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The Competitiveness of Scientific Research and Measures to Increase It

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Abstract—In this paper, the consideration of the problem of the competitiveness of scientific research as an independent scientific line in the context of the science of science, whose main methodological instruments could be the adapted economic concepts of competitiveness and clusters, as well as mathematical models of competitive interactions (including models described in the terms and equations of population dynamics) and the methods of scientometric analysis, is proposed. It is shown that solution of the problem of increasing the competitiveness of post-Soviet scientific research falls within the domains of information communication. In addition, the role of the international movement for public access to scientific knowledge in increasing the competitiveness of scientific research is considered.

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Despite that fact that governments bear the responsibility for the level of scientific research and almost entirely finance fundamental research in their countries, well developed and interconnected global markets of scientific research, mental labor (researchers), large research infrastructures, scientific periodicals, and training programs for scientists exist. Since competitiveness also exists, the notion of the competitiveness of the particular objects and agents that compete in these scientific markets can be introduced. For indices of their competitiveness, we can take various ratings (competitiveness indices) represented by publication and patent activity, citation frequency, the impact factors of journals, etc.

The competitiveness of fields and lines of scientific research, which are closely connected with the dynamics of scientific frontiers and clusters of publications, should be distinguished from the competitiveness of particular studies represented by the citation frequency of corresponding publications. For example, the high competitiveness of medicobiologic investigations as a whole, as well as of studies in the field of nanosciences and information communication technologies is evident today all over the world. This is represented by a rapid growth in the number of papers and, consequently, of the journals of these types as well, and their frequent citation; i.e., these fields and lines of investigations are characterized by rapidly developing scientific frontiers and clusters of publications. At the same time, other fields and lines of investigations, in which no scientific breakthroughs take place for long periods, come into the stage of "satiation" in accordance with the logarithmic model of growth and later also enter into the stage of "dying," in accordance with the economic concept of a life cycle. Short life cycles of scientific research are typical for marginal and deadlocked fields and lines. We take the term marginal to mean fields and lines of investigations that are conducted apart from the context of the worldwide tendencies for developing these fields, and without regard for accumulated scientific knowledge, although in some cases such investigations can involve scientific breakthroughs and discoveries, especially if they are made by extraordinary researchers.

Naturally, the continuous processes of knowledge specialization and differentiation also bring about processes of their synthesis, or interdisciplinary knowledge. It is well known that scientific breakthroughs and discoveries take place, mainly, at the boundaries of science. Examples of such interdisciplinary knowledge are synergetics, nanosciences, ecology, etc.

Quantitatively, each field and line of scientific research is described by its cluster of publications, in which a kernel (works that laid the foundation for this cluster) and the subsequent most frequently cited works can be specified. The more extensive a cluster of publications is, the more developed and competitive is a given field or line of investigation. This competitiveness is represented by better opportunities to obtain additional financial support and researchers from other (less competitive) fields and lines of investigations, as well as attracting university graduates that are just beginning their scientific research.

It is reasonable that the problem of competitiveness of scientific research can itself be a particular line of scientific investigation in the context of the science of science. For its basic methodological instruments, the adapted economic concepts of competitiveness and clusters [1, 2]; the mathematical models of competitive interactions, including models described in the terms and equations of population dynamics [3, 4]; and the methods of scientometric analysis [5, 6] can be used.

In studies of the competitiveness of any subject, process, or system, it should be kept in mind that these operate with the simultaneous processes of both competitiveness and cooperation; here, if the first process is intensified, the second one is intensified as well. For example, in economics, we understand the well-studied processes of amalgamation and incorporation of competitive firms and companies in the market. As a response to defiance of globalization and competitiveness from the USA and Japan, Europe is following the path of constructing the European Research Area. Predicting a future of European international scientific cooperation, experts of the Eurocommission have recommended this path to the countries of Latin America, Maghreb, Mashrek, Subsaharian Africa, and the Community of Independent States in the context of the experience of Sixth Framework Program of the European Community for Research Technology Development and Demonstration Activities (FP6) [7]. We destroyed the powerful scientific area early in the 1990s and now make no efforts to reconstruct it by applying other principles; in doing so, we undermine the competitiveness of post-Soviet scientific research as a whole. In this connection, note that the charitable activity of an international scientific foundation, the Soros Foundation, in the 1990s in the post-Soviet scientific area was a boon for particular scientists and increased their competitiveness, but, actually, was aimed at undermining the competitiveness of the whole of post-Soviet science.

When discussing the subject of competitive scientific research, it is necessary to identify it somehow. We take the term *competitive research* to mean research, whose results are published in internationally recognized scientific journals that are included in the databases of the Institute for Scientific Information of the USA [8], which determines the indices of the competitiveness (or the rating) of publications, the citation frequency, and journals' impact factors.

Next it is necessary to organize regular monitoring of such research. In the mid-1990s, a complete database on post-Soviet scientific research was generated by the Soros Foundation, which supported post-Soviet scientists in the context of a program of urgent help (grants of $500, which were given if publications in journals having impact factors were available). However, this database is inaccessible to us. The Sixth European Program ended, and we again do not have direct access to information on the post-Soviet scientific teams that took part in network consortiums with European partners. Using the capabilities of the CORDIS (Community Research and Development Information Service) online communication platform, we collected a portion of the information on projects in which Ukrainian and Russian partners took part during FP4–FP6 in order to identify scientific frontiers and centers of scientific superiority [9].

But this was only a small part (no more than 20–30%) of the Ukrainian and Russian participation in projects of the Framework Programs of the European Community for Research Technological Development and Demonstration Activities. Recently, FP7 started, and we may find ourselves in the same situation, without information on those concerned with advanced and competitive scientific research. Monitoring of such research could be taken up by official national, regional, and subject contact points for connections with the FP7 for post-Soviet countries.

Many post-Soviet investigations have been made in the context of preparing dissertations. The increase in their competitiveness was severely retarded by the absence of the lists of foreign journals in which publications are made when candidates for academic degrees defend their dissertations. Finally, in late 2006, on the web site of the Higher Attestation Commission of Russia the first list of this kind was presented; however, it ignored the very nonuniform distribution of journals in the *SCI* database of the Institute for Scientific Information of the USA by fields and lines of scientific research and, consequently, also by their impact factors (IFs). But well before this list appeared, Valentina Markusova, a leading Russian specialist in the work with databases of this institute, noted directly in a *Poisk* paper (in a discussion of the disciplinary nonuniformity of investigations) that in the *Journal Citation Report* database of 2005, among 6086 journals (just those included in the *SCI* database) 50 journals have an impact factor in the range from 14.325 to 49.794. Among these 50, only three journals are unrelated to the field of life sciences[10].

When the creators of the list of the Higher Attestation Commission (HAC) of Russia "cut off" the list of journals included in the *SCI* database at the IF value ≥ 6, then the list includes 1379 journals, of which only 74%, according to our estimate, are related to life sciences. This creates unequal conditions for publications in all other fields of science. But publication of this list of highly rated journals is of great interest to wide scientific circles, which perform research in the field of natural, exact, and technical sciences, since with such a list one can judge the features of competitive investigations and basic scientific frontiers. In this list, e.g., about 50 journals in the field of cellular medicine and biology (with the *Cell* keyword) and about 30 journals, without regard for oncological journals (with the *Oncology* and *Oncological* keywords), are devoted to cancer investigations (with the *Cancer* keyword); the same number of journals are devoted to clinical studies in various fields of medicine and about 40 journals describe medicogenetic investigations. A large number of journals are related to pharmacology and pharmaceutics (approximately 15 journals with the *Drug* keyword only). At the same time, very few journals are devoted to prophylactic medicine and the scientific foundations of a healthy life style, but this is just another topic of discussion related to the policies of transnational corporations and, consequently, large amounts of money.

Returning to the initial goal, which was advanced with the making of the list in question, we present the basic justified alternatives that are possible upon its creation. In the ideal case, it is best for any post-Soviet HAC to make a decision recognizing all papers published in the *SCI*, *SSCI*, and *A&HCI* databases of the Institute for Scientific Information of the USA (lists of these papers are presented for public access on the website of this institute: http://www.isinet.com) regarding all candidates of academic degrees. And this will be justified (in view of the high scientific level of all 9000 journals included in these databases), largely owing to the double anonymous reviewing of papers by leading scientists in the corresponding fields [8].

In this case, the necessity of annually correcting this list is avoided, since the impact factor of journals is a rather variable index.

And if one follows the path of the Higher Attestation Commission of Russia and assigns threshold values of the IF, then this threshold for the *SCI* database must be decreased from 6 to the level of the IF values of the Russian academic journals included in this database; on the average, these values are 0.5–0.6 [11]. Note that the *SCI* database traditionally includes about 100 Russian and no more than 10 Ukrainian scientific journals. Analogous threshold values must also be assigned for the two other databases, in view of their smaller sizes (the *SSCI* and *A&HCI* databases include about 2000 and 1000 journals, respectively) and the range of IF variations.

But now the problem must consist not in the identification of journals that were already recognized by the worldwide scientific community long ago, but in stimulating the publication of post-Soviet scientists in them. It is known that in developed countries the salary of academic workers depends on their publication activity and the quality of publications, which is defined by the ratings (the IFs) of the corresponding journals. Many of us know the slogan "Publish or perish" [12]. This path is also followed by ambitious developing countries (Turkey, Iran, China, etc.), which have elaborated their own bonus schemes [8, 13–15]. For example, in Turkey the bonus for a publication in an internationally recognized journal ranges from $100 to $300 depending on the journal [13]. Iran, owing to the stimulating publication policy of its Science, Research, and Technology Ministry [14, 15], by our estimates, must already have overtaken Ukraine for the number of SCI publications (about 3000 such publications in a year), while China as early as 1995 overtook India (10000—12000 SCI-publications), which has always had many of its own English-language journals and good scientific traditions created by Great Britain [16].

In the mean, Russia produces about 25000 SCI-publications per year. In this case, by our estimates, half of these are represented by publications in the journals of the Russian Academy of Science, which are given for translating abroad and for which royalties are paid [8]. If we extend the bonus scheme to the remaining 12500 SCI-publications at a rate of $200 per paper, we obtain $2500000 per year. On the Russian scale, this is a very small sum. On the basis of data on the dynamics of increasing the number of SCI-publications in countries that introduced stimulating bonus schemes [14, 16], it can be concluded that upon introducing a Russian bonus scheme at the state level, within 3 or 4 years Russia can become one of worldwide leaders in publication activity, by going from 8th to 2nd place (with a general publication activity at the level of 75000–80000 publications per year).

Now, let us talk about the Russian scientific journals recommended by the HAC of Russia. Compared to the previous list, the new one is somewhat shorter, but along with weak journals, well-known journals of high quality also vanished from it. For example, this occurred to all three journals of VINITI (the All-Russia Institute for Scientific and Technical Information of Russian Academy of Sciences), some of which are translated in the USA: *Nauchno-Tekhnicheskaya Informatsiya, ser. 1. Organizatsiya i Metodika Informatsionnoi Raboty* as well as *Nauchno-Tekhnicheskaya Informatsiya, ser. 2. Informatsionnye Protsessy i Sistemy* and *Mezhdunarodnyi Forum po Informatsii.* Here, these journals are leading ones in the field of scientific information processes and systems in the entire post-Soviet scientific information area. "Ekonomist," a very old Russian economic journal, is also absent in this list. The same is true for several other journals. At the same time, this list includes a rich variety of the "Vestnik" journals of provincial universities, which publish the papers, mainly, of their scientific workers and lecturers. These journals are not widely extended beyond their regions, even though they have subscription indices. However, conceptually, candidates for academic degrees must have an all-Russian scientific publication tribune. Therefore, it is necessary to make an accurate list of the criteria for recommendation of journals by the HAC of Russia. The major problems here are connected with the absence or the formalities of the procedures for reviewing publications and payment for them. We have noticed a positive tendency where journals' editorial boards that respect themselves do not care about a HAC recommendation and even take no interest in it, since it eventually brings a large number of frankly poor aspirant papers, which are written only in view of necessity, not in view of the quest of their authors to make a contribution to science.

To increase the competitiveness of post-Soviet scientific research, in addition to the introduction of stimulating schemes of bonuses for publications in internationally recognized journals, it is necessary to intensify the mutual publication activity of scientists from countries of the former USSR. For this purpose, it is primarily necessary to mutually recognize the national lists of journals recommended by the HAC.

An important part in increasing the competitiveness and the attractiveness of national scientific systems is played by the large research infrastructure, which we know as the network of scientific centers for collective use. In Europe, plans to allot 17000000000 in the context of FP7 in order to develop this infrastructure have been made [17]. Recently, the European Strategy Forum on Research Infrastructures published the European Roadmap for Research Infrastructures, in which 35 infrastructural projects, were presented, whose total cost is more than 13000000000 (http://cordis.europa.eu/esfri; http://cordis.europa.eu/infrastructures) [17].

The research infrastructure is a critical element in creating scientific superiority and enlisting world-class scientists and, consequently, has a profound effect on the competitiveness of scientific research and national scientific systems in countries that have this infrastructure.

Interesting discussions about the competitiveness of scientific research and reforming the scientific system are conducted in Ukraine on the pages of the "Zerkalo Nedeli" sociopolitical paper. Here, the opinions and interests of representatives of the traditional academic elite, on the one hand, and young scientists, who advocate integrating Ukraine into the worldwide scientific area, on the other hand, clash. The opinion of the young scientists was well expressed by biologist Aleksandr Demchenko. To the statement by local candidates for academic degrees that "national publications are necessary to defend dissertations" he answers "In the present situation with national journals, both dissertations and publications come to one common information–grave. Only if the level of journals will become higher will the form of dissertations widely used on the West be possible. Thus, a dissertation is comprised of one's published works, to which a candidate for a degree adds only an extended review of the literature (to demonstrate his erudition), a general discussion, and conclusions, where his own contribution is noted" [13].

This is one more possible line of activity for any post-Soviet Higher Attestation Commission: bringing the quality of Russian journals to the mean level of foreign ones at the cost of introducing universally accepted scientific standards for such journals, including (and this is the main thing) standards for the scientific review of papers. But this can be efficiently done only after recognizing all foreign and "convertible" journals on the lists of the HAC and stimulating the publication of post-Soviet scientists in them, as well as after the wide introduction of Russian citation indices (the Russian Science Citation Index and the index of Russian Foundation for Basic Research).

Note that great prospects for increasing the competitiveness of scientific research are opened by the new paradigm of public access to scientific and humanitarian knowledge and the particular instruments of this paradigm, namely, institutional electronic archives (repositories and libraries) of public access to scientific publications and online scientific public-access journals. In the context of the international movement for the public access to scientific and humanitarian knowledge, the traditional system of scientific communication is changing progressively to a hybrid one, in which the importance of the online component constantly increases. Here, in online scientific journals as well as in traditional ones, much attention is given to scientific review, on which all scientific systems have depended since the mid-seventeenth century.

At the same time, the Internet provides a means for public access to the results in scientific publications without any regulation based on scientific review and the approval of scientific results on the part of the editorial boards of journals. This will also have revolutionary consequences in the immediate future. Extraordinary researchers, who understand these opportunities, are entirely freed from any pressure and regulation of their activity on the part of employers, publishers, journal editorial boards, and reviewers; they have a right to present their work on the Internet and receive immediate recognition, without haunting the thresholds of journal and book editorial boards, as it was quite recently. If formerly it was often impossible to publish extraordinary works that did not fit an existing scientific paradigm or theory, or met with opposition on the part of existing scientific schools and groups, then now these obstacles are entirely removed owing to the "internetization" of science. Here, a prominent example is the activity of Russian mathematician Grigorii Perel'man, who refused the traditional method of accepting the results of his work and presented his unreviewed mathematical work containing proof of the Poinckaré theorem in the OA-archive of preliminary works (preprints) on the server of the Los Alamos Scientific Laboratory. On August 22, 2006, this work was awarded the highest mathematical prize (the Fields Medal).

In this connection, academician V.N. Strakhov recently noted that "the science of the early twenty-first century is a destruction of the predominant stereotypes of mentality plus 'sitization' of all scientific research" (http://rfbr.uipe.ru/pdf/1-01o.pdf).

Thus, we can conclude that intellectuals in the epoch of globalization, despite its unifying and equalizing character in relation to creative and educational activity, have increased in importance as never before. Now, they can be independent "globalized players" and influence international processes in the intellectual sphere; for this purpose, they need nothing except a computer and the Internet.

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