Péter Sasvári – Bálint Teleki – Anna Urbanovics

The Opportunities of the Performance-based Publication Model in Hungary

Summary: The performance-based publication model is a direct rewarding system among the scientific community, referring to the reward that authors receive for their publications. The amount of the reward depends on the citation index level of the journal in which a given article is published. Based on international best practices, the paper aims to investigate the possibilities of the implementation of this publication model within the Hungarian context. The model's main advantage is that rewarding takes place at the individual level so its distribution is independent from the institutional level. After reviewing the best practices used in various countries worldwide, an empirical analysis is carried out which is based on the total number of publications in Hungary in 2019 indexed by Scopus. It means a total of 12,281 publications, based on scientometric indicators. Two models are used, model A considers the Hungarian co-authorship rate of the publications while model B takes the amount of the reward into account based on the publication without the co-authorship rate. Results show that in Hungary, the disciplines of Medicine and Engineering are the most competitive at an international level where we find a high proportion of highly indexed Q1 and Q2 publications. Beside these, results demonstrate the dominance of multiple authorship and journal articles in the research sample. As a conclusion, the proposed publication model could be implemented within the Hungarian context, based on the analysis, its estimated cost would be around 6 billion Hungarian forints.

Scientific competitiveness is given more and more attention these days. The states want to promote their own scientific competitiveness through various means and ensure the most successful international and domestic position possible for their institutions and researchers, and from the scope of these means, the excellence programmes should be highlighted, which are developed by the states as national level policies. One special type of these programmes is the direct subsequent financing model, which targets the individual level of researchers. The key point of the model is that instead of providing incentive to entire research workshops and institutions or specific priority topics, the researchers are supported directly from the state budget, based on their titles published. The performance-based financing

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models have become established practices in numerous countries by now, where authors are rewarded for their highly-rated articles, and a kind of motivational score system is built on this by the heads of universities. It is reasonable to compare Hungary to the states of the closest region, therefore we will analyse the policy instruments used in the Czech Republic and Slovakia. The purpose of this paper is to review the opportunities and costs of the performance-based financing model based on the examples of the performance-based financing model used in the Czech Republic, Slovakia and at the University of Public Service, and also on the publication performance of Hungary measured by its Scopus indexed titles in 2019.

THEORETICAL BACKGROUND

Approaches related to the measurement of scientific research effectiveness

The rating ofscientific performance and the classification of researches are increasingly carried out based on the number of articles and citations published in the journals which are considered prestigious based on the so-called impact factor (Csaba et al., 2014).

The Scopus database serves as a data source of numerous evaluation rankings, such as the QS[1] and THE Times[2] international university rankings, which are tools used to measure the competitiveness of higher education institutions. The Scopus database offers a much wider selection of indexed periodicals compared to the Web of Science citation database.

The Scopus database indexes a number of periodicals from our region in the broader and the narrower sense (2,220 journals in total), and this provides the comfort of publishing in local periodicals to the authors and the scientific community of the countries examined. The

degree of indexation of these periodicals has a prominent role in the case of Hungarian authors as well, therefore the possible termination of their inclusion in Scopus would cause a significant loss of publication. In terms of their function, the Scopus and the Web of Science databases are similar databases, however, the Scopus offers a much wider selection of social sciences and arts and humanities periodicals – and conference papers, books, series of books in general – due to heightened pressure by certain international publishing companies. The main priority of the Hungarian institutions is being included in international university rankings in order to maintain and improve their position and competitiveness in the international science community. As we have mentioned briefly above, among these rankings the QS and the THE table rankings are the most common and the most well-known. Both of them have switched to using the Scopus database in recent years, therefore it is reasonable to carry out our analysis around the assessment of the Scopus database.

Excellence programmes

In order to advance in the international university rankings, and in this sense, to improve international competitiveness, the universities and the countries set up a number of incentive systems. A good example for these are the excellence programmes introduced on the government level and operated as single policy programmes, which shift universities from quantity publication to quality publication. This paper discusses the money-per-publication model from among the excellence programmes, which ensures performance-based financing for the titles published. One of the most successful examples of this worldwide is China, owing to which China has caught up to be the second

largest scientific power after the USA. The essence of the model is that a wider scope of researchers can be reached through the performance-based financing, and the rewards payable to the researchers after their published titles has a significant motivation effect on the researchers. The types of remuneration systems are the following (Altbach, 2012).

❶One-price reward: universities pay the same amount to all internationally indexed papers, regardless of where these papers are published.

❷Original JIF-based reward: universities award papers different amounts based on impact factor (JIF) and classification of the journals in which the papers were published. Some universities create categories based on this, while other universities use the impact factor as a multiplier to differentiate the cash reward based on a basic amount.

❸JCR Quartiles-based reward: Universities award papers different amounts based on the JCR Quartile modified by the Chinese Academy of Science.

❹Citation-based reward: universities award papers on the basis of the citations received in a given citation window and pay the rewards accordingly.

When authors are rewarded per title, by now primarily the quality parameters (indexation) are taken into consideration, therefore the publication shifted from quantity to quality, as the publication in indexed journals became conscious. This is the reason why by now the countries prefer using multiplier procedures based on the impact factor or other quality indicators.

Performance-based financing models

The Czech and the Slovak models function similarly to the Chinese model. The financing models used in the two countries have been successful since the introduction thereof, and together with additional science policy instrument they have caused significant results in the improvement of the scientific (especially the publication) performance of the two countries. Before presenting the models, it is important to note that in both the Czech and the Slovak models there are types of pillars which are not particularly related to the publication activity . However, it is beyond doubt that the direct rewarding of the authors has a significant motivational factor in both countries and thus the pillars related to publication are important elements of the performance-based financing models.

In the Czech model, the performance is measured and supported according to the following pillars:

Pillar I: publication results according to discipline categorization , according to a scoring system applicable to each discipline of science. This is complemented by the so-called Subpillar I, which defines the process and method[3] of the *peer review* for selected groups. (Groups mean the different types of scientific works, e.g. articles in periodicals, books, etc.)

Pillar II: each institution shall submit a limited number of the selected results, which will be evaluated both on the national level (Field Verification and Evaluation Panel – OVHP) and the international level (European research Council).

Pillar III: evaluation of patents and non-publication results.

[Government of the Czech Republic, 2012; Government of the Czech Republic, 2016:4; Georgala et al., (2016)]

The pillars of the Slovak model have a similar structure, which are determined by research financing sub-programme No. 077012 (European University Association, 2008):

• assessment related to the quality of the research activities of the given higher-

education institution according to the last complex accreditation (value 0.43);

- the share of the higher education institution in the amount of funds received in last two years within the framework of foreign grant schemes (value 0.10);
- the share of the higher education institution in the volume of funds acquired in last two years for research activities from public-administration bodies, but excluding state programs (value 0.09);
- the share of higher education institution in the volume of transfer-like funds acquired in the last two years for research activities from entities other than public-administration bodies and from foreign entities, excluding grant schemes (value 0.03);
- the share of the higher-education institution in the average number of postgraduate students in full-time doctoral studies after the dissertation examination in the last calendar year (value 0.10);
- the share of the higher-education institution in publishing activities with the use of scales for scientific, research or artistic activities (value 0.225);
- the share of the higher-education institution in artistic creation according to a specific scoring system (value 0.025).

In both models the titles indexed by Scopus and Web of Science were prominent. The key to the success of the models described is the financing structure which was developed differently, where authors are paid from the budget according to their publication activity and per article. The value of the titles is weighted according to their type and the indexation (Scopus/Scimago and Web of Science). The distribution is published in a completely open manner, including an itemized list and verified for everybody. Some authors (Fabián, 2013; Pisár et al., 2019) are sceptical about the Czech results, while the

Slovak results are considered as a success story (Matlovič et al., 2017).

Figure 1 shows the growth in performance achieved through performance-based financing since 2005. This performance-based financing model was introduced first in the Czech Republic in 2005 and then in Slovakia two years later, therefore our ratios are also adjusted to this year. The much steeper growth curves of Slovakia and the Czech Republic stand out, while the Polish and the Hungarian curves fell short. The fact that the Hungarian growth is the last in the comparison of the group of Visegrad countries is rather alarming, since this shows that the Hungarian publication performance is unable to keep up with the growth tendencies of the surrounding countries. As a result, Hungary is unable to maintain its competitiveness and relative position even within the region. This shows continuous and large-scale breakaway to the detriment of the Hungarian performance. As it is represented in the data as well, it is not that the Hungarian performance is not increasing, however, it is not growing as fast as it is observed in the other states of the region.

The assessment of the research-development and scientific potential of Hungary

The study of the National Research, Development and Innovation Office (in Hungarian: Nemzeti Kutatási, Fejlesztési és Innovációs Hivatal; hereinafter referred to as NRDI Office) (NRDI Office, 2019) gives an overview of the innovation and research potential of Hungary in 2019, and it identifies the various development opportunities as well. According to the 2020 evaluation system of the European Innovation Scorecard, Hungary is one of the moderate innovator states among the European Union Member States.

Figure 1

CHANGES IN THE NUMBER OF PUBLICATIONS IN THE GROUP OF VISEGRAD COUNTRIES IN 2019
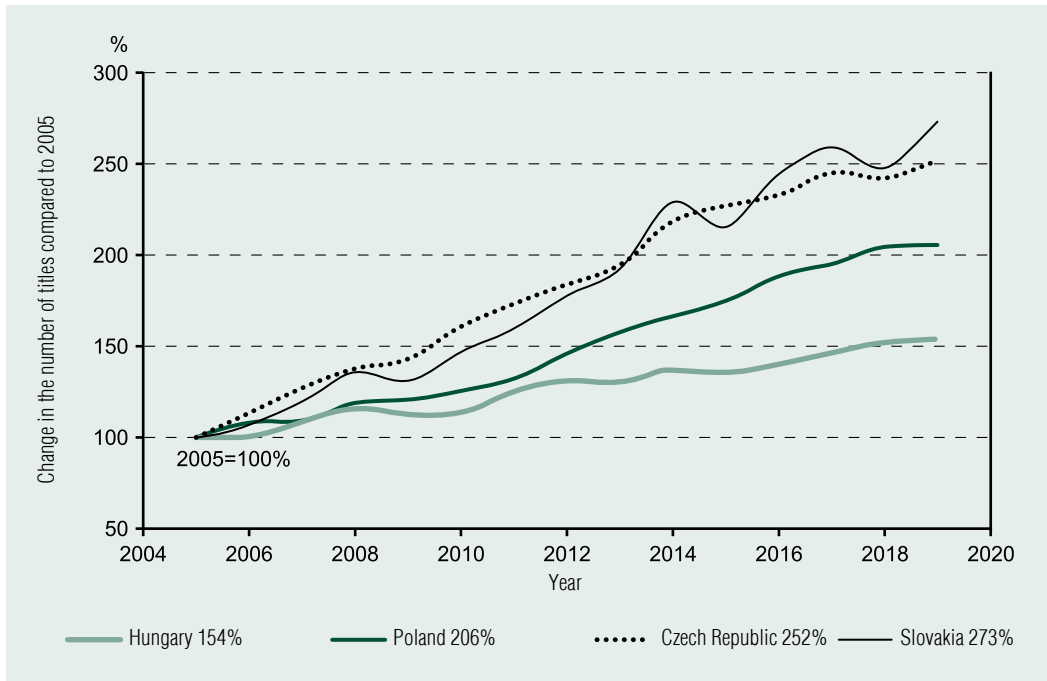
Source: own edited (based on Scopus data)

According to most of the non-innovator companies asked, no innovation is necessary in their own activities, which assumes some kind of conceptual obstacle. The main purpose of fundamental research is facilitating the industrial research and development, through new theoretical models and by achieving the latest high-quality research results, even those of international relevance. As the study of the NRDI Office states, the development and incentive of research infrastructures enable the following points:

- attracting excellent research projects;
- responding to global challenges, including the social and economic challenges in particular;
- the experimental researches are open to businesses, and their findings facilitate the

provision of more complex products and higher quality services;
- facilitate joining international networks;
- guarantee knowledge-sharing among the operators of the academic – business – government sector;
- ultimately determine the scientific competitiveness of the country.

Hungary falls short of the European Union average also in terms of the funds allocated to research, development and fundamental research, while Hungary is in the middle in the EU-funded Horizon 2020 tenders as well. However, it should be emphasised that within this tender system Hungary is the most successful in the tenders supporting the ERC fundamental research. This again highlights the potential of the Hungarian

scientific community, which could gain further incentive through performance-based financing. This could facilitate attracting new European Union grants, tenders, and the enhancement of the scientific and research-development competitiveness.

THE RESEARCH PROCESS

In our analysis we examined the complete 2019 publication performance of Hungary within the titles indexed by Scopus. The Hungarian reference is created by assigning a publication to any of the Hungarian institutions.

We followed two models to calculate the performance-based financing system for the Hungarian performance. We took the Slovak and the Czech models as examples, and also the Q tender system, which was first established in Hungary and used by the University of Public Service (NKE); as far as we know, this system is unique to this day. One of the models, *Model A*, takes into account the co-authorship ratios as well, therefore it calculates with a remuneration based on the quartile of the periodical and the number of authors. Meanwhile, *Model B* calculates with fix article remunerations which depend on the quartile of the periodical only. *Model A* highlights the authorship ratio, therefore it shows the proportionate contribution of one author to the title, while *Model B* ignores this and would pay the full amount to the sole author as well.

We can verify the recommendations for the Czech, the Slovak and also the NKE models through the clearly apparent results thereof. With respect to the international outlook, according to the literature reviewed and also the empirical research, the Slovak model is more effective than the Czech model. At the same time, institutions of both countries were listed in international rankings. The Slovak model is based not only on the performance-

based financing of publications, however, this is the aspect which can be quantified with scientometric measuring. It should be noted that the Slovak model takes the national titles into account as well, which we were unable to correlate completely with the articles published in the local Hungarian periodicals, which are recorded in the Hungarian Science Bibliography (in Hungarian: Magyar Tudományos Művek Tára hereinafter referred to as MTMT). The introduction of additional pillars in Hungary would require changes in numerous other dimensions of the Hungarian higher education and scientific community, which is not a task this paper undertakes. The authors participated in the establishment of the performance-based financing system used by NKE, which was built along the lines of the Slovak model, in the framework of consulting. Considering the Slovak budget lines and the total amount of funds spent on it, we can calculate the payment amounts after the titles in HUF. These are described in detail in later chapters of this paper.

The distribution of publications by institution is shown in *Figure 2,* based on the total performance in 2019. As we had already discussed in the chapter about theory, among the institutions, research institutes and the academy of sciences have a decisive role in the scientific activity in most countries, including Hungary. The Hungarian Academy of Sciences (in Hungarian: Magyar Tudományos Akadémia; hereinafter referred to as MTA) is the most active among the institutions with 2321 articles. It is important to note that the articles attributed to MTA include articles of research institutions and workshops related to MTA, since in 2019 the workshops were still allowed to use the name of MTA temporarily in the institutional display of their titles. The leading institutions are also good examples for their research potentials and resources such as the Budapest University of Technology and Economics (BME), Eötvös Loránd University

THE MOST ACTIVE HUNGARIAN INSTITUTIONS IN TERMS OF PUBLICATIONS IN 2019
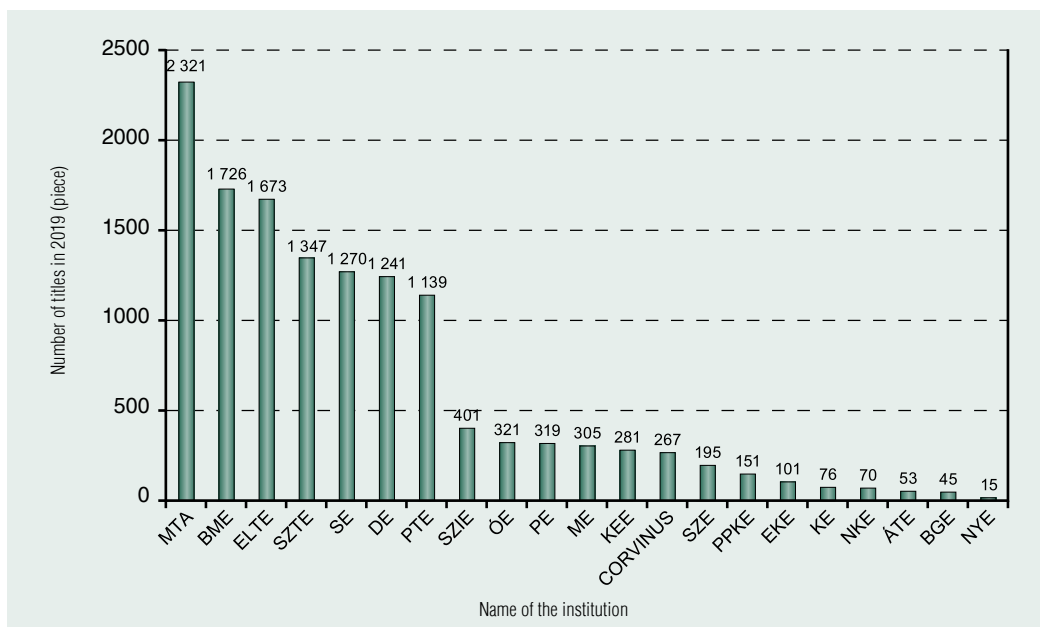
Note: ÁTE=University of Veterinary Medicine Budapest (in Hungarian: Állatorvostudományi Egyetem), CORVINUS=Corvinus University of Budapest (in Hungarian: Budapesti Corvinus Egyetem), BGE=Budapest Business School (in Hungarian: Budapesti Gazdasági Egyetem), BME=Budapest University of Technology and Economics (in Hungarian: Budapesti Műszaki és Gazdaságtudományi Egyetem), DE=University of Debrecen (in Hungarian: Debreceni Egyetem), ELTE=Eötvös Loránd University (in Hungarian: Eötvös Loránd Tudományegyetem), EKE=Eszterházy Károly University (in Hungarian: Eszterházy Károly Egyetem), KE=University of Kaposvár (in Hungarian: Kaposvári Egyetem), KEE=Central European University (in Hungarian: Közép-Európai Egyetem), MTA=Hungarian Academy of Sciences (in Hungarian: Magyar Tudományos Akadémia), ME=University of Miskolc (in Hungarian: Miskolci Egyetem), NKE=University of Public Service (in Hungarian: Nemzeti Közszolgálati Egyetem), NYE=University of Nyíregyháza (in Hungarian: Nyíregyházi Egyetem), ÓE=Óbuda University (in Hungarian: Óbudai Egyetem), PE=University of Pannonia (in Hungarian: Pannon Egyetem), PPKE=Pázmány Péter Catholic University (in Hungarian: Pázmány Péter Katolikus Egyetem), PTE=University of Pécs (in Hungarian: Pécsi Tudományegyetem), SE=Semmelweis University (in Hungarian: Semmelweis Egyetem), SZE=Széchényi István University (in Hungarian: Széchényi István Egyetem), SZTE=University of Szeged (in Hungarian: Szegedi Tudományegyetem), SZIE=Szent István University (in Hungarian: Szent István Egyetem).
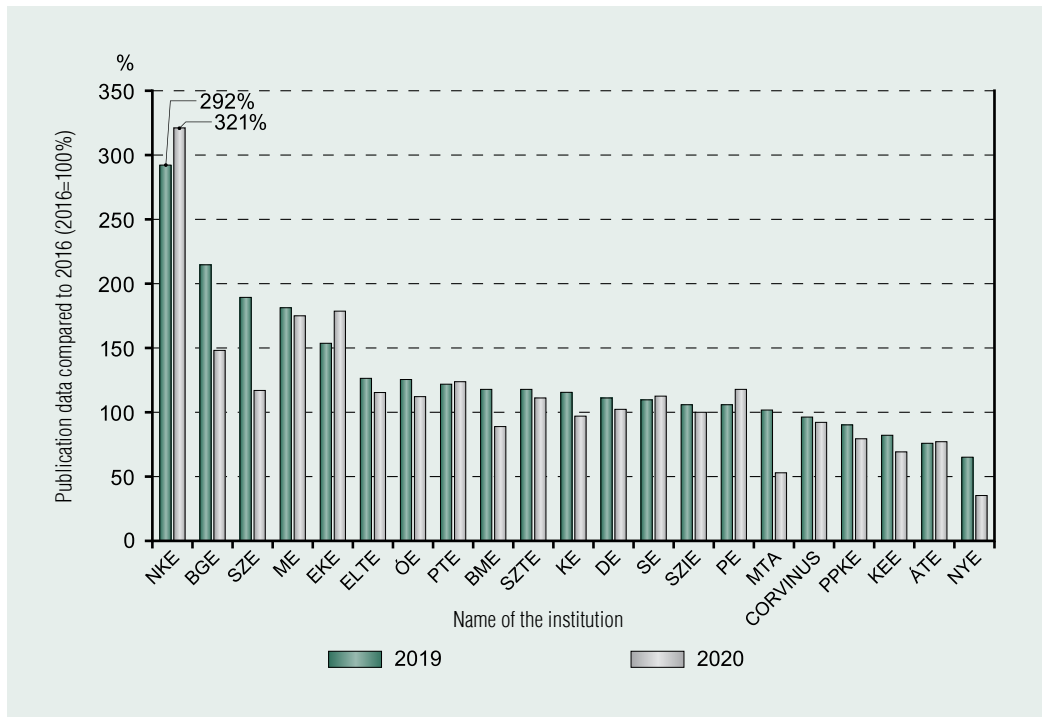
Source: own edited (based on Scopus data)

(ELTE), University of Szeged (SZTE) and Semmelweis University (SE). In the case of ELTE, SZTE, the University of Debrecen (DE) and the University of Pécs (PTE), the importance of science universities also stands out. The remaining institutions share the remaining 16 percent in terms of the publication performance.

However, it is even more interesting to identify those institutions which have been able to increase the number of their Scopus-rated titles in recent years, and to specify the rate of such increase.

We took the performance-based financing system introduced at NKE as the model of our analysis. *Figure 3* shows that compared to the reference year (2016), the university achieved 292 percent growth by 2019 and 321 percent growth by 2020. Although currently the institution is not in the top 10 Hungarian institutions in terms of absolute values, the growth experienced shows positive results. Naturally, the growth of this extent is owed to not only the direct payments but also to a kind of conscious international visibility and an activity aimed at improving competitiveness,

Figure 3

THE 2019 AND THE 2020 PUBLICATION DATA OF THE HUNGARIAN INSTITUTIONS COMPARED TO 2016, BY PERCENTAGE


Note: for the abbreviations see Figure 2

Source: own edited (based on Scopus data)

and the performance-based rewarding of the authors for their titles published is definitely one of the cornerstones of this success.

We can see two trends in the comparison of the Hungarian and the Slovak institutions. The first trend is that many universities exceed 100 percent by 2019 compared to the reference year, which means that they clearly have an increasing publication performance (except for 5 institutions). The institutions which were able to increase their publication performance in 2020 compared to 2019 further should be highlighted among these institutions. NKE clearly stands out in this list as well, with a threefold increase in performance (also compared to 2016). *(See Figure 4)*

The statistical population was 12,281 articles, the total publication performance of Hungary in 2019 with respect to the titles indexed by the Scopus. We completed the full determination of the article types, the disciplinary classification of the articles, the quartile categorisation thereof, and the authors of the articles. The determination of the volume of the titles is complete as well, in case of volumes that might be missing, we based the estimate on multiple documents of the same type. It is important to note in this regard that in the case of journal articles the number of pages is not a definitive indicator, since in our model developed the grant system and the payment are based on the SJR quality quartile of the articles.[4] If a

THE 2019 AND THE 2020 PUBLICATION DATA OF THE UNIVERSITY OF PUBLIC SERVICE AND THE SLOVAK INSTITUTIONS OF HIGHER EDUCATION COMPARED TO 2016 IN PERCENTAGE
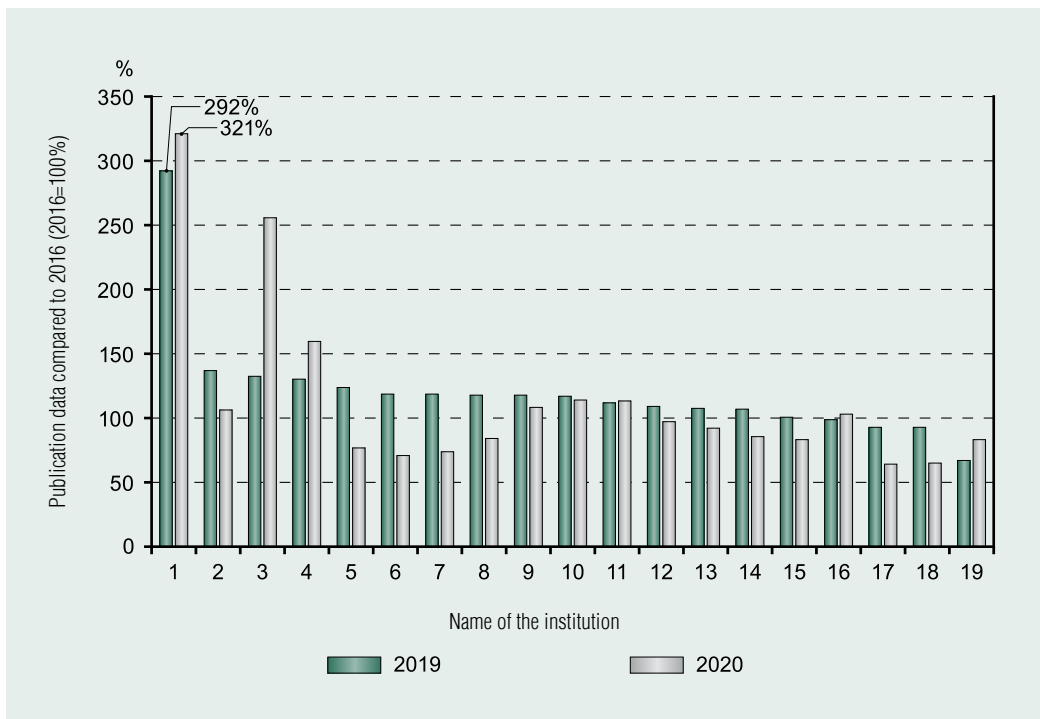
Notes: 1 = NKE, 2 = Slovak University of Agriculture in Nitra, 3 = Selye János University, 4 = Alexander Dubcek Universitiy of Trencin, 5 = Tecnical University of Kosice, 6 = University of Zilina, 7 = Slovak University of Technology in Bratislava, 8 = Constantina the Philosopher University in Nitra, 9 = University of Presov in Presov, 10 = Comenius University Medical School, 11 = Veterinary University Medicine in Kosice, 12 = Katolicka Univerzita v Ružomberku, 13 = Comenius University, 14 = Technical University in Zvolen, 15 = Matej Bel University, 16 = Pavol Jozef Safarik University in Kosice, 17 = Slovak Medical University, 18 = University of Economics Bratislava, 19 = University of SS Cyril and Methodius Trnava

Source: own edited (based on Scopus data)

title has no quartile (e.g. book, part of a book, conference article), then we continue the calculation with the average volume of multiple publications of the same type. If the quartile is still determined as a journal article, then we continue to calculate with a remuneration of HUF 100,000/unit, which amount will be described later. For 2,488 of the 12,281 titles the calculation of the page numbers is relevant, of which 1,695 documents have page numbers. The volume of the titles was calculated from the difference of the last and the first page. Some

publishing companies give their titles unique identifiers and the titles are included in the Scopus database without page numbers. In this case, the volume was replaced by the average of the other types of titles. Every type of title has a different ratio of page numbers. For all types of titles, 68 percent had page numbers, which means 19,037 pages in total.

In course of the calculation of the *Model A*, we determined the co-authorship ratio of the Hungarian authors:

• completely for single-author titles,

- by sampling for titles with 2 to 17 authors,
- or by estimating for titles with 18 or more authors.

The size of the 12,281-title sample in course of the calculation of the number of Hungarian authors shows 3,287 titles (27 percent). For single-author titles, the Hungarian co-authorship ratio was determined completely (1,451 titles). For articles with 2 to 17 authors we used sampling; we analysed 1,525 2-author titles, and we worked with a 15x20 sample in the case of titles with 3 to 17 co-authors. We took 20 samples from each category, and projected the average co-authorship ratio of Hungarian authors calculated from it to the other titles which were not analysed. We used estimates for titles with 18 to 2,951 co-authors. In the case of 17-author titles, the average number of Hungarian authors was 3.516. In the case of titles with 2-16 authors, the ratio

of Hungarian authors decreased by an average of 0.016. Based on this, we determined the size of the estimated Hungarian authorship participation rate for each authorship category (with a minimum of 1 person).

RESEARCH RESULTS

Descriptive statistics of the titles analysed

In the analysis we started off from the total publication performance of Hungary within the titles indexed by Scopus. This means 12,281 titles in total.

Figure 5 shows the titles analysed broken down to types. It is clear that 74 percent of the titles were journal titles, and there are also conference papers representing 14

Figure 5

DISTRIBUTION OF TITLES PER PUBLICATION TYPE IN 2019

| Journal article, 9020 | Review, 765 | Book, 15 |
| Conference paper, 1763 | Book chapter, 314 | Other, 408 |
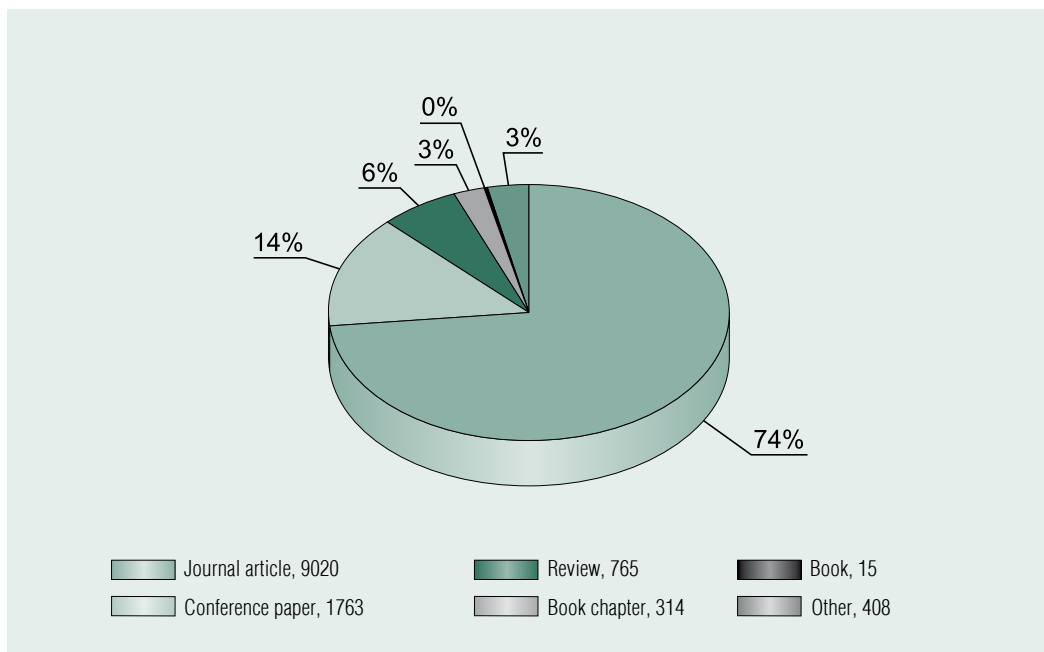
Source: own edited (based on Scopus data)

percent, reviews (summary type) titles with 6 percent, book chapters with 3 percent and books (15 books). These smaller categories represent merely 3 percent in total, such titles are editorials, letters or erratums, databases, notes and reviews. This leads to the conclusion that publishing in journals – which is a priority according to international trends as well – is given priority also by the Hungarian authors.

Figure 6 shows the distribution of the titles based on the area of science and branch of science classification categorisation system of the All Science Journal Classification (ASJC) of the SciVal research support system. According to these data, the largest number of titles is related to medicine, which is followed by engineering and physics and astronomy. The fewest titles were published in dentistry and health professions.

Figure 6

DISTRIBUTION OF THE TITLES IN AREAS OF SCIENCE ACCORDING TO THE ASJC (ALL SCIENCE JOURNAL CLASSIFICATION) IN 2019
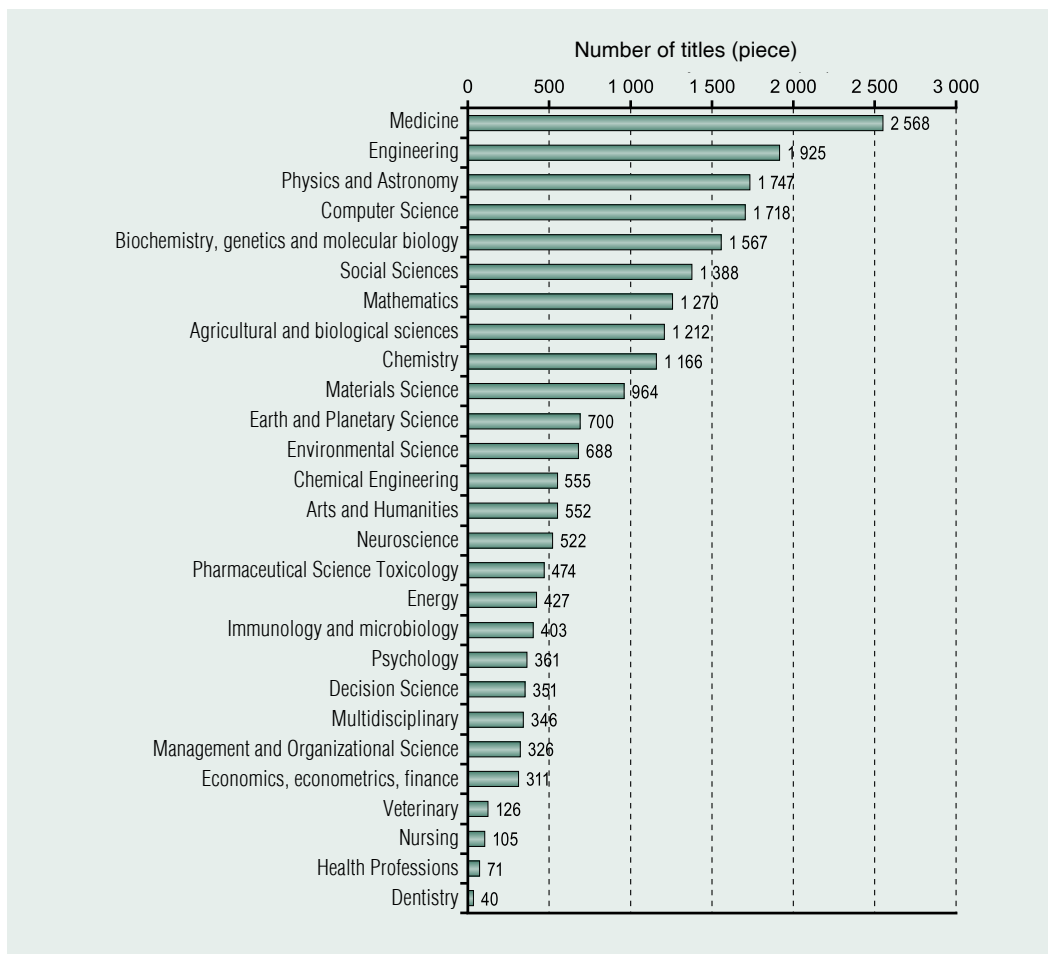
Source: own edited (based on SciVal data)

The areas of science are traditionally divided into 2 larger collection categories. One is STEMM (Science, technology, engineering, mathematics, and medicine) and the other is HASS (humanities, arts and social sciences). In the Hungarian performance, we can see that the branches of science with the most publications belong to the STEMM category, which can be traced back to two things. On the one hand, the Hungarian scientific community switched to international indexed publishing decades ago in these branches of science, and in general, productivity is much higher in these disciplines. According to Figure 6, the branch of science within HASS with the most publications is social sciences (1,388 titles), which is at the 6th place.

Measuring international competitiveness achievable through the titles analysed

SciVal also provides the breakdown of titles according to the area of science classification used by the crucial international university rankings. *Table 1* shows the Hungarian-related titles published in 2019 according to the 5 areas of science of the QS.

This shows an evident dominance of life sciences and medicine, followed by the category of natural sciences and then the category of engineering and technology. The number of citations per publication also follows this order, led by life sciences and medicine. The discipline citation impact shows how often a given publication is cited relative to other

Table 1

DISTRIBUTION OF TITLES IN AREAS OF SCIENCE ACCORDING TO THE QS (QUACQUARELLI SYMONDS CLASSIFICATION) IN 2019

Area of science	Number of titles (piece)	Number of citations (piece)	Number of authors (person)*	Number of citations per title	Citation impact in the area of science
Life Sciences & Medicine	5,279	23,580	43,172	4.5	1.61
Natural Sciences	4,439	16,053	35,594	3.6	1.17
Engineering & Technology	3,914	9,989	21,956	2.6	1.07
Social Sciences & Management	2,075	4,421	6,059	2.1	1.16
Arts & Humanities	569	444	1,134	0.8	1.06

Note: * It is important to note in this regard that an author may appear more than once in the number of authors based on his / her titles.

Source: own edited (based on SciVal data)

publications in its own discipline. According to this indicator, life sciences and medicine stand out again.

Table 2 analyses the key areas of science according to the THE Times rankings. The THE specifies 11 disciplines. Physics dominates in the numbers of publications and citations, followed by clinical and preclinical medicine, and engineering and technology. The last in the list is psychology, education,

and law, while in terms of citations, law, education, and arts and humanities are in last places. With respect to the number of citations per title, clinical and preclinical medicine is dominant with a value of 5.1, and according to the disciplinary citation impact, this discipline is on the top of the list with the value of 1.88. With respect to the latter indicator, psychology stands out with a value of 1.78.

Table 2

DISTRIBUTION OF TITLES IN AREAS OF SCIENCE ACCORDING TO THE (TIMES HIGHER EDUCATION CLASSIFICATION) IN 2019

Area of science	Number of titles (piece)	Number of citations (piece)	Number of authors (person)*	Number of citations per title	Citation impact in the area of science
Physical Sciences	4,883	17,345	36,664	3.6	1.16
Clinical, pre-clinical and health	3,299	16,817	29,898	5.1	1.88
Engineering and Technology	2,880	7,856	17,750	2.7	1.01
Life Sciences	2,721	10,370	20,690	3.8	1.22
Computer Science	1,718	2,645	6,909	1.5	1.02
Social Sciences	1,068	1,924	2,595	1.8	1.24
Arts and Humanities	570	448	1,138	0.8	1.06
Business and Economics	529	919	1,229	1.7	0.88
Psychology	361	1,132	1,783	3.1	1.78
Education	166	221	422	1.3	1.23
Law	97	77	220	0.8	0.77

Note: * It is important to note in this regard that an author may appear more than once in the number of authors based on his / her titles

Source: own edited (based on Scopus and SciVal data)

The analysis based on the QS and the THE shows those disciplines in the Hungarian science which are dominant in both the number of titles and visibility and impact. It is evident that in Hungary the STEMM disciplines are the most competitive at the international level.

The journals (and thereby the articles) included in the Scopus are classified into four categories of the same size according to their weighted, specific citations, i.e. according to their SJR value and to the rankings within the disciplinary categories, starting from the top 25 percent of the rankings to the bottom 25 percent. . This is the so-called the quartile classification: Q1: top 25 percent; Q2: 25 to 50 percent; Q3: 50 to 75 percent; Q4: 75-100 percent. This allows journals and articles from different disciplines and specific areas

of science to be directly comparable (namely, based on their position in their respective areas).

Figure 7 shows the distribution of Q quality classification of the journal titles. The decisive predominance of Q1 titles is evident, this category is followed by Q2 titles, and then by the Q3 and Q4 categories. The 'other' category contains those journal titles the journals of which do not have a Q classification yet or are not properly recorded in the Scopus database. The outstanding ratio of the two highest indexed quality categories is definitively forward-looking, especially in light of recent promotion regulations. Naturally, these titles achieve the most citations and the greatest scientific impact, therefore their dominance has a positive effect on the competitiveness of Hungarian science. In this regard, the
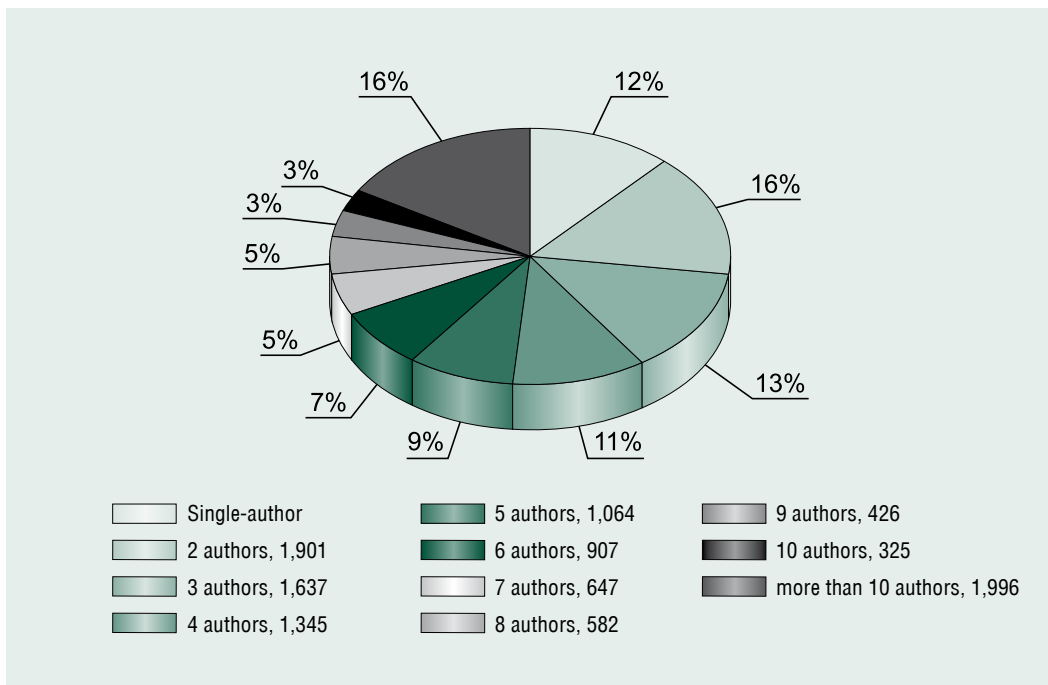
Figure 7

DISTRIBUTION OF JOURNAL ARTICLES ACCORDING TO THE BEST QUARTILES IN 2019

Q1: 5,130   Q3: 1,314   Other: 88
Q2: 2,528   Q4: 724
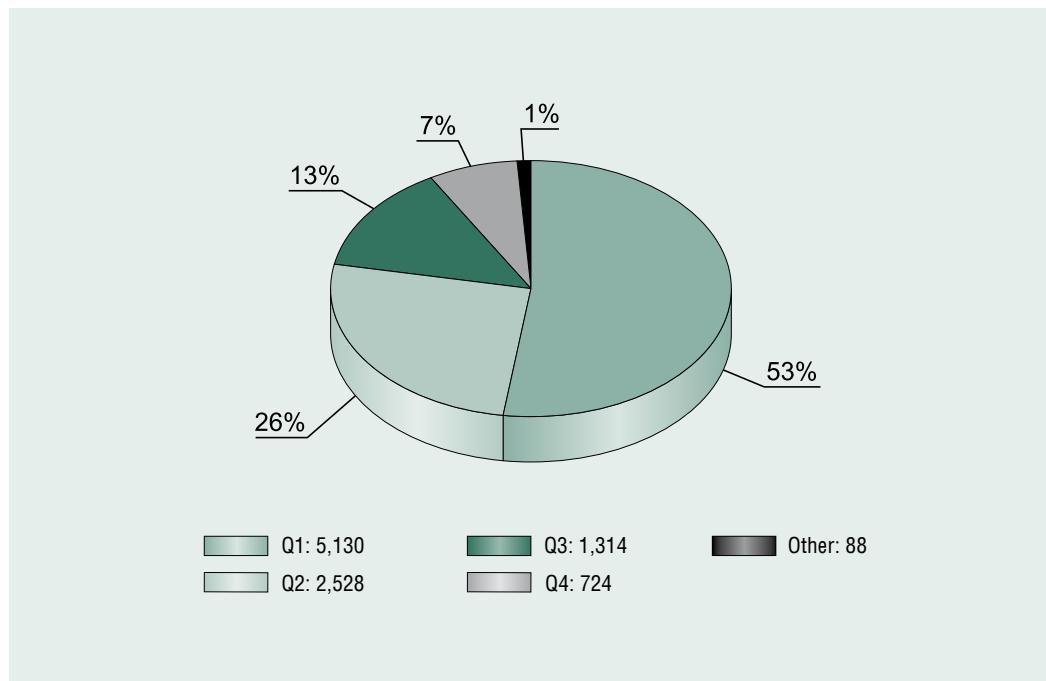
Source: own edited (based on Scopus and Scimago data)

Figure 8

NUMBER OF PUBLICATIONS ACCORDING TO THE NUMBER OF CO-AUTHORS IN 2019

Source: own edited (based on Scopus and Scimago data)

performance-based financing can help achieve higher number of titles.

The frameworks of performance-based financing in Hungary

Figure 8 shows the distribution according to the number of authors. The author numbers raise the issue of co-authorship ratios and can also be traced back to the traditional customs of the disciplines (for more details see Sasvári et al., 2020).

In their research, they have proved by empirical studies that the ratio of single authors is constantly decreasing in Hungary as well, while multi-authorship is on the rise. This benefits primarily the authors of the STEMM sciences, where by tradition multi-

authorship dominates. In engineering and technology sciences, there are smaller authors' collectives, while in life sciences and medicine larger authors' collectives are operating. It is clear that the ratio of single and smaller authors' collectives among all publications is 52 percent, while the ratio of publications with more than 10 authors is 16 percent. The issues of authors cause differences mainly in the case of the two proposed models (*models A and B*), because not only Hungarian authors can be included in any given authors' collective.

Figure 9 summarises the median of co-authors in the publications analysed. It is noticeable that for each type of publication, the small and medium authors' collectives are dominant (2-5 authors). Consequently, due to the significant predominance of journal

Figure 9

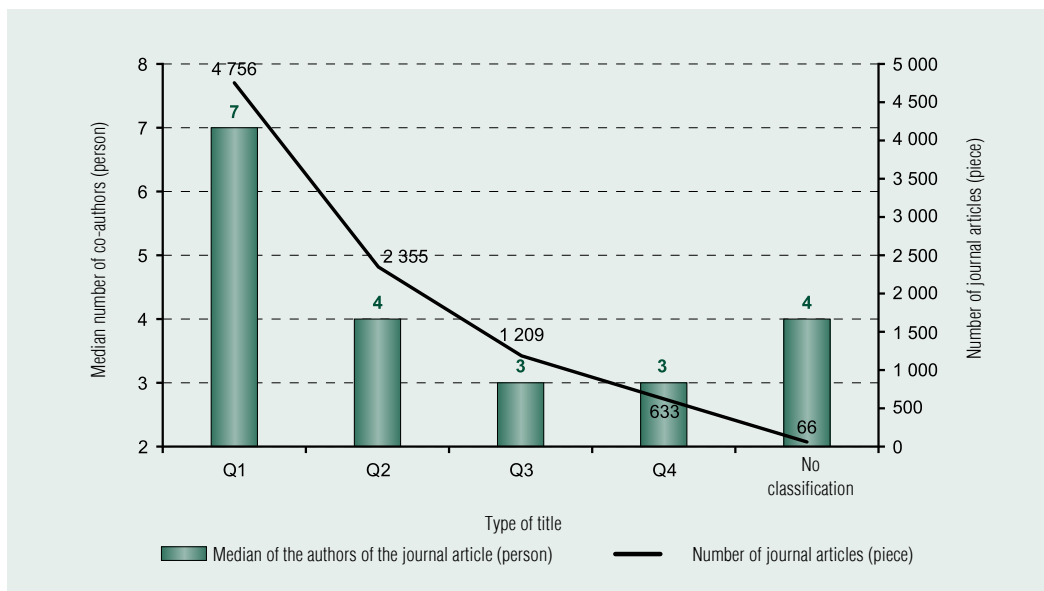## MEDIAN OF CO-AUTHORS ACCORDING TO THE TYPES OF TITLES IN 2019
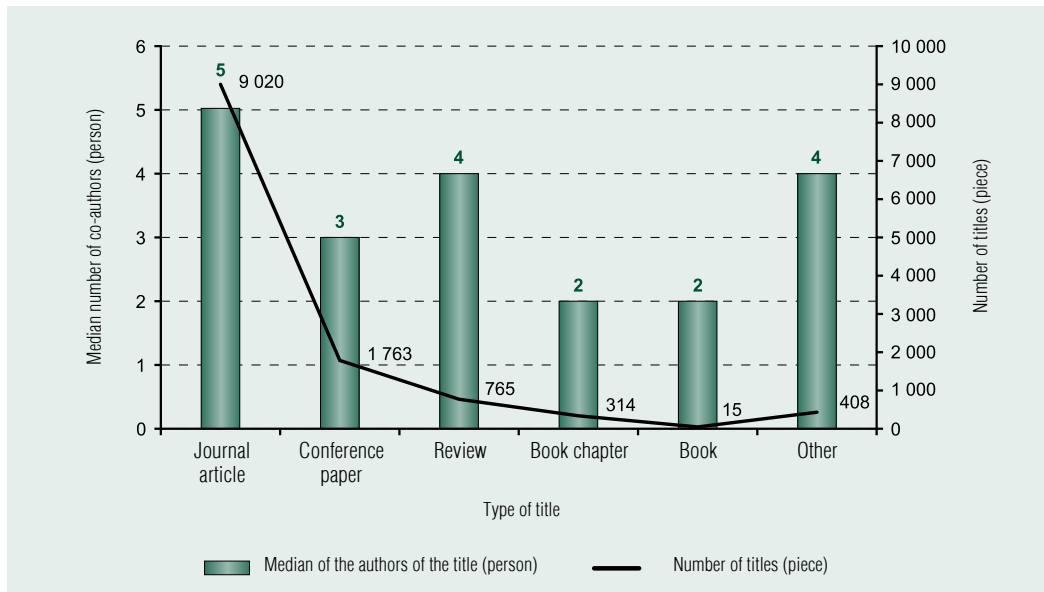
Note: Since the titles do not have normal distribution, we use the median.
Source: own edited (based on Scopus and Scimago data)

Figure 10

MEDIAN OF CO-AUTHORS ACCORDING TO THE QUARTILES IN 2019

Source: own edited (based on Scopus and Scimago data)

titles, we can declare with certainty that multi-authorship dominates.

Figure 10 examines the journal titles. It stands out that there are higher author numbers in the higher quartiles. In the case of Q1 titles, the median is already 7 authors, and due to the predominance of these articles, the dominance of medium authors' collectives is significant. This raises the issue of research collaborations, at both domestic and international levels. This trend is a good indication that the authors who are active in the most productive areas of science prefer multi-authorship and even research in larger authors' collectives, and this form is becoming more and more widespread. This can be traced back to the fact that while in this way authors have to put in less work in order to write 1 title, this is not taken into account in the calculation of citations and the impact factor (Lozano, 2013).

Figure 11 also summarises the volume of the titles, which we use in our models for conference papers. Based on this, we can determine the average title volumes, which develop as seen in the figure for each type.

The calculated amounts

Before determining the exact amounts, we elaborate the calculation methodology recommended for both sides. *Model A* calculates on the basis of the Hungarian co-authorship ratio, while in case of *Model B*, the payment would be made according to a title-based approach, without taking into account the Hungarian co-authorship ratio.

The advantage of *Model A* is that the rewards are granted fairly and proportional to the participation, while its disadvantage is that very high-rated publications are characterised by multi-authorship, and therefore the amount

Figure 11

THE AVERAGE VOLUME OF TITLES IN CASE OF EACH TYPE OF TITLE IN 2019
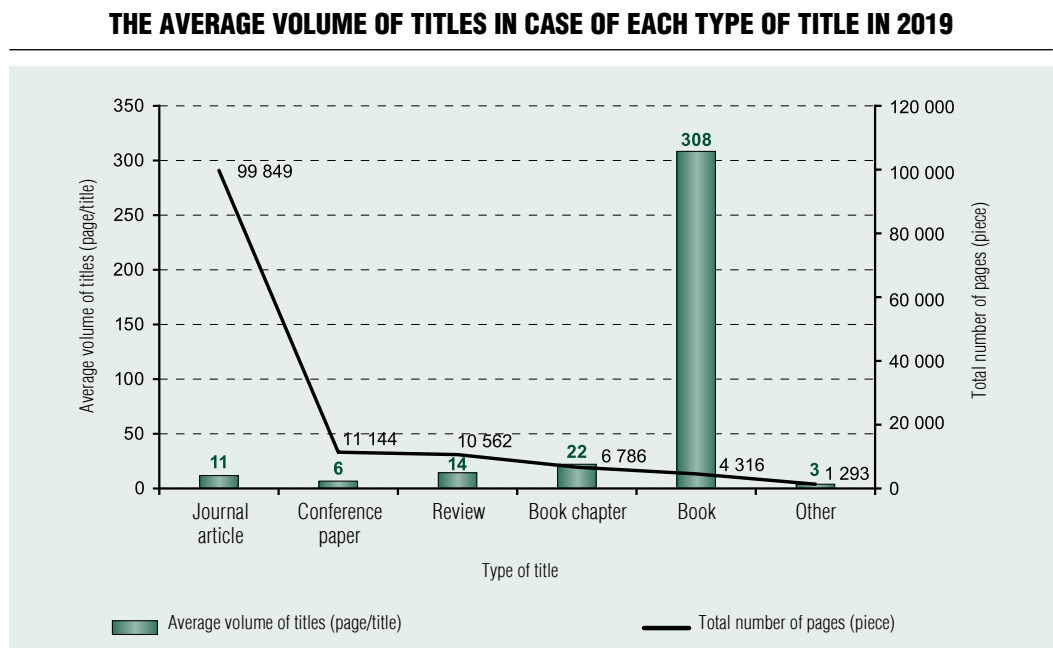
Source: own edited (based on Scopus and Scimago data)

of the reward can be reduced to a fraction – due to the low co-authorship ratio – despite the fact that only the high-rated journals provide prestige. The biggest difference between the two calculation methodologies is that in *Model A* the remuneration for the title would be divided proportionally to the number of authors, while in *Model B,* all Hungarian authors entitled to payment – regardless of the number of authors – would receive the full amount payable for the title. The exact amounts were determined on the basis of the 2019 titles with Hungarian connection, however, it is important to keep in mind that as a result of this – just as in Slovakia and the Czech Republic – the number of publications in Hungary may increase in the coming years (which is also the goal), and therefore the funds to be spent could also increase substantially.

Remuneration amounts per unit:
- Q1 category journal article – gross HUF 800 000/piece,
- Q2 category journal article – gross HUF 400 000/piece,
- Q3 category journal article – gross HUF 200 000/piece,
- Q4 category journal article – gross HUF 160 000/piece,
- No. category journal article – gross HUF 100 000/piece,

Book, part of book or conference paper indexed by the Scopus – gross HUF 80 000/sheet.

We carried out our calculations based on these indicators.

Table 3 shows the calculated amounts per type of title. All title types ensure international visibility, therefore all types were taken into consideration (e.g., editorial greetings and letters, or erratums, databases, notes, review and short surveys). In both models, the largest amounts are allocated to journal titles. In the case of *Model A*, the total (calculated with the co-authorship ratio) is HUF 3,711,379,814, while in the case of *Model B* (disregarding

the co-authorship ratio) the total is HUF 5,824,646,667.

Table 4 shows the amounts based on the quartile classification. We can see that the authors of the Q1 titles receive the most substantial amounts. In terms of totals, *Model A* provides a total (calculated with the co-authorship ratio) of HUF 3,655,176,232, while *Model B* (disregarding the co-authorship ratio) provides the total of HUF 5,756,393,333. Although *B model* would require a significantly higher amount to be paid to authors to reward their titles, there are a number of arguments in favour of the model. If the full amounts were paid to all eligible authors, the Hungarian authors would be encouraged to join in collaborations. In contrast to *Model A,* in *Model B* the authors are not bound by the constraints of sharing to shrink down authors' collectives, and they would not have to restrict co-authorship, either. As seen in the descriptive analysis of the publications as well, titles which have a higher international rating – simultaneously with the increase in the quality ratings – require the expansion of the authors' collectives. It is very difficult to publish single-author titles at this level, and the enhancement of the Hungarian performance would prosper as a result of joining international collaborations. The Hungarian authors should be encouraged to participate in these collaborations so it would be possible to publish even in the highest rated scientific journals of the world – such as Nature, Science – as a member of an international collective, and we think this would be feasible with *Model B*.

CONCLUSION, RECOMMENDATIONS

The National Research, Development and Innovation Fund currently supports outstanding scientific programs that promote

Table 3

THE CALCULATED AMOUNTS PER TYPES OF TITLE IN 2019

Type of title (HUF)	Version A (HUF)	Version B (HUF)
Journal title	3,201,248,887	5,092,403,333
Book	12,559,114	14,386,667
Book chapter	21,349,207	26,253,333
Conference paper	50,192,506	73,213,333
Database[a]	898,172	2,880,000
Editorial[b]	53,303,782	66,516,667
Erratum[c]	18,673,161	38,606,667
Letter[d]	35,654,144	53,210,000
Note[e]	32,771,653	40,013,333
Retracted article[f]	573,333	800,000
Review[g]	275,445,022	405,043,333
Short survey[h]	8,710,833	11,320,000
Total	3,711,379,814	5,824,646,667

Note:
[a] Database: document with searchable format, in which a data source accessible online is published. Its purpose is to present the data source, and present the parameters, contact details and potential new uses - e.g. data analysis - thereof.
[b] Editorial: the summary of several titles, or opinion or news.
[c] Erratum: the error report, correction of a previously published title, ot the withdrawal of a title.
[d] Letter: independent letter or a response letter between the author and the editor.
[e] Note: summary of questions and answers, notes and debates, or the collection of comments.
[f] Retracted article: Published articles that the author(s) or publisher has requested to retract
[g] Review: Significant review of original research, also includes conference papers.
[h] Short survey: brief summary of an original research or conference titles.
Further information on the different types of titles: https://www.elsevier.com/__data/assets/pdf_file/0007/69451/Scopus_ContentCoverage_Guide_WEB.pdf

Source: own edited (based on Scopus and Scimago data

Table 4

THE CALCULATED AMOUNTS PER QUARTILES BASED ON THE 2019 TITLES

Quartile classification	Version A (HUF)	Version B (HUF)
-	1,359,635	1,673,333
Q1	2,568,782,410	4,288,000,000
Q2	769,588,249	1,068,400,000
Q3	216,819,865	278,800,000
Q4	98,626,074	119,520,000
Total	3,655,176,232	5,756,393,333

Source: own edited (based on Scopus and Scimago data)

the advancement of the Hungarian scientific performance. We recommend that the performance-based publication model was included in this framework.

According to the maximum amount, currently an amount of HUF 5 824 646 667 would be necessary to implement the performance-based financing system, based on number of titles published in 2019. For this reason, in our opinion, the sum of approximately 6 billion forints should be planned in the 2021 budget as priority appropriation, within the Research Fund of the National Research, Development and Innovation Fund. In our opinion, this amount would be at least a proportionate investment in terms of competitiveness return.

Our further recommendations

❶ Encouraging the Hungarian authors to publish internationally indexed titles, both through individual incentives and participation in research collaborations.

❷ Among the publications indexed by Scopus and in line with the system of promotion requirements and policy, giving priority to highly indexed Q1 and Q2 titles among the authors, with differentiated financial support, even with a higher multiplier. Currently, D1

titles are not prioritised by these regulations, and writing titles which are indexed by the SJR in the top 10 percent would contribute significantly to improving the international scientific visibility and thus to achieving a higher impact factor and more international citations.

❸ The precise development of the performance-based financing system, taking into consideration the goals, possibilities and peculiarities of the Hungarian scientific system and community. These indicators could be included as multiplier indicators in the course of the development of the grant system. Such indicators could be weighting by discipline and branch of science.

❹ Development of the technical details of the performance-based publication model. We recommend following the Slovak model: every year in October, the authors apply with their own titles within their own institutions, and the institutions collect these applications and send the compiled applications to the responsible ministry. The ministry transfers the grant to the institutions for the titles published, and the institutions forward the (unchanged) amounts to the authors.

❺ Continuous monitoring and the assignment of additional resources in order to properly support the increasing performance generated by motivational tools are essential for a conscious development.

Notes

[1] 'QS' is the abbreviation for the QS World University Rankings, which is published annually by the Quacquarelli Symonds Limited company. The ranking ranks the performance of the universities worldwide, and it makes general and specific rankings. It has been operating independently since 2010, in close cooperation with the Elsevier publishing company, therefore its rankings measure the indicators related to scientific performance based on the titles to be found in the Scopus database. Detailed information about the rankings: https://www.topuniversities.com/university-rankings/world-university-rankings/2021

² 'THE' is the abbreviation for the Times Higher Education World University Rankings, which is published annually by the Times Higher Education company. The THE rankings rank the universities worldwide, by making general, specific and regional (Asia, Latin America, BRICS and developing economies) rankings. The rankings were first published in 2010, and the company has had a close cooperation with the Elsevier publishing company since 2014, therefore they build the rankings on the Scopus database. Detailed information about the rankings: https://www.timeshighereducation.com/world-university-rankings/2020/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats

³ The *peer review* method means the double-blind review, in course of which the identity of the author and the evaluator remains unknown for the other party throughout the review.

⁴ SJR stands for SCImago Journal & Country Rank. The SJR is an open and accessible online portal that lists publication surfaces (primarily journals, but also conference books and book series) and the countries based on the Scopus database (which is owned by the Elsevier publishing company). Along the lines of these indicators, we have the opportunity to analyse and compare the major periodicals and performances of the countries, disciplines of science and branches of science. Detailed information about the portal: https://www.scimagojr.com/aboutus.php

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