparing 2017 against 2010. Here is the list of countries with the lowest publication growth for the past 7 years: the Netherlands (18%), Israel (18%), Wales (17%), Germany (14%), United States (13%), France (11%), Romania (4%), Greece (2%). Notably, Japan and Taiwan have decreased the number of new WoS publications over the past 7 years.

A number of target indicators of the scientific state of the art has been used in the last decade to objectively assess the performance of Russian researchers. These indicators include the general number of a researcher's or a research institution's publications, the researcher-specific citation index (deemed to indicate the "relevance" of their papers), and the h-index, which combines both of the former indicators.

Publication activity is but one quantitative indicator that covers the number of publications in this or that information system. The United States is the undisputed leader in terms of publications in premier WoS-indexed journals. As of 2017, the number of Russian publications in the world's premier journals has increased considerably (by 88%), as compared to 2010. Over the last few years, Russia has firmly kept its 14th rank in this system. Compared to 2001, Russia has moved down by 5 ranks, from 9 to 14. [2] *Table 1* shows the top 15 countries in terms of publication numbers.

Certainly, quantity alone is no objective indicator of the scientific importance of papers, which is why it is a good practice to analyze the demand for papers with specific target audience. The generally accepted measure of recognition is the so-called h-index, a quantitative performance indicator.

As the h-index is based on the total number of publications in the database, it is not surprising to see the United States lead the ranks, see *Table 1*. Notably, the countries that have sharply increased their publication numbers over the past 10 years, the h-index is not as high compared to the leading countries. For example, China ranks 2nd in terms of publication numbers, but only 11th by the h-index.

Notably, the h-index of the skyrocketing countries is only half that of countries that currently have similar publication numbers. This might indicate a lackluster quality of their pa-

pers, meaning the scientific community is not interested in them. The value is also affected by the publications "age", as the h-index is cumulative, meaning it is affected by how long a paper has been indexed by the database. In order to nullify the cumulative effects, we have to restrict our sample to the past 5 years. The h5-index of China is only 2 ranks below its publication number rank. This proves that analysis of the publication activity and relevance must be based on a restricted time period with respect to such countries.

The following countries have been stably leading in terms of both quality and quantity: United States, England, Germany, France, and Italy. Their indicators have been steadily high over the past 10 years, indicating they are efficient at stimulating national research efforts. We must also note China and Japan, whose citation rates have considerably increased over the last few years. This indicates the world public's interest to these countries and their scientific accomplishments.

At the same time, Russia's h-index rank (both h-5 and unrestricted) is identical to its publication numbers rank. On the one hand, this signifies some stability in the country's science; however, given the general downfall, this is not enough to make Russia one of the global scientific leaders.

International publication activity is essentially about the national scientific level as compared against other countries, especially when it comes to fundamental research, which, by definition produces nothing but publications. Analysis of publication scope and volume for the last 7 years shows the following. There is a clear linear growth in terms of total WoS publication numbers: approximately 4% per annum. On top of that, Russia's publication activity has skyrocketed since 2013 due to governmental incentives. Notable is the sharp increase in the publication numbers in 2015, caused by external factors such as adding new sources to the database (new journals, new conference proceedings, and even archival versions thereof).

Analysis of Russia's WoS publication dynamics shows that for the two years to come, the country will keep growing at the same pace, and the growth will reach approximately 20 to 22%. Even Russia's scientific incentives are going to be kept in place, the average growth will constitute 17% per annum for five years to come, bringing Russia to the 10th or 11th rank.

Important information can be obtained by analyzing the structure of scientific publications, which can be used to make findings on how developed this or that research field is, and which field the country specializes in.

By comparing Russian publications against global scientific efforts with breakdown by research fields, one can note the following trends: the global leaders are engineering (13.27), chemistry (7.68), physics (6.87), and computer science (6.03); for Russia, the leading fields are physics (24.5), chemistry (13.71), and technology (11.08).

When it comes physics, Russia's scientific representation in publications is much more significant compared to other fields of research. In Primorsky Krai, the structure of research efforts is not very different from the national structure, with chemistry (13.47), physics (11.24), and technology (8.63) being the top fields of research; however, due to the regional specifics, geology at 9.44% makes an outlier, too. It should be borne in mind

that no significant changes in the region's publication breakdown have occurred over the past 10 years. Russia's contribution to the world's scientific space cannot be comprehensively evaluated by analyzing only the global base of scientific publications. For example, some studies cannot be published due to being classified.

IV. CONCLUSION

In an economy where knowledge is the dominant resource, science transforms into a direct productive force, a fundamental production factor. The country's scientific development has for the last few years been a priority of public policies, as Russia has begun to make a considerable contribution to the global scientific space from the standpoint of indicators accepted in Russia and worldwide. Research and educational institutions are building up their publication activity and publish papers that the scientific community finds relevant and useful, a fact suggested by the citation dynamics. Fundamental research is fundamental to future applied research and commercial production. These trends mainly manifest themselves in the economic growth of a number of technology-intensive high-tech industries such as aerospace industry, missile production, nuclear energy, etc. The accumulated scientific and technological potential may considerably boost the country's knowledge economy shall the government effect an appropriate economic, industrial, and scientific policy. Meanwhile, joint efforts and scientific dialog enable a rather quick transition to the knowledge economy.

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