TRAMES, 2014, **18**(**68/63**), 4, 345–356

THE IMPORTANCE OF BIBLIOMETRIC INDICATORS FOR THE ANALYSIS OF RESEARCH PERFORMANCE IN GEORGIA

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Abstract. The present analysis of research productivity of scholars in Georgia was motivated by the disadvantageous position of Georgia in international listings of the most cited scientific articles. We used official databases provided by governmental Shota Rustaveli National Scientific Foundation (SRNSF) from 2007 to 2013. In this research we have restricted our analysis by the consideration of bibliometric indicators of the leaders of the awarded projects. Three bibliometric characteristics: the number of publications and citations, as well as H-index of project leaders was obtained from SCOPUS database. According to our results, just 58% of all leaders of awarded projects in SRNSF grant competition, have an article (at least one) in the Scopus database for the entire period of their scholarly activity. From our analysis it follows that the quality of reviewing of the projects, presented to the SRNSF grant competition, does not promote a selection of the most productive project teams; there is no correlation between values of SRNSF reviewer's evaluation scores and the bibliometric data of project leaders in the Scopus database. As a result, in 2007–2012 in spite of large enough (for Georgia) funding, the problem of the low productivity and quality of scientific research in Georgia has not been resolved. We conclude that, in order to improve the situation with the low productivity of research in Georgia, the governmental programs of science support should be based on the new system of evaluation of the quality of presented projects; namely, peer-review approach should be combined with the bibliometric methodology. Besides local interest, for Georgian researchers and governmental authorities, the results of presented research have general importance in the light of ongoing international discussions about the necessity of inclusion of bibliometric data in evaluation procedures of research productivity. Presented results and discussions will be especially helpful for scholars and research administrators from countries in transition and could facilitate in elaboration of effective research funding policy.

Keywords: bibliometrics, Scopus, H-index, research productivity

DOI: 10.3176/tr.2014.4.03

1. Introduction

It is well known that scientific advance is the basis for the economic and cultural development of a country. Therefore objective evaluation of the quality of research activity of scholars, scientific and educational institutions acquires utmost importance among other characteristics necessary to understand a country's present position and its possible future development (Moed 2005, Allik 2008).

At the same time, it is necessary to emphasize that the level of scientific progress of the country cannot be estimated simply by the number of people involved in scientific work or by the total of financial funds allocated by the government for the research purposes.

According to contemporary scientometric and bibliometric concepts, the main indicator of a country's scientific advance is the number and quality of research works published in leading scientific journals (May 1997, Valencia 2004). Based on these publications, different quantitative characteristics of scientific research productivity, e.g. bibliometric indexes, can be calculated. These indexes are based on counting the number of articles and citations in peer-reviewed international scientific journals. It should be pointed out here that although discussions about the reliability of certain bibliometric indexes are still continuing, practically no one contests that the productivity of scientific research should be evaluated through the analysis of the amount and quality of publications as well as corresponding citation data (Aksnes 2004, Abramo et al. 2008 2009, 2011, Chirici 2012).

At present, in many countries around the globe, the importance of evaluating scientific research performance is well recognized. Such data about scientific research productivity helps governmental decision-makers to build long-term strategic plans, answer questions about which research directions should be built in future or which ongoing research activity should be supported in accordance with the economic and political objectives of a country. Moreover, such bibliometric analyses are necessary to understand the country's position relative to global and domestic standards of research quality and production. From this point of view it is understandable why such analysis are carried out not only in leading economically developed countries, but also in many relatively poorer developing countries as well as countries with transitional economy (Allik 2003 2008, Wolszczak-Derlacz and Parteka 2010, Hammouti 2010, Suleymenov et al. 2011). Indeed, governmental funding of research in countries with enormous social, economic or political challenges and restricted amount of available resources should be highly effective, which cannot be achieved without correct bibliometric analyses.

For the last decade the evaluation of the productivity of scientific research become common practice in former soviet republics (Allik 2003, 2008, 2013, Suleymenov et al. 2011). Georgia is one of such post-Soviet country with transitional economy. As it follows from the Scopus-Scimago ranking, Georgia is in the ninth ten of the international list of productivity of scientific researches. According

to bibliometric indicators, the quality and influence of Georgian scientific research are generally low compared to the majority of former soviet bloc countries and many developing countries. Information contained in the Scopus-Elsevier publications database indicates that articles of authors claiming affiliation in Georgian research organizations rarely appear in internationally recognized journals and the number of citations is rather low (a clear indication of this situation was presented recently by J. Allik (2013) showing that Georgia is among 65 out of the analyzed 148 countries, which does not meet certain criteria of scientific productivity during the last decade). Against this background the objective assessment of scientific productivity of Georgian research institutes, universities and scholars acquires special importance. It is worth mentioning here that our research is the first case of the purposeful analysis, based on reliable official data of the productivity of scientific research carried out in Georgia. By this research we aimed to take the first step to fill the existing gap and present the results of analysis of the productivity of research works based on databases kindly provided by the Shota Rustaveli National Scientific Foundation, the sole governmental research funding organization in Georgia.

2. Methods and used data

As mentioned in the previous section, this work is based on data obtained from the databases of the Shota Rustaveli National Scientific Foundation (SRNSF). The Georgian National Research Foundation was established in 2005, what was definitely progressive step toward developing of Georgian science. Till present, 6 national grant competitions have been organized. Among other useful things the SRNSF has done for Georgian science, it is necessary to emphasize the creation of reliable databases about the awarded scientists, presented grants and the amount of financing of projects. Only after the creation of these databases it became possible to competently analyze the efficiency of governmental support of science and assess the productivity of conducted scientific researches in Georgia.

Information about the leaders of projects, which were funded from 2007 to 2012 within the mentioned research grant competitions, was provided by SRNSF in response to our official request. This information included full names of the awarded project leaders, their affiliations, titles of projects, mean reviewers' evaluation scores to project and the total amount of funding allocated for each (1–3 year duration) project in English.

As mentioned above, according to the present views, the productivity of scientific research should be assessed by the number of articles published in the recognized international peer-reviewed journals and citations on them.

Comprehensive information about publications in such journals and citations presently can be found in three main databases: Web of Science of Thomson Reuters, Elsevier SciVerse SCOPUS and Google Scholar. These are the most respected databases where the main application is the calculation of the scientific

relevance of scholarly journals and evaluation of scientific productivity of scholars and/or research organizations. Web of Science of Thomson Reuters still remains as the main source of bibliographic information but according to literature this and the SCOPUS database, for the time period of our interests, provide qualitatively almost similar citation results (though it is understandable that quantitatively the results concerning the ranking of individual scientists may differ) (Aksnes and Taxt 2004, Meho and Yang 2007, Mikki 2010, Chirichi 2012). Thus, like many other authors of bibliometric research works published in recent years, we used SCOPUS database for the present analysis (e.g. Meho and Yang 2007, Abramo and D'Angelo 2011, Chirici 2012). The above discussed information on the international ranking of countries, according to their scientific productivity, was also obtained from the affiliated to Scopus, Scimago system.

According to the common practice in scientomtric analysis, in order to assess scientific productivity of Georgian scientists, the leaders of projects funded by SRNSF for the last 6 years, we used three bibliometric indexes: The exact number of publications, the number of citations, and h-index values of leaders of awarded projects have been found in Scopus.

Thus we compared two groups of Georgian scientists, the leaders of awarded SRNSF projects, those who have at least one article indexed in Scopus for the entire period of scientific activity and those who do not have such publications. The total number of awarded projects, the amount of allocated funding, mentioned above three bibliometric indexes and reviewers evaluation scores have been used for analysis.

The performed methods of analysis included standard statistical procedures, linear correlation calculation, significance testing, testing of fitting quality and types of probability distributions.

3. Results and discussion

As we pointed out above, the governmental Shota Rustaveli National Scientific Foundation is practically the only domestic source from which Georgian scientists may get funding for their research works on competitive basis. The annual amount of funding, allocated by the government of Georgia for the SRNSF grant competitions in 2007–2012 was not constant. The annual amount of available funding (i.e. the total amount of money allocated for awarded projects with 1–3 year duration) varied from about 7 to 24 million Lari (1GEL equals approx. 0.62 USD).

In order to speak about the research productivity and effectiveness of funding we needed to establish to what extent the published works of leaders of projects funded by SRNSF, are presented in international scientific information databases (here Scopus). For this purpose we grouped the projects according to information on articles of the project leaders found in the Scopus database. The projects whose leaders have at least one published article found in Scopus by the end of the year 2013, were selected for further analysis of productivity of scientific research. This

was done in accordance with the accepted scientometric conception that authors without articles in international scientific databases, are regarded as having "zero productivity" (Yang et al. 2013).

We found that in 2007–2012 just only 58.4% of total budgetary funding, allocated for the 5 consecutive SRNSF grant competitions, has been spent on projects whose leaders had at least one article found in the Scopus database. The percentage of project leaders who have articles in the Scopus database (by the end of year 2013) for the entire period of scholarly activity, varied approximately in range of 35–49% for different years of observation.

This certainly points to a serious problem in the policy of selection of research groups for the governmental programs of support of science in Georgia in 2007–2012, as well as confirm that as mentioned above, the low productivity of Georgian science according to international databases is unfortunately true.

A large number of awarded projects, whose authors neither before, nor after receiving a grant, have never published articles in the peer-reviewed journals indexed in Scopus, has to have some explanation.

In general it is understandable that the organization of grant competitions always is a complex process, the outcomes of which may be influenced by many different causes. In the case of SRNSF grant competitions, among others, two possible causes come to mind when thinking about such high percentage of the funded projects that are unproductive from the scientific point of view. These causes may be: 1) possible incomplete coverage in the Scopus of research topics of the projects funded by SRNSF and 2) above-mentioned problems of peer reviewing and criteria for selecting successful projects. Let us discuss these issues in more detail.

We start with the question of research topics coverage in Scopus. It follows from a brief overview of special literature that incomplete coverage of certain fields of science in international databases, including Scopus, is often the subject of discussions among researchers and specialists in bibliometrics (e.g. Glänzel 2006, Chirici 2011, Yang, et al. 2013). Therefore, it cannot be excluded that the poor coverage of certain research topics, which are specific for Georgia (e.g. works written in Georgian about Georgian language or literature) may indeed cause some decrease of the level of calculated research productivity when assessing by the total number of articles included in Scopus database (especially taking into account that in this work we have considered all awarded projects in all research areas covered by SRNSF).

At the same time if we recall that our grouping principle was very simple (at least one article in the Scopus database for the entire duration of the project leader's scholarly activity), it seems unlikely that an incomplete coverage may be the sole explanation for the absence of the scientific productivity in 35–49% of awarded projects.

Indeed out of 8, SRNSF scientific research directions (1. Georgian Studies 2. Humanities, Economic and Social Sciences, 3. Mathematics, Mechanics, Telecommunication, IT, 4. Natural Sciences, 5. Earth Sciences and Environment,

6. Life and Medical Sciences, 7. Engineering Sciences, High-Tech Materials, 8. Agricultural Sciences) and about 250 sub-directions, just one direction, Georgian Studies, and its 2–3 sub-directions (e.g. History of Georgia, Georgian Literature, Kartvelian Languages) can be regarded as country-specific. Thus, even if we assume that research works in these subdirections may not be in the scope of thousands of scientific journals indexed in international databases (which sounds scientifically incorrect), it remains unclear why the results of works funded by the SRNSF, in 7 out of the mentioned 8 research directions (which are at least partly covered in Scopus) could not be generalized as scientific articles and submitted for peer-reviewing in the international journals. Let us point out here again that we speak about the overall scientific productivity of project leaders for the entire period of research activity, evaluated by the end of 2013.

Moreover, even if we exclude research direction 1(Georgian Studies) from our analysis, the share of the unproductive projects still exceeds 35%.

We cannot thus accept the supposition that all problems of low scientific productivity of works funded by SRNSF grants for last years, can really be explained just by the poor coverage of some research topics in the Scopus database. At the same time we realize that in any case the question of the research productivity according to scientific directions of the SRNSF grant competition, deserves to be carefully investigated; such analysis is presently underway.

Let us now proceed to the consideration of a question of the quality of reviewing of projects, winners of SRNSF grant competitions. We look at this question in the light of its possible relation with a large number of unproductive researches, which do not lead to the outcome in the form of scientific articles that could be published in the journals indexed in the Scopus list.

For this analysis we excluded projects, the leaders of which have no published articles found in the Scopus database by the end of 2013. We considered only those projects (390 out of 667 in total) whose leaders have at least one article found in the Scopus database. Accepting the well-known view that H-index is a "good tool to quantify an individual's scientific research output" (Hirsh 2005), we have ranked projects according to H index values of their leaders. One important thing from this ranking is that the top two scientists, residents of Georgia, have H = 27, H = 16 and next two H = 15. These are quite good values of H indexes taking into consideration that according to B. Hammouti (2010), in bigger countries than Georgia, such as Tunisia, Morocco and Algeria, the leading resident scientists have H = 12, H = 21 and H = 17 respectively. This is significant because the mentioned countries hold much higher positions than Georgia in the SJR ranking list. Besides, according to J. Allik (2013), unlike Georgia, these three countries are among 82 countries with the highest value of High-quality Scientific Index.

This undoubtedly indicates that the scientific potential of Georgian researchers is quite good, which is in complete contradiction with the present position of the country in international scientific databases.

On the other hand, the poor position of Georgia regarding research productivity is further confirmed by the fact that 30% of awarded leaders, out of all project leaders found in the Scopus (390 in total), have no cited articles (H = 0, including self-citations). 18 % of project leaders have $H \geq 5$, and 5% have $H \geq 10$, out of 273 which have at least 1 citation in Scopus. Strong difference in H index values between top level scientists and the majority of leaders of awarded SRNSF projects is obvious. Thus it is not surprising that the decrease in H index values of awarded project leaders is well described by power law function of type $y = ax^p + b$ (coeff. of determination, $R^2 = 0.95$).

As mentioned above, H-index is regarded among the best quantitative indicators of individual scientific productivity (Hirsh 2005, Hammouti 2010, Abramo and D'Angelo 2011). Therefore, it was quite expected that project leaders with higher H index values should be more productive, i.e. have more articles published in peer- reviewed journals, as well as more citations in Scopus database. Indeed, we saw that the number of articles found in Scopus authored by project leaders with lower values of H, decreased more than by one order (though here this relation is not described by power-law function). In any case, the decreasing trend is well visible and is statistically significant according to Mann-Kendall test (confidence coefficient = 0.95). Decrease in the number of citations according to the decrease of H indexes looks much more impressive. As it follows from Fig. 1, the number of citations decreases more than by two orders for projects whose leaders have lower H index values, comparing to leaders with higher H indexes. Relations presented in Fig. 1, are also well described by the power law function, coeff. of determination, $R^2 = 0.89$. It is quite understandable that this obvious decrease is statistically significant (by Mann-Kendall test, the confidence coefficient equals 0.95).

The results of our analysis presented in Fig. 1 were expected in the light of accepted views about the importance and informativity of H-index, as well as count of articles and citations for evaluation of research productivity.

Meanwhile, these results are very important because the original data of SRNSF grant competitions once again proves the well-known rule that scientists

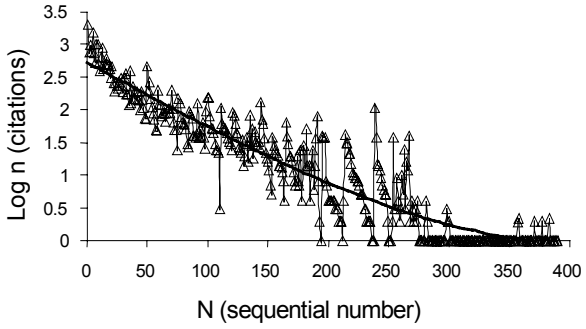

Figure 1. Log of citations of project leaders vs. their sequential numbers ranked by H index.

with better bibliometric indicators are more productive. Therefore it becomes clear that in order to improve a situation with low productivity of scientific works in Georgia, the selection criteria of grant competitions should unequivocally be based on the accounting of bibliometric characteristics of research team members. This is in complete accordance with recent views presented in international bibliometric and scientometric literature (see e.g. Aksnes et al. 2004, Abramo et al. 2008, 2011, Chirici 2012). Such selection criteria, based on bibliometric data, will increase chances that the members of awarded project teams will be able to better organize research work, plan and carry out reliable observations and experiments, analyze data in the most reliable way, generalize results and finally prepare the final product of research – a research article in accordance with accepted worldwide standards.

Here we of course do not claim that the relationship between the quality of projects and scientific productivity (or bibliometric characteristics) of their authors may be linear or that such relationship can be assessed on the individual level. We just say that between the quality of projects presented to the grant competition and the competence of their authors, expressed through their bibliometric characteristics of scientific productivity, there should be some correlation, quantifiable for statistically large enough sampling. The opposite statement would be in contradiction with common sense and scientific experience of mankind.

In our analysis we had a large enough sampling of 390 projects, whose authors have articles in Scopus database, and we suggested that the correlation between scientific productivity of project leaders and the quality of projects can be observed in the data sets of SRNSF grant competitions.

To investigate such dependence it is necessary to first say that the quality of the projects presented at the grant competitions SRNSF is estimated according to evaluation scores of domestic and international independent referees. Therefore, we need to find out whether there is any correlation between scientific productivity (assessed through the number of published articles, the number of citations and H index values) of awarded project leaders and the mean evaluation scores of independent referees. For this we ranked evaluation scores according to H-index values of project leaders.

As it follows from Fig. 2, the values of the mean evaluation scores do not reveal any significantly decreasing trend contrary to what was found above for bibliometric characteristics of authors with a lower scientific productivity. Furthermore, there is no correlation between the mean evaluation scores and features of scientific productivity (number of articles, citations, H-index values) of project leaders.

At first glance, the absence of dependence between reviewers' evaluation and project leaders' bibliographic data can be regarded as an indication that reviewers are completely independent in their decisions and thus their evaluations should be completely objective. At the same time when we consider statistically large enough samplings of the number of project leaders, about 25% of which have by about three order more citations than others (see Fig. 1), the absence of at least a

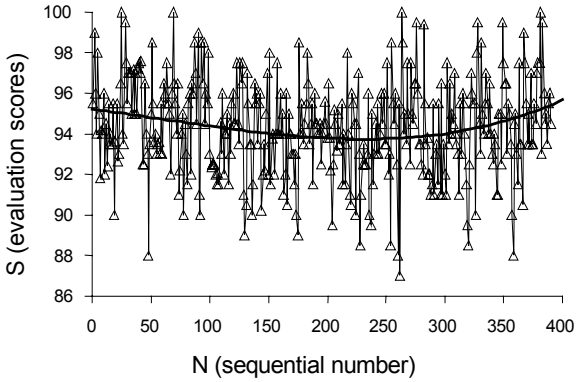

Figure 2. Mean evaluation scores, S, of awarded projects in 2007–2012, whose leaders have at least one article in Scopus database, vs. N, sequential number of project leaders ranked by H index.

weak correlation between reviewers' evaluation scores and bibliometric characteristics of project leaders seems extremely unlikely.

The obtained result is thus in contradiction with the assumption about a possible relation between the quality of projects and the authors' bibliometric information. Meanwhile, as it was underlined above, bibliometric characteristics are understood as a measure of scientific productivity (e.g. Abramo et al. 2008, 2011, Chirici 2012) which encompasses things such as: researchers' working experience, competence, an ability to prepare research articles, etc.

Thus the absence of any relations between the quality of projects and project leaders' scientific productivity is completely illogical. The only solution of such a contradiction is the admission of inadequacy of peer-reviewing in grant competitions of SRNSF.

The current research results clearly show that the inclusion of 'informed peer-reviewing' approach in the SRNSF projects' quality assessment procedures is one of the most pressing and important tasks. There is no doubt that without the use of objective modern approaches for the needs of decision-making in science funding, the goal of the increase of productivity of scientific works and an improvement of the present unsatisfactory situation with the position of Georgia in the international scientific databases, will remain unachievable.

Therefore, our results can be regarded as evidence that the low scientific productivity of the grantees of SRNSF can, among other things, be caused by the low-quality peer-reviewing that leads to the financing of research groups which in a consequence are unproductive (or underproductive). Indeed, we see in Fig. 3 that in spite of spending quite enough budgetary resources, the number of published articles by the SRNSF grantees in 2006–2012 does not reveal any significant increase compared to the situation before funding.

As it follows from international scientometric literature, the problems of the quality of peer- reviewing in assessment of scientific research productivity is not new (e.g. Abramo, D'Angelo 2009, 2011, Mikki 2010). In many countries, the

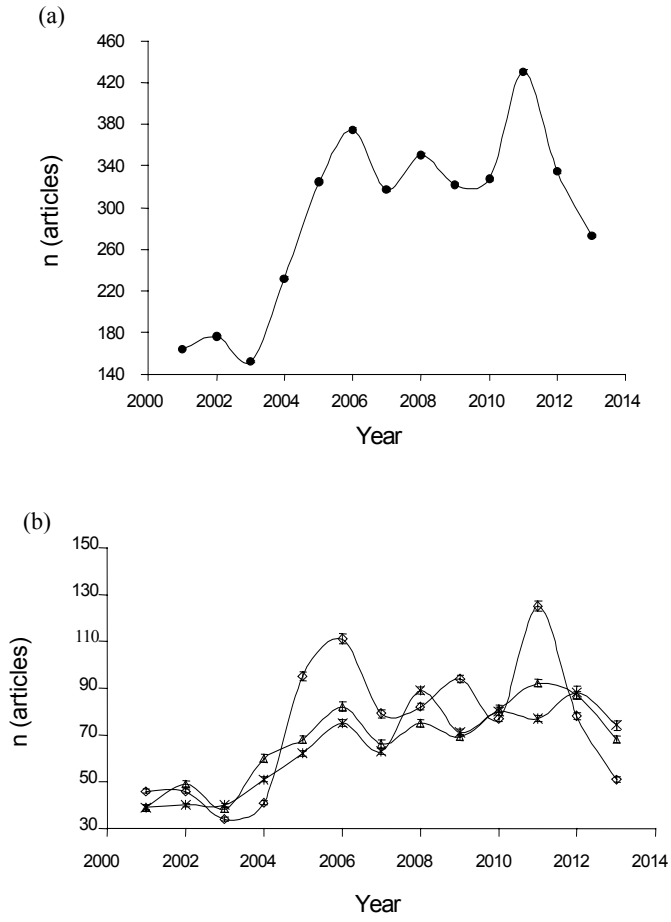

Figure 3. The total of articles published yearly, from 2000 to 2013 by the leaders of projects funded by SRNSF, a) all awarded in 2007–2012 grant competitions project leaders, b) leaders of projects awarded in 2007 (asterisks) 2008 (circles) and 2009 (triangles).

governments pay increasing attention to the development of new approaches, which together with the competent peer-reviewing are based on countable bibliometric characteristics in evaluating personal or institutional research productivity. Such combined scientific productivity evaluation systems are already developed and implemented in many countries, e.g. the Research Excellence Framework (REF) in the UK, the Quinquennial Research Evaluation (VQR) in Italy, the Excellence in Research for Australia initiative (ERA), etc.

All these and similar new approaches finally lead to the so-called 'informed peer-reviewing', which enables to achieve optimal selection of most promising projects through the combination of the peer-review expertise and accounting of the authors' citation information, as well as other quantitative bibliometric indicators (Abramo, D'Angelo, 2011).

Our analysis on the example of Georgia, a country in economical and political transition, shows that the implementation of 'informed peer-reviewing' approach is an important step towards the effective use of governmental resources aimed at increasing the countries' research productivity.

4. Conclusions

The objective of this work was an evaluation of the scientific productivity of the Georgian scientists, leaders of projects, which have been funded from 2007 to 2013 through the governmental research funding agency, SRNSF. We analyzed databases of SRNSF including a list of leaders of the awarded projects, the amount of granted funding and average evaluation scores of independent reviewers. Bibliometric data (such as the number of publications, the number of citations, and h-index) about project leaders has been obtained from the SCOPUS databases.

It was shown that just 58% of funded project leaders have at least one article in the Scopus database for the whole period of scholarly activity. To find some explanation of why 42% of all leaders funded by SRNSF have not been found in Scopus database, we have calculated the relations between referees' scores and bibliometric characteristics of those project leaders who have been found in Scopus. According to the presented results, the project leaders with higher bibliometric indexes (here H index) are capable of carrying out competitive scientific works, which resulted in the published articles in journals indexed in Scopus databases. At the same time it was shown that the reviewers' evaluation scores are completely independent from bibliometric characteristics of the leaders of projects presented to the grant competition. On the basis of the results of our analysis we suggest that in order to resolve the existing problems of low productivity of scientific research in Georgia, as well as in other countries in transition, a selection procedure should combine independent peer-reviewing and bibliometric data analysis at any level of implementing the governmental programs of funding of science.

The results of our analysis have a general importance for countries in transition and will facilitate in the elaboration of effective research funding policy in order to raise the level of a country's research productivity.

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References

Abramo, G., C.A. D'Angelo (2011) "Evaluating research: from informed peer review to bibliometrics". *Scientometrics* 87, 499–514. DOI 10.1007/s11192-011-0352-7

Abramo, G., C. A. D'Angelo, and F. Pugini (2008) "The measurement of Italian Universities' research productivity by a non parametric-bibliometric methodology". *Scientometrics* 76, 2, 225–244.

Abramo, G., C. A. D'Angelo, and A. Caprasecca (2009) "Allocative efficiency in public research funding: can bibliometrics help?". *Research Policy* 38, 1, 206–215.

Aksnes, D. W. and R. E. Taxt (2004) "Peers reviews and bibliometric indicators: a comparative study at Norvegian University". *Research Evaluation* 13, 1, 33–41.

Allik, J. (2003) "The quality of science in Estonia, Latvia, and Lithuania after the first decade of independence". *Trames* 7, 1, 40–52.

Allik, J. (2008) "Quality of Estonian science estimated through bibliometric indicators (1997–2007)". *Proceedings of the Estonian Academy of Sciences* 57, 4, 255–264.

Allik, J. (2013) "Factors affecting bibliometric indicators of scientific quality". *Trames* 17, 3, 199–214.

Chirici, G. (2012) "Assessing the scientific productivity of Italian forest researchers using the Web of Science, SCOPUS and SCIMAGO databases". *iForest* 5, 101–107.

Glänzel, W. (2006) "On the h-index – a mathematical approach to a new measure of publication activity and citation impact". *Scientometrics* 67, 315.

Hammouti, B. (2010) "Comparative bibliometric study of the scientific production in Maghreb countries (Algeria, Morocco and Tunisia) in 1996–2009 using Scopus". *Journal of Materials and Environmental Science* 1, 2, 70–77.

Hirsch, J.E. (2005) "An index to quantify an individual's scientific research output". *Proceedings of the National Academy of Sciences of the United States of America* 102, 46, 16569–16572. doi: 10.1073/pnas.0507655102

Lotka, A.J. (1926) "The frequency distribution of scientific productivity". *Journal of the Washington Academy of Sciences* 16, 12, 317–323.

May, R.M. (1997) "The scientific wealth of nations". *Science* 275, 793–796.

Meho L, Yang K (2007) "Impact of data sources on citation counts and rankings of LIS faculty: Web of Science versus SCOPUS and Google Scholar". *Journal of the American Society for Information Science and Technology* 58, 13, 2105–2125.

Mikki, S. (2010) "Comparing Google Scholar and ISI Web of Science for earth sciences". *Scientometrics* 82, 2, 321–331.

Moed, H. F. (2005) *Citation analysis in research evaluation*. Dordrecht: Springer.

Suleymenov, E., N. Ponomareva, A. Dzhumabekov, T. Kubieva, and G. Kozbagarova (2011) "An assessment of the contributions of Kazakhstan and other CIS countries to global science: the Scopus database". *Scientific and Technical Information Processing* 38, 3, 159–165.

Valencia, M. (2004) "International scientific productivity of selected universities in the Philippines". *Science Diliman* 16, 49–54.

Wolszczak-Derlacz, J. and A. Parteka (2010*) Scientific productivity of public higher education institutions in Poland: a comperative bibliometric analysis*. Warsaw: Sprawne Panstwo.

Yang, J., M.W. Vannier, F. Wang, Y. Deng, F. Ou, J. Bennett, Y. Liu, and G. Wang (2013) "A bibliometric analysis of academic publication and NIH funding". *Journal of Informetrics* 7, 318–324.