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# The impact of research collaboration on academic performance: An empirical analysis for some European countries

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ABSTRACT

The aim of this paper is to investigate the impact of internal and external research collaborations on the scientific performance of academic institutions. The data are derived from the international SCOPUS database. We consider both quantity (the number of publications) and quality indicators (the field-weighted citation impact and the share of publications in the 10% most-cited articles) to evaluate universities' performance in some European countries (Germany, France, Italy, the UK and Russia). To this end, we develop a non-overlapping generations model to evidence the theoretical idea of research externalities between academic institutions. Moreover, we implement an empirical model to determine the extent to which the impact of internal and external collaborations on universities' performance is sensitive to the geographical dimension of the data.



## 1. Introduction

Universities' degree of scientific openness towards other academic institutions is becoming more important in the analysis of knowledge flows between researchers. This topic is central to the accumulation of human capital and talents' allocation for countries' economic growth.

Teams of scientific specialists have replaced independent researchers, and R&D laboratories have replaced independent inventors [5]. The investigation of scientific teams is relevant because it leads to evidence of the changes in the research production function that otherwise would be less clear. Indeed, academic collaborations could improve the effectiveness of research, just as specialization improves general productive efficiency.

For these reasons, in this paper our research question asks which forms of collaboration are more effective at raising the performance level of scientific universities in five European countries: France, Germany, the UK, Italy and Russia. In particular, we select the top 254 European universities for the 20 years from 1996 to 2015 to identify the impact of three types of collaborations: internal, external and institutional. In this way we investigate the extent to which the degree of openness towards the international context is important for the academic quality performance of each university.

To satisfy our goal regarding academic scientific research, we consider the number of publications for the quantitative aspect and two variables for the qualitative one. In particular, we compute a new index of quality by reducing the above three variables through principal component analysis. Thus, we implement a random-effect panel data model with clustered errors to explore the statistical features of the sample. Since we could suspect that endogeneity exists because of the simultaneity of decisions, we run also a generalized method of moments (GMM) model, in which the number of students in mobility is used as an instrument for the collaboration variable. The findings are particularly interesting: more external collaborations positively affect universities' performance.

The paper is developed in the following way. Section 2 reviews the main findings on the influence of scientific collaboration on research performance, research productivity and citations of

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publications. Section 3 describes the data. Section 4 presents the theoretical framework. Section 5 deals with the empirical strategy and the results, while Section 6 discusses the policy implication of the analysis and provides some remarks concerning further research.

## 2. Literature review

Collaboration in different forms (international as well as national and intra-organizational) supports the development of universities' research quality and quantity. Research collaboration is necessary for increasing the general research productivity of universities. Collaboration (primarily collaboration with developed countries) can also help universities in less developed countries to build their research capacity and increase their research performance. Collaboration in general leads to an increase in the levels of citations and the visibility of research. Collaborated (especially internationally collaborated) publications receive a higher number of citations than single-authorship papers and are more visible than purely national or one-author papers. National researchers' collaboration with their colleagues from other countries can be set as one of the priorities in national research policies (see e.g. Ref. [46] for a discussion of the priorities of S&T cooperation in Russia). We can find many pieces of evidence in support of these statements about the positive influence of collaboration on the research performance of universities. Dakik et al. [21] in their study evaluating the research performance of the Medical Faculty at the American University of Beirut (AUB) state that "… Collaboration with international investigators resulted in more original publications than work done only at AUB (65% v 35%, $p < 0.001$), and a higher journal impact factor for the publications (3.20 (3.85) v 1.71 (2.36), $p < 0.05$)." Abramo et al. [1]; measuring the research performance of Italian university scientists and researchers in the private sector, state that "The analyses demonstrate that university researchers who collaborate with those in the private sector show research performance that is superior to that of colleagues who are not involved in such collaboration." The findings of the paper by Akakandelwa [7] on the analysis of the collaborative publication activity of the University of Zambia include the following: "… The study also established a positive relationship between author productivity and author collaboration. The more collaborative an author is, the more productive that author is." Savic et al. [65] measure the research performance of the Faculty of Sciences at the University of Novi Sad in Serbia and show that "… researchers involved in inter-department collaborations tend to be drastically more productive (by all considered productivity measures), collaborative (measured by the number of co-authorship relations) and institutionally important (in terms of the betweenness centrality in the co-authorship network) compared to those who collaborate only with colleagues from their own research departments." Isiordia-Lachica et al. [40]; in their analysis of the research performance of the Universidad de Sonora (Mexico) in 2000–2009, state that "… International co-authorship produced higher citation rates." Olmeda-Gómez et al. [55] measure the research performance of Catalonian universities in 2000–2004 and show that "… As a whole, they prefer to collaborate with institutions in the United States, the United Kingdom, France, Germany and Italy, and obtain better visibility when publishing with English-speaking authors." We can find even more evidence supporting the positive influence of collaboration on research performance in cases of different countries – developed, developing and least developed – in different fields of science (see Table A.1 in Appendix A).

Since the basis for the empirical part of our paper is non-overlapping generations, we also provide a brief review of this method. This method is widely applied primarily in the fields of genetics (see e.g. Refs. [58,59]), mathematical biology (see e.g. Refs. [63,73]) and population studies (see e.g. Refs. [13,31]), in which the main focus of analysis is the generation of some biological species. The theoretical foundation for the application of the non-overlapping generations approach in economics can be found in Acemoglu [4]. Further empirical applications of the non-overlapping generations approach in economics are quite rare. In economic research the complementary approach, overlapping generations, is more widespread (see e.g. Refs. [29,42,71], among many other examples). Meanwhile, we can find some cases of the application of the non-overlapping generations approach in economics. For example, Aldieri and Vinci [8] apply this approach to the analysis of the effects of research and development (R&D) spillovers on the productivity of Italian manufacturing firms. Bovenberg and Mehlkopf [15] use the non-overlapping generations model to build an optimal model of a pension scheme. Grove et al. [36] assess the longitudinal robustness of the functions of sport from the point of view of sport fans. Sarabia and Sarabia [64] model the behavior of a family business using the non-overlapping generations approach. Other examples of the non-overlapping generations approach in economics are related to income distribution and inequality (see e.g. Refs. [37,57]). Applied to the field of higher education and university studies, the overlapping generations approach is used primarily for the analysis of the temporal distribution of education expenditures (see e.g. Refs. [24,26,38,47]).

## 3. Methodology

### 3.1. World University Rankings

To select the "best" (that is, the most productive) research universities in the studied countries, we use here the latest data from the three most comprehensive and widely used university rankings (the Academic Ranking of World Universities; Times Higher Education (THE) World University Rankings; and Quacquarelli Symonds (QS) World University Rankings). The Academic Ranking of World Universities (ARWU) has been issued annually since 2003 by Shanghai Jiao Tong University (2003–2008) and Shanghai Ranking Consultancy (since 2009). The Times Higher Education (THE) World University Rankings (THE WRU) have been issued annually by the Times Higher Education (THE) magazine since 2010 in collaboration with the Quacquarelli Symonds World University Rankings (QS WRU), which have been issued annually by Quacquarelli Symonds Limited since 2004 (until 2009 in collaboration with Times Higher Education and since 2010 on its own). We include a university from the studied countries (the UK, Italy, Germany, France and Russia) in our panel data analysis model if this university is ranked in at least one of the following world university rankings: Ranking of World Universities 2016 (more than 1200 universities in the rank Top-500 are published), Times Higher Education World University Rankings 2016–2017 (978 universities in the rank) or QS World University Rankings 2016–2017 (916 universities in the rank).

The structure of the three above-mentioned world university rankings is presented in Tables 1–3, and the number of universities from Germany, France, Italy, Russia and the UK that are ranked in ARWU 2016, THE WUR 2016–2017 and QS WUR 2016–2017 are shown in Table 4. The key bibliometric indicators of these universities in 2015 as well as their positions in the Academic Ranking of World Universities 2016, Times Higher Education World University Rankings 2016–2017 and QS World University Rankings 2016–2017 are given in Tables B.1–B.5 in the Appendix.

We should make a very important note here. All these world university rankings primarily rank the research activity in

**Table 1**
Methodology of formation of Systems Academic Ranking of World Universities.

| Criterion | Indicator | Weighting | Source |
|---|---|---|---|
| Quality of education | Alumni as Nobel laureates & Fields Medallists | 10% | A |
| Quality of faculty | Staff as Nobel Laureates & Fields Medallists | 20% | A |
| | Highly cited researchers in 21 broad subject categories | 20% | B |
| Research output | Papers published in Nature and Science[*] | 20% | C |
| | Papers indexed in Science Citation Index-expanded and Social Science Citation Index | 20% | |
| Per capita performance | Per capita academic performance of an institution | 10% | |

Notes: Source code: Official websites of Nobel Laureates & Fields Medallists; B - Thomson Reuters' survey of highly cited researchers. C - Web of Science Citation Index-expanded and Social Science Citation Index. [*] Not applicable to institutions specialized in humanities and social sciences whose N&S scores are relocated to other indicators. Source: About “Academic Ranking of World Universities”. Shanghai Ranking Consultancy. 2014. Retrieved 26 September 2014. Since 2009 the Academic Ranking of World Universities (ARWU) has been published and copyrighted by Shanghai Ranking Consultancy.

**Table 2**
Methodology of formation of Times Higher Education (THE) World University Rankings.

| Overall indicator | Individual indicator | Percentage weighting |
|---|---|---|
| Industry Income – innovation | Research income from industry (per academic staff) | 2.50% |
| International diversity | Ratio of international to domestic staff | 3% |
| | Ratio of international to domestic students | 2% |
| Teaching – the learning environment | Reputational survey (teaching) | 15% |
| | PhDs awards per academic | 6% |
| | Undergrad. admitted per academic | 4.50% |
| | Income per academic | 2.25% |
| | PhDs/undergraduate degrees awarded | 2.25% |
| Research – volume, income and reputation | Reputational survey (research) | 19.50% |
| | Research income (scaled) | 5.25% |
| | Papers per research and academic staff | 4.50% |
| | Public research income/total research income | 0.75% |
| Citations – research influence | Citation impact (normalized average citation per paper) | 32.50% |

Source: World University Rankings subject tables: Robust, transparent and sophisticated “(16 September 2010). *Times Higher Education World University Rankings*.” (16 September 2010). Times Higher Education World University Rankings.

**Table 3**
Methodology of formation of Quacquarelli Symonds (QS) World University Rankings.

| Indicator | Weighting | Elaboration |
|---|---|---|
| Academic peer review | 40% | Based on an internal global academic survey |
| Faculty/Student ratio | 20% | A measurement of teaching commitment |
| Citations per faculty | 20% | A measurement of research impact |
| Employer reputation | 10% | Based on a survey on graduate employers |
| International student ratio | 5% | A measurement of the diversity of the student community |
| International st aff ratio | 5% | A measurement of the diversity of the academic staff |

Source: “*QS World University Rankings: Methodology*”. *QS (Quacquarelli Symonds). 2014. Retrieved 29 April 2015.*

**Table 4**
Number of Universities of the studied countries ranked in each of world universities rankings.

| Country | Academic Ranking of World Universities 2016 | Times Higher Education World University Rankings 2016–2017 | QS World University Rankings 2016–2017 |
|---|---|---|---|
| France | 21 | 25 | 39 |
| Germany | 37 | 40 | 42 |
| Italy | 19 | 38 | 28 |
| Russian Federation | 3 | 24 | 22 |
| United Kingdom | 36 | 91 | 71 |

Publication activity of universities: methodological issues.

universities but not the quality of education itself and the education programs, level of students' knowledge, professional skills of the teaching staff and quality of the infrastructure and equipment of universities. All these university rankings are strongly biased towards overestimation of the number of publications and citations. This bias can easily be seen from the weights that are set on the indicators forming these rankings (Tables 1–3). The three above-mentioned rankings treat universities primarily as “generators” of highly cited publications but not as “places for teaching the students.” This means that the much higher positions in this ranking will be taken by so-called “research universities,” where the activities are biased towards research and development. This is a typical model for big Anglo-Saxon universities in the USA and the UK (as well as Canada, Australia and New Zealand) and to a lesser extent for universities in other Western European countries. A more detailed discussion of the limitations of world university rankings and their influence on the research activity and research evaluation policy in different countries can found for example in the studies by Marginson [49], Kehm and Stensaker [44], Aguillo et al. [6], Bowman and Bastedo [16] and Chen and Liao [18].

### 3.2. Scopus vs. Web of Science database

Here we analyze the publication activity of universities. To run the publication activity analysis, we should first choose the science citation database for deriving the data. Scopus[1] and Web of Science[2] are the world's two largest scientific citation databases. The Scopus database was formed by the publishing corporation Elsevier in 2004. As of May 2017, Scopus covers 67.6 million documents. Web of Science (WoS) was built on the basis of the first global citation database, the Science Citation Index, which was developed by E. Garfield and the Institute for Scientific Information (USA) in 1964. This database was launched in the early 1990s and is now owned by Thomson Reuters. Web of Science consists of its key database, the Web of Science Core Collection, and four additional databases (the KCI – Korean Journal Database; MEDLINE; SciELO Citation Index (leading open-access journals from Latin America, Portugal, Spain and South Africa); and Russian Science Citation Index (RSCI)). As of May 2017, the Web of Science Core Collection (including the Emerging Sources Citation Index (ESCI)) covers 65.2 million papers. Adding the KCI, MEDLINE, SciELO and RSCI databases to the Web of Science Core Collection increases the coverage of Web of Science to 73.9 million documents.

Scopus and Web of Science have specific advantages and limitations for different aspects of the analysis of publication activity. A discussion on the advantages and limitations of the Scopus and Web of Science databases can be found for example in the studies by Meho and Yang [50], Falagas et al. [28], Archambault et al. [12], Vieira and Gomes [72] and Shashnov and Kotsemir [66]. Since we are trying to detect the research performance of universities, we should have in operation a system of organization profiles. The key advantage of Scopus in this regard is the system of unique author and organization identifiers (profiles). Therefore, the user can analyze the publication activity of individual authors and organizations in Scopus. In Web of Science, these opportunities are seriously restricted. Therefore, taking into account the serious limitations of Web of Science in the analysis of individual authors and organizations, we run an analysis of milkfish research in the Scopus database, since Scopus provides the user with unique organization identifiers.

To derive publication activity indicators for universities in Russia, Italy, Germany, France and the UK, we use the Scopus SciVal analytical tool. Scopus SciVal is “a ready-to-use solution with unparalleled power and flexibility, SciVal enables you to visualize research performance, benchmark relative to peers, develop collaborative partnerships and analyze research trends” (see more about the features of the SciVal tool in Refs. [20,61]).[3] In our analysis we use the “Benchmarking” sub-tool of SciVal. As stated on the SciVal official website, “Benchmarking” can be used to “compare and benchmark your Institution to other Institutions, Researchers and Groups of Researchers using a variety of metrics.”

### 3.3. Indicators from the Scopus SciVal tool used in our analysis

In our analysis we use indicators of publication activity, citations and different forms of scientific collaboration (international, national and intraorganizational). This list of indicators is presented as follows.

#### 3.3.1. Number of publications in the Scopus database

The number of publications in all the sources indexed in Scopus (journals; conference proceedings; books; book series; trade publications; multi-volume reference works) for a given university for all fields of science in a given year, taking into account articles, reviews and conference papers as document types.

#### 3.3.2. Field-weighted citation impact (FWCI)

This indicator (field_cit) measures the relative citation level of publications of a specific country, university or individual researcher. FWCI is the ratio of citations received relative to the expected world average for the subject field, publication type and publication year. This is a normalized indicator of citations. Therefore, it can be applied to cross-disciplinary and intertemporal analyses.

#### 3.3.3. Outputs in the top 10 citation percentile (%) (output_top10)

This indicator shows the extent to which an entity's (country's, organization's) publications are present in the most-cited percentiles of a given publication volume. In our case this indicator shows the share of the publications of a university that are in the top 10% of the most-cited publications in the Scopus database.

#### 3.3.4. Share of publications in international collaborations (int_coll)

This indicator measures the share of publications in which the affiliation(-s) of the authors is set (and was (were) automatically detected) with at least two different countries. This indicator measures the integration of a country/organization/individual researcher into international scientific collaboration.

#### 3.3.5. Share of publications in national collaborations (nat_coll)

This indicator measures the intensity of national interorganizational collaborations. In essence, it is the share of publications for which the affiliation(-s) indicates at least two different organizations of one country.

#### 3.3.6. Share of publications in institutional (intraorganizational) collaborations (instit_coll)

This indicator measures the intensity of intraorganizational collaborations, that is, collaborations between different subdivisions of one organization. In essence it is the share of publications for which the affiliation(-s) of the author(-s) - is only one organization.

### 3.4. Problems of measuring the publication activity of organizations

We should take into account here the limitations of the use of bibliometric indicators. The first limitation is that bibliometric indicators measure only a certain pure technical part of the research productivity of a university regarding basic research – only publication activity. Meanwhile, quite a large number of different aspects of universities' research activity are beyond the scope of bibliometric indicators. The forms of university research activity that remain uncovered by bibliometric analysis are: joint research with industry and government in all forms; inter-university exchange of researchers; scientific expertise work of university researchers; and further commercialization of research carried out by universities in the form of patents and new products. For all these “missed” forms of research activity, statistical indicators are in general unavailable.

The other limitation of our analysis is that we focus only on the publication activity that is covered by the Scopus database. Since quite a small portion of nations' journals (especially in the case of Russia) is indexed in Scopus, we miss quite a significant number of national publications prepared by the universities under

[1] See more details at https://www.elsevier.com/solutions/scopus.
[2] See more details at http://clarivate.com/?product=web-of-science.
[3] More information is available at https://www.elsevier.com/solutions/scival.

consideration. National publications that are not covered by the Scopus or Web of Science database can be much more influential (both on the national and the international level) than papers that are indexed in international citation databases. One more limitation that comes from using the Scopus (or Web of Science) database is that it covers primarily journal articles and conference proceedings, while books and book chapters are covered to a lesser degree. Nevertheless, quite a large share of the publication activity of university researchers and teachers consists of textbooks, monographs and analytical reports. These types of publications in general remain beyond the scope of bibliometric indicators.

Below we discuss the problems of measuring and interpreting each specific bibliometric indicator that is used in our research model.

The number of publications is a basic indicator of the publication activity of a country, university or individual researcher. There are many factors that determine the number of publications of a university in the Scopus database. Regardless of the bibliometric analysis that we run, we should always bear in mind that databases like Scopus and Web of Science are in essence collections of journals, conference proceedings and book series. Therefore, if country A has 5000 journals indexed in Scopus while country B has only 25 journals, country A (and its universities) will by definition have a much higher number of publications in the Scopus/Web of Science database than country B. For example, as of October 2016, Russia has 271 journals indexed in the Scopus database.[4] Comparing this with the other countries in our analysis – France (1059 journals); Germany (2672 journals); Italy (850 journals); and the United Kingdom (6837 journals) – shows that the publication activity of the UK is much better covered by and presented in Scopus than that of Russia. This means that many very poor UK journals (with an impact factor less than 0.05) are indexed in Scopus and in general are treated as “high-quality international journals that are indexed in Scopus.” On the other hand, many top-class (on the national level) Russian journals are not indexed in Scopus for various reasons (not only their quality but also the lack of willingness of the editorial board to promote the journal in Scopus; the absence of a country-wide government campaign for the mass promotion of all the best national journals in Scopus) and in general are treated as “weak journals that are interesting only for Russian readers.” This results in Scopus seriously underestimating the publication activity of Russia (and its universities). The other very important point here is the model of the university. If a given university works like a research university, its primary goal is the generation of a large volume of publications in top-level journals. On the other hand, universities with the primary goal of teaching students pay more attention to education itself and do not publish as many publications as research universities. Therefore, “research universities” will “by default” have a higher number of publications than “classical” (i.e. “teaching”) universities. Not only the model but also the type of universities matters. If a given university is a big classical university with many faculties covering many different disciplines, it will have many more publications than narrowly specialized universities due to the contribution of research activity from teams of its members from thematically different faculties and departments. The indexing of journals of a specific university indexed in the Scopus/Web of Science database can also seriously increase its publication activity, since many articles will be indexed in Scopus/Web of Science by default. Finally, the membership of university staff members in editorial boards of journals indexed in Scopus matters. Universities where many staff members are members of editorial boards of journals indexed in Scopus/Web of Science will have a higher number of publications.

When using the field-weighted citation impact (FWCI) indicator, organizations with a more or less comparable number of publications should be compared. Obviously, if we compare small organizations (with 50 + researchers) that are working on only one highly cited topic (e.g. the mapping and measuring of brain neurons) with a huge classical multidisciplinary university (with 5000 + teachers and researchers), the small organization will have a much higher FWCI. The other important point here is that, when comparing country A with a high FCWI level and country B with a low FCWI level, it is obvious that organizations in country A will have higher levels of FCWI than organizations in country B.

As in the case of the field-weighted citation impact and the share of publications in international collaborations, small organizations working on a narrow, very highly cited topic will have a much larger share of publications in the 10% most-cited publications in Scopus. This indicator will also be much higher for small organizations that are working on mega-collaboration projects (with up to 3000 + authors in one publication). The above-mentioned situations should be taken into account. This indicator is more relevant to the direct comparison of big polythematic (i.e. working in different fields of science) organizations (i.e. so-called big “classical universities”). We should also bear in mind here that the intensity of international cooperation seriously differs across disciplines. In such fields as for example genetics, oncology, nuclear physics and radioastronomy, the intensity of international collaboration is high, while only national authors (without intensive international collaboration) in general write publications on history or literature. Therefore, when comparing small organizations that specialize in one topic (or several closely related ones), we should take into account the fact that organizations working in the field of genetics will have a much higher intensity of international collaboration than organizations working in the field of history. For big organizations with a polythematic departmental structure, direct comparison of the intensity of international collaboration is more relevant. Another question arises when analyzing mega-authorship publications with 50 or more authors. Since the real contribution of each of hundreds (and in some cases thousands) of authors is hard to detect, these publications should be analyzed separately from publications with a more or less “normal” number of co-authors (up to 25). Meanwhile, in Scopus (as well as in Web of Science), there is no automatic tool for excluding publications for which the number of co-authors is above a certain threshold.

## 4. Theoretical framework

This section will be devoted to presenting a basic non-overlapping generations model, as in Acemoglu [4], Aldieri and Vinci [8] and Aldieri et al. [9]; in which this model is applied to measure the effects of scientific collaboration on the research performance of the best Russian universities. We assume two economies: the domestic ($D$) and the foreign one ($X$). In each country institutions of higher education consist of two different types of universities in which the academic researchers, assumed to be risk-neutral with an inter-temporal preference rate equal to zero, live for two periods. In the first period, researchers, to strengthen their expertise and increase the research quality indicators of their academies, will choose their talent (research skills) and the optimal allocation of the latter between domestic and non-domestic partnerships. In the second period, scientific papers are

[4] We should note here that the affiliation of journal with a specific country is determined by the address of its publisher. Since some English language versions of Russian journals (especially those that are published by the Russian Academy of Sciences) are published abroad, these journals are determined by Scopus as being journals of Germany/the Netherlands/the USA and so on.

produced in the form of a partnership of researchers from two different types of academies. The benefits from the scientific partnership, captured by the research performance, taking into account both quantitative and qualitative characteristics, will appear at the end of this second period and concern both quantitative and qualitative characteristics.

In both countries scientific papers are produced according to the following functional forms:

$$P^d_{d,i,j,t} = A^d_d\left[(1-\beta)e^d_{i,t}\right]^{\gamma}\left[(1-\alpha)e^d_{j,t}\right]^{(1-\gamma)} \tag{1}$$

$$P^x_{d,i,j,t} = A^f_d\left[\beta e^d_{i,t}\right]^{\delta}\left[a e^f_{j,t}\right]^{(1-\delta)} \tag{2}$$

$$P^f_{f,i,j,t} = A^f_f\left[(1-b)e^f_{i,t}\right]^{\nu}\left[(1-a)e^f_{j,t}\right]^{(1-\nu)} \tag{3}$$

$$P^x_{f,ti,j,} = A^d_f\left[b e^f_{i,t}\right]^{g}\left[\alpha e^d_{j,t}\right]^{(1-g)} \tag{4}$$

where $0<\alpha,\beta,a,b,\gamma,\delta,\nu,g<1$, $P^d_{d,i,j,t}$ $(P^f_{f,i,j,t})$ stands for domestic scientific research partnerships' output and $e^d_{i,t}$ $(e^f_{i,t})$ and $e^d_{j,t}$ $(e^f_{j,t})$ measure respectively the talent of the *i-th* and *j-th* researchers in domestic and foreign economies. Parameters $A^d_d, A^f_f, A^f_d, A^d_f$ capture both the role of public research funds in the two countries and some technological and geographical proximity effects. We consider $A^f_d$ and $A^d_f$ as linear combinations of $A^d_d$ and $A^f_f$.

As in Aldieri et al. [9], we assume randomness of the matching functions, which implies for all the *i-type* researchers the same probability of meeting a *j-type* researcher. Moreover, terminating the match and switching the partner are costly. The consequential anonymity of contracts implies that *j(i)-type* researchers' decisions concerning talent skills depend on the whole distribution of talent across all the *i(j)-type* ones.

The aforesaid research performance indicators of the different universities, in both the geographic areas, depend on scientific production and may be written as:

$$I^d_{i,t} = \left[P^d_{d,i,j,t}\right]^{\theta}\left[P^x_{d,i,j,t}\right]^{(1-\theta)} \tag{5}$$

$$I^d_{j,t} = \left[P^d_{d,i,j,t}\right]^{\theta}\left[P^x_{f,i,j,t}\right]^{(1-\theta)} \tag{6}$$

$$I^f_{i,t} = \left[P^f_{f,i,j,t}\right]^{\tilde{\theta}}\left[P^x_{d,i,j,t}\right]^{\left(1-\tilde{\theta}\right)} \tag{7}$$

$$I^f_{j,t} = \left[P^f_{f,i,j,t}\right]^{\tilde{\theta}}\left[P^x_{f,i,j,t}\right]^{\left(1-\tilde{\theta}\right)} \tag{8}$$

with: $0<\theta,\tilde{\theta}<1$.

In the two economies, all kinds of university researchers maximize respectively the following utility functions:

$$U^d_{i,t} = I^{d,e}_{i,t} - \frac{\phi_i e^{d^{(1+\lambda)}}_{i,t}}{(1+\lambda)} \tag{9}$$

$$U^d_{j,t} = I^{d,e}_{j,t} - \frac{\phi_j e^{d^{(1+\lambda)}}_{j,t}}{(1+\lambda)} \tag{10}$$

$$U^f_{i,t} = I^{f,e}_{i,t} - \frac{\mu_i e^{d^{(1+\lambda)}}_{i,t}}{(1+\lambda)} \tag{11}$$

$$U^f_{j,t} = I^{f,e}_{j,t} - \frac{\mu_j e^{d^{(1+\lambda)}}_{j,t}}{(1+\lambda)} \tag{12}$$

where $\phi_i$, $\phi_j$, $\mu_i$ and $\mu_j$ are taste positive parameters capturing the disutility of accumulating scientific skills and $I^{d,e}_{i,t}, I^{d,e}_{j,t}, I^{f,e}_{i,t}$ and $I^{f,e}_{j,t}$ are expected values. The above equations may easily be rewritten as follows:

$$U^d_{i,t} = A^{d^{\theta}}_d A^{x^{(1-\theta)}}_d (1-\beta)^{\gamma\theta}\beta^{\delta(1-\theta)}(1-\alpha)^{(1-\gamma)\theta}a^{(1-\delta)(1-\theta)}e^{d^{\gamma\theta+\delta(1-\theta)}}_{i,t} \times \int e^{d^{\theta(1-\gamma)}}_{j,t}dj_d\int e^{f^{(1-\theta)(1-\delta)}}_{j,t}dj_f - \frac{\phi_i e^{d^{(1+\lambda)}}_{i,t}}{(1+\lambda)} \tag{13}$$

$$U^d_{j,t} = A^{d^{\theta}}_d A^{x^{(1-\theta)}}_f (1-\beta)^{\gamma\theta}b^{g(1-\theta)}(1-\alpha)^{(1-\gamma)\theta}\alpha^{(1-g)(1-\theta)}e^{d^{\theta(1-\gamma)+(1-g)(1-\theta)-1}}_{j,t} \times \int e^{d^{\gamma\theta}}_{i,t}dj_d\int e^{f^{g(1-\theta)}}_{i,t}di_f - \frac{\phi_j e^{d^{(1+\lambda)}}_{j,t}}{(1+\lambda)} \tag{14}$$

$$U^f_{i,t} = A^{f^{\tilde{\theta}}}_f A^{x^{(1-\tilde{\theta})}}_f (1-b)^{\nu\tilde{\theta}}b^{g\left(1-\tilde{\theta}\right)}(1-a)^{(1-\nu)\tilde{\theta}}\alpha^{(1-g)\left(1-\tilde{\theta}\right)}e^{f^{\nu\tilde{\theta}+g\left(1-\tilde{\theta}\right)}}_{i,t} \times \int e^{f^{\tilde{\theta}(1-\nu)}}_{j,t}dj_f\int e^{d^{\left(1-\tilde{\theta}\right)(1-g)}}_{j,t}dj_d - \frac{\mu_i e^{f^{(1+\lambda)}}_{i,t}}{(1+\lambda)} \tag{15}$$

$$U^f_{j,t} = A^{f^{\theta}}_f A^{x^{(1-\tilde{\theta})}}_d (1-b)^{\nu\tilde{\theta}}\beta^{\delta\left(1-\tilde{\theta}\right)}(1-a)^{(1-\nu)\tilde{\theta}}a^{(1-\delta)\left(1-\tilde{\theta}\right)}e^{f^{\tilde{\theta}(1-\nu)+(1-\delta)\left(1-\tilde{\theta}\right)-1}}_{j,t} \times \int e^{f^{\nu\tilde{\theta}}}_{i,t}dj_f\int e^{d^{\delta\left(1-\tilde{\theta}\right)}}_{i,t}di_d - \frac{\mu_j e^{f^{(1+\lambda)}}_{j,t}}{(1+\lambda)} \tag{16}$$

Assuming $\phi_i=\phi_1$, $\phi_j=\phi_2$, $\mu_i=\mu_1$ and finally $\mu_j=\mu_2$, on the basis of the above theoretical model, we can set out the following consequential results, which will be tested empirically in the following sections:

**Result 1**. *There are positive externalities between researchers' talents, regardless of the country, in the sense that small variations in talents' investments of all agents will make everyone better off. Moreover, when a small group of j-type (i-type) researchers invests more in research skills, other researchers will answer and the performances of all academies will improve.*

## 5. Empirical strategy and results

As we may observe in the methodological section, we obtain three variables to identify the level of academic performance: the number of publications (public) for the quantitative level of

**Table 5**
Principal components.

| Component | Eigenvalue | Difference | Proportion | Cumulative |
|---|---|---|---|---|
| Comp1 | 2.209 | 1.635 | 0.736 | 0.736 |
| Comp2 | 0.573 | 0.355 | 0.191 | 0.927 |
| Comp3 | 0.218 | – | 0.073 | 1.000 |

scientific research and two variables (field_cit and output_top10) for the qualitative one. To obtain an index for the overall quality of academic performance, we implement a principal component analysis (pca) procedure [11,41]. In particular, pca is a statistical technique used for data reduction. The leading eigenvectors stemming from the decomposition of the covariance matrix of the variables describe a series of uncorrelated linear combinations of the variables that represent most of the variance.

Table 5 and Graph 1 show the results of the above analysis.

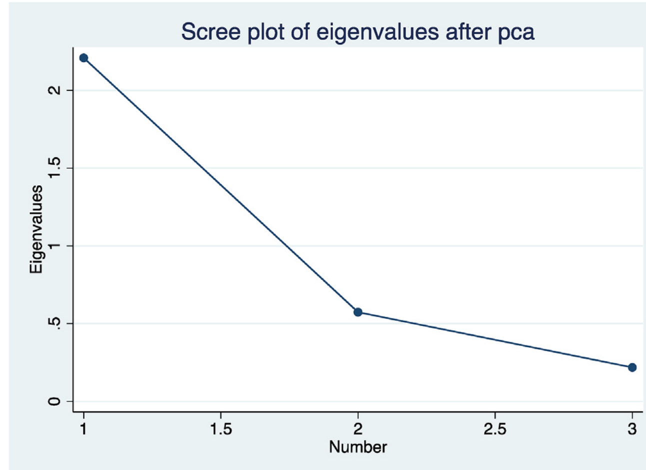
We consider the first component (PC) as our new dependent variable to identify the overall quality of academic research, explaining more than 70% of the variance. The model that is estimated is the following: $PC_{i,k} = C\,(Coll, x_{i,k}, z_i, w_k)$ (17).

Our empirical analysis aims to estimate the effect of internal collaborations (nat_coll), external collaborations (int_coll) and institutional collaborations (instit_coll) on the quality indicator of some European universities, measured by the new quality index (pc) obtained above. In particular, we investigate five countries: France, Germany, Italy, the UK and Russia. We have a panel data sample of 5080 (254 × 20) observations: 45 French universities + 50 German universities + 40 Italian universities + 92 English universities + 27 Russian universities over the 1996–2015 period of time.

The university-specific characteristics (vector $x_{i,k}$) include the number of postgraduate students (post_graduates). The institution-specific characteristics that affect the quality of a unit's publications ($z_i$) consider the “age” of an academic institution (age), that is, the years elapsed from its establishment to 2017, and the number of faculty staff (pstaff). Moreover, we take into account universities' potential by adding their size (number of students). The data about the numbers of students, faculty staff and postgraduate students are taken from the personal pages of the studied universities in the Times Higher Education (THE) World University Rankings 2016–2017.[5] The data on the age of universities (taken from the year of their establishment) are taken from the Wikipedia website.[6] Summary statistics for the selected variables are reported in Table 6.

The publications in scientific fields ($w_k$ in the model) are grouped into six sectors: biomedical and chemical sciences, engineering and computer science, medical sciences, multidisciplinary, physical and engineering sciences, and social sciences and humanities.

We introduce different methods to estimate (17). First, we run an OLS, taking into account time dummies and heterogeneity from country and scientific fields. Second, we develop a random-effect panel model to pick out the individual and time features of the sample. Finally, to handle the potential endogeneity of collaborations, we use GMM techniques for instrumental variables, which allow endogenous variables to be instrumented by excluded instruments.




**Graph 1.** Plot of eigenvalues after pca.

**Table 6**
Descriptive statistics.

| Variable | Mean | Std Dev. |
|---|---|---|
| pc | 0.01 | 1.707 |
| public | 1137.81 | 1302.311 |
| Field_cit | 1.28 | 0.483 |
| Output_top10 | 13.02 | 7.038 |
| Int_coll | 34.15 | 12.460 |
| Nat_coll | 22.83 | 7.504 |
| Instit_coll | 27.69 | 11.364 |
| age | 227.70 | 221.421 |
| pstaff | 1626.46 | 1241.742 |
| students | 22200.24 | 14915.580 |
| Post_graduates | 6484.15 | 6891.405 |

Note: 5080 observations.

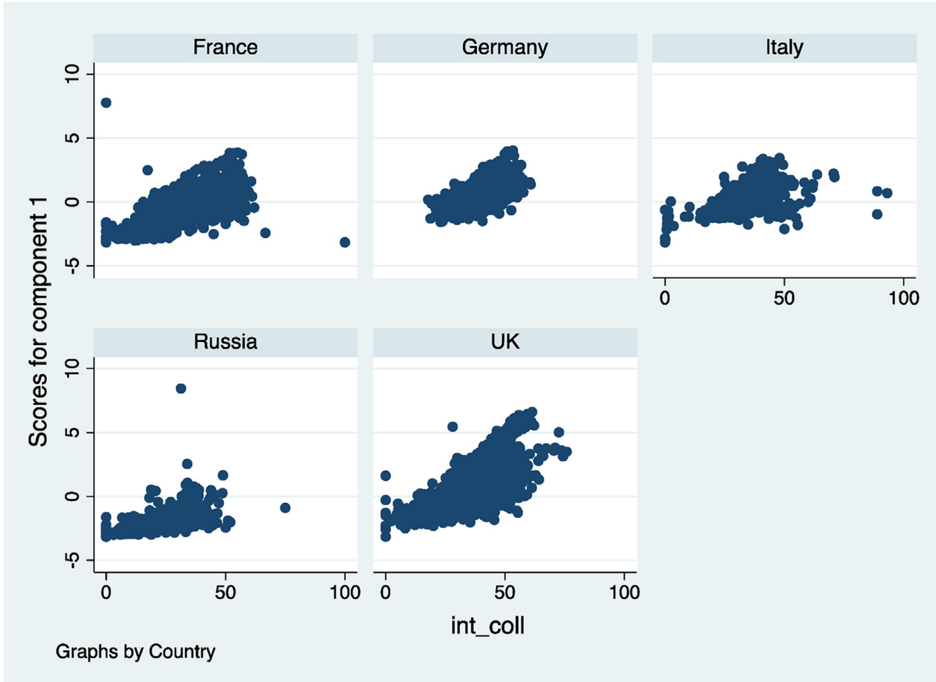
The consistency of the endogeneity test as well as the coefficient estimates of the GMM depend on the relevance and validity of the instruments. These are relative to the variables that have an effect, both theoretically and conceptually, on the suspected endogenous variable (collaborations) but that do not otherwise affect the quality index of research.

**Table 7**
Empirical results.

| Coeff. Est[d]. | OLS[b] | | RE Model | | GMM | |
|---|---|---|---|---|---|---|
| | Coeff.[c] | s.e.[a] | Coeff. | s.e.[a] | Coeff. | s.e.[a] |
| Int_coll | 0.05*** | (0.002) | 0.03*** | (0.001) | 0.05*** | (0.004) |
| Nat_coll | 0.02*** | (0.003) | 0.01*** | (0.001) | −0.10*** | (0.022) |
| Instit_coll | 0.01** | (0.002) | 0.01 | (0.001) | 0.01 | (0.004) |
| age | 0.01*** | (0.001) | 0.00 | (0.002) | 0.01 | (0.001) |
| pstaff | 0.01*** | (0.001) | 0.01*** | (0.001) | 0.01*** | (0.001) |
| students | −0.01*** | (0.001) | −0.01*** | (0.001) | −0.01*** | (0.001) |
| Post_graduates | 0.01*** | (0.001) | 0.01*** | (0.001) | 0.01*** | (0.001) |
| $R^2$ | 0.73 | | 0.76 | | | |

[a] *** Coefficient significant at the 1% level.
[b] Year, field and country dummies are included in the estimation procedure. The year 1996, the biomedical and chemical sciences field and the country France are reference indicators.
[c] Standard errors are corrected for heteroscedasticity.
[d] 5080 observations.

[5] https://www.timeshighereducation.com/world-university-rankings/2017/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats or QS World University Rankings 2016–2017 https://www.topuniversities.com/university-rankings/world-university-rankings/2016.
[6] www.wikipedia.org.




**Graph 2.** pc-Int_coll plot by country.

The identification of the causal effect of collaborations on the academic performance index will be achieved if the instruments are uncorrelated with the structural error but correlated with the endogenous regressor (collaborations). To evaluate whether potential instruments are weak and whether the instruments are orthogonal to the error process, opportune tests are employed.

First, the relevance of the instruments is assessed by evaluating the *F*-test for joint significance in the first-stage regression. The first-stage regression is a reduced-form regression of the endogenous variable on the full set of instruments and other exogenous regressors.

A rule of thumb states that an *F*-statistic below about 10 is indicative of a weak instrument problem [67,69]. In our case we obtain $F = 62.43$, clearly far above the threshold value of 10.

Second, the validity of the instruments is tested by an overidentification test. Since we use only an instrument for national collaborations, the number of international students, we cannot implement these statistical tests (Table 7).

As we may observe from the empirical findings, international collaborations help universities' quality index. Graph 2, relative to the link between the quality index and the international collaborations by country, evidences a homogeneous pattern for France, Germany and the UK and heterogeneous behavior for Italy and Russia, which exhibit more concentrated data towards low levels of collaborations and the quality index of research.

## 6. Conclusions and policy implication

The scientific openness degree of universities towards other academic institutions is becoming more important in the analysis of knowledge flows between researchers. This topic is central to the accumulation of human capital and talents' allocation for countries' economic growth.

For this reason our main objective in this paper is to investigate the effects of scientific collaborations on universities' performance in five countries: France, Germany, the UK, Italy and Russia. The academic quality is measured through a new index computed from quantitative and qualitative variables by principal component analysis.

This topic has become important in any debate on policies to foster productivity in different countries. We approach this issue both theoretically and empirically. In particular, the rationale behind the model is that the scientific publications published by collaborations generate positive externalities for all the universities involved in the economic process, as introduced through the theoretical model.

Moreover, we estimate different econometric models to evidence the impact of scientific collaborations on universities' performance. The data refer to the top 45 French, 50 German, 92 English, 40 Italian and 27 Russian universities observed for 20 years from 1996 to 2015. First, we run an OLS, taking into account time dummies and heterogeneity from country and scientific fields. Second, we develop a random-effect panel model to pick out the individual and time features of the sample. Finally, to handle the potential endogeneity of collaborations, we use GMM techniques for instrumental variables, which allow endogenous variables to be instrumented by excluded instruments. Indeed, we use the mobility of students as instruments for the endogeneity of the collaborations variable.

The findings of all the models evidence the importance of collaborations for academic performance. Furthermore, we show that the knowledge flows that arise among researchers from different universities are relevant to enhancing the quality of research.

The results of our work have a relevant implication for science policy. Knowledge exchange among researchers is crucial to obtain the highest research quality. With this aim Italian and Russian universities should improve their interactions with international institutional partners.

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## Appendix A. Review of studies of the effects of scientific collaboration

**Table A.1**
Evidences for support of the statements about the positive influence of collaboration on research performance from academic literature.

| Authors, years | Country(-ies)/institution(-s), field(-s) of science, year(-s) of analysis | Note about research collaboration derived from the abstract of the paper |
|---|---|---|
| **Cases of International collaboration** | | |
| Landry et al. [48] | Industry-university collaboration | It was found that collaboration between researchers and industry had significantly more impact on productivity than collaborations between researchers and their peers or researchers and other institutions |
| Fu et al. [32] | Acupuncture research, 1980–2009 | International collaborative papers are the most frequently cited. |
| Kato and Ando [43] | International collaboration in chemistry | The results also indicate that researchers who collaborate internationally accumulate science and technology human capital through collaboration. |
| Sweileh et al. [70] | Worldwide, tramadol studies | Collaboration among pharmaceutical industry, clinical researchers and academic institutions can improve research quantity and quality on tramadol |
| **Cases of developed countries** | | |
| Zucker and Darby [76] | Japan, firms, biotechnology | … we find that identifiable collaborations between particular university star scientists and firms have a large positive impact on firms' research productivity, increasing the average firm's biotech patents by 34%, products in development by 27%, and products on the market by 8% as of 1989–1990 |
| Olmeda-Gómez et al. [55] | Catalonian universities, 2000–2004 | As a whole, they prefer to collaborate with institutions in the United States, the United Kingdom, France, Germany and Italy, and obtain better visibility when publishing with English-speaking authors. |
| Abramo et al. [1] | Italian university scientists and researchers in the private sector | The analyses demonstrate that university researchers who collaborate with those in the private sector show research performance that is superior to that of colleagues who are not involved in such collaboration. |
| Olmeda-Gómez et al. [56] | Spanish universities, 2000–2004 | Greater visibility is attained with international co-authorship than with any other type of collaboration studied. |
| Andersen et al. [10] | Publication activity at Aalborg Hospital | . Results also show a relation between the score level of publications and the number of collaborations for the publication, i.e. large collaborations are more frequently published in top journals. |
| Abramo et al. [2] | Italian university population working in the hard sciences over the period 2001–2005 | The results show that the researchers with top performance with respect to their national colleagues are also those who collaborate more abroad, but that the reverse is not always true |
| Abramo et al. [3] | Italian university researchers, 2001–2005 | The results of the investigation, which assumes co-authorship as proxy of research collaboration, show that both research productivity and average quality of output have positive effects on the degree of international collaboration achieved by a scientist. |
| Beaudry and Allaoui [14] | Canada, nanobiotechnology | Results suggest that individual funding and a strong position in the past collaborative network has a positive effect on research output. In contrast to a number of studies, contracts are not found to have a negative influence on publication, quite the contrary |
| Graue et al. [35] | Diabetes research in four Nordic countries (Denmark, Iceland, Norway and Sweden) from 1979 to 2009 | International collaborative research networks facilitate funding opportunities and contribute to further development of professional research competence. |
| Kodama et al. [45] | Four Japanese universities, stem cell-related research | … we demonstrated a research assessment by proposing and introducing key performance indicators and found that a certain degree of interdisciplinarity and internal collaboration may bring about high research productivity. |
| De Filippo et al. [22] | 81 public and private universities in Spain, 2002–2011 | Collaboration profiles show that the university system changed from a model in which authorship from a single institution was the norm, to one in which international collaboration is the most prevalent. |
| Elhorst and Zigova [27] | Austria, Germany, Switzerland; all academic economists employed at 81 universities and 17 economic research institutes | … empirical results support the hypotheses that collaboration and that the existence of economies of scale increase research productivity |
| Gausia et al. [33] | 11 University Departments of Rural Health (UDRH) in Australia | Better collaboration between UDRH staff and others may help increase the quality and value of Australian rural health research. |
| O'Leary et al. [53] | University of Toronto's Faculty of Medicine, 2008–2012 | The academic departments with the highest levels of collaboration and interdisciplinary research activity also had the highest research impact. |
| **Cases of developing countries** | | |
| Numprasertchai and Igel [52] | University Laboratories in Thailand | Collaboration provides access to a greater breadth and depth of research knowledge than pure inhouse development |
| Stein et al. [68] | brain-behavior research in South Africa | Local and international collaboration may be useful in increasing research capacity in South Africa, and ultimately in improving mental health services |

(*continued on next page*)

**Table A.1** (*continued* )

| Authors, years | Country(-ies)/institution(-s), field(-s) of science, year(-s) of analysis | Note about research collaboration derived from the abstract of the paper |
|---|---|---|
| Donato and De Oliveira [25] | Portugal, Oncology, 1997–2006 | Articles with international collaboration where those which obtained the highest citation rate |
| Geracitano et al. [34] | Latin America, environmental studies, 1999–2008 | the establishment of collaborative studies could be one of the strategies to improve Latin American visibility in environmental studies |
| Obamba and Mwema [54] | Symmetry and asymmetry: New contours, paradigms, and politics in African academic partnerships | This paper suggests that strategic international research collaboration between research communities located within Africa and those in developed countries, as well as regional partnerships among African universities themselves, represent the most productive framework for reinvigorating and strengthening research capacity within sub-Saharan universities |
| Franco et al. [30] | Embrapa company, animal reproduction, 2008–2012 | The proposal of collaborative research improved the scientific production of the group and also the development of products, processes, and technical information to the private sector |
| Huamaní and Mayta-Tristán [39] | Peru, Medicine, 2000–2009 | The most productive Peruvian institutions collaborate more intensively with foreign journals rather than local institutions. |
| Wang et al. [74] | National Taiwan University (NTU) and Peking University (PKU), 2000–2009 | Article impact followed a decreasing order of international collaboration, inter-institutional collaboration, and independent articles for both universities. |
| Riahi et al. [62] | Iran, Immunology and Microbiology, 2000–2012, | … scientific collaborations with researchers in other countries could play a major role in enhancing the level of knowledge of our researchers |
| Chuang and Ho [19] | Highly cited publications in Taiwan | . International collaboration was responsible for the increasing number of highly cited papers over the years. |
| Isiordia-Lachica et al. [40] | Mexico, Universidad de Sonora, 2000–2009 | International co-authorship produced higher citation rates |
| Rasolabadi et al. [60] | Epilepsy research in Iran | It is necessary to prepare conditions for epilepsy researchers to collaborate more with international scientific societies in order to produce more and high quality papers |
| Chakravarty and Madaan [17] | Chandigarh city affiliations, 1964–2014 | An important finding of the paper undertaken is that foreign collaborations and foreign journals have remained the epicenter of the research activity. …. National and international collaborations also form the basis of growth of research productivity |
| Savic et al. [65] | Faculty of Sciences, University of Novi Sad, Serbia | The obtained results show that the organizational structure of the institution has a profound impact on both inter- and intra-institutional research collaboration. Moreover, researchers involved in inter-department collaborations tend to be drastically more productive (by all considered productivity measures), collaborative (measured by the number of co-authorship relations) and institutionally important (in terms of the betweenness centrality in the co-authorship network) compared to those who collaborate only with colleagues from their own research departments. |
| Zdravkovic et al. [75] | Five southern African Universities, mathematics, physics, chemistry, 1995–2014 | The results also show that collaboration with southern scientists is equally valued as that with northern scientists, but for different reasons. We conclude that supporting international and national collaboration which includes increased scientific mobility, strong scientific groups and networks, are key factors for capacity building of research in southern African Universities |
| **Cases of the least developed countries** | | |
| Dakik et al. [21] | Medical faculty at the American University of Beirut (AUB), 1996–2001 | Collaboration with international investigators resulted in more original publications than work done only at AUB (65% v 35%, $p < 0.001$), and a higher journal impact factor for the publications (3.20 (3.85) v 1.71 (2.36), $p < 0.05$) |
| Akakandelwa [7] | University of Zambia, 2002–2007 | The results confirm that the patterns of collaboration between UNZA researchers and foreign researchers fit the Lotka Law of distribution. The study also established a positive relationship between author productivity and author collaboration. The more collaborative an author is, the more productive that author is. Finally, the study observed a growing collaboration between University of Zambia researchers and other researchers in the Southern African universities. |
| Menon et al. [51] | University of Zambia | For researchers, collaboration provides opportunities to work with other leading scholars in their field. This international dimension of universities is also essential to promote competition and produce high quality education and research output. Outputs of such collaborations include more innovative research outcomes, enhanced ability to address global challenges and stronger research capacity. |
| de Filippo et al. [23] | Revista de Biología Tropical/International Journal of Tropical Biology and Conservation (Costa Rica), 2003–2012 | Data showed an increasing collaboration between authors, institutions and countries, and a direct relationship between the increase of this collaboration and the received impact. |

## *Appendix b. Universities of France, Germany, Italy, UK and Russia that are indexed in ARWU and/or THE WUR and/or QS WUR in 2016–2017 and their key bibliometric indicators in 2015*

**Table B.1**
Universities of France that are indexed in ARWU and/or THE WUR and/or QS WUR in 2016–2017 and their key bibliometric indicators in 2015.

| Scopus ScVal name | ARWU 2016 | THE WUR 2016-2017 | QS WUR 2016-2017 | N of Pubbs | FWCI | Int collab |
|---|---|---|---|---|---|---|
| Universite Paris 6 | 39 | 121 | 141 | 6 379 | 1.71 | 56.8 |
| Universite d'Aix-Marseille | 101-150 | 301-350 | 411-420 | 4 845 | 1.66 | 55.3 |
| Universite Grenoble Alpes | | | 206 | 4 312 | 1.37 | 54.2 |
| Universite Paris 7 | 101-150 | 201-250 | 262 | 4 090 | 1.86 | 53.0 |
| Universite Paris-Sud | 46 | 179 | 241 | 3 817 | 1.95 | 55.8 |
| Universite Paris 5 | 151-200 | 201-250 | 377 | 3 594 | 1.77 | 46.3 |
| Universite de Strasbourg | 101-150 | 301-350 | 260 | 2 894 | 1.55 | 55.3 |
| Universite Claude Bernard Lyon 1 | 201-300 | 351-400 | 501-550 | 2 552 | 1.50 | 50.7 |
| Universit? de Lorraine | 201-300 | | 701+ | 2 204 | 1.46 | 51.9 |
| Universite de Bordeaux | 151-200 | 301-350 | 501-550 | 2 154 | 1.79 | 49.3 |
| Universite de Montpellier | 301-400 | 351-400 | 327 | 1 911 | 1.52 | 56.6 |
| Universite de Nice-Sophia Antipolis | 401-500 | 401-500 | 601-650 | 1 348 | 1.48 | 55.5 |
| Universite Toulouse III - Paul Sabatier | 201-300 | | 461-470 | 1 279 | 1.66 | 52.9 |
| Universite Paris Sorbonne - Paris IV | 401-500 | 351-400 | 221 | 1 256 | 1.57 | 51.1 |
| Universite de Lille 2 | | | 701+ | 1 254 | 1.98 | 36.4 |
| Universite de Nantes | | 401-500 | 701+ | 1 252 | 1.63 | 43.5 |
| Universite des Sciences et Technologies de Lille | | | 501-550 | 1 201 | 1.07 | 57.5 |
| Universite de Rennes 1 | | 501-600 | 601-650 | 1 062 | 1.21 | 49.2 |
| Universite de Franche-Comte | | 501-600 | | 986 | 1.43 | 44.5 |
| Universite de Caen | | | 701+ | 984 | 1.40 | 43.4 |
| Universite de Poitiers | | | 701+ | 898 | 1.31 | 47.0 |
| Universite Joseph Fourier | 151-200 | | | 818 | 1.72 | 41.4 |
| Universite de Versailles | 401-500 | | | 778 | 1.97 | 51.0 |
| Ecole Normale Superieure | 87 | 66 | 33 | 597 | 1.64 | 61.1 |
| Ecole des Mines de Paris | 401-500 | 251-300 | | 445 | 1.15 | 42.7 |
| Ecole Normale Superieure de Lyon | 301-400 | 201-250 | 177 | 443 | 2.27 | 60.7 |
| Ecole Ponts ParisTech | | 351-400 | 268 | 433 | 1.56 | 37.0 |
| CentraleSupelec | | 201-250 | 164 | 414 | 1.96 | 57.5 |
| INSA de Lyon | | 501-600 | 421-430 | 396 | 1.19 | 46.2 |
| Universite Paris 1 Pantheon-Sorbonne | | 401-500 | 228 | 363 | 0.89 | 30.3 |
| Ecole Polytechnique | 301-400 | 116 | 53 | 344 | 1.29 | 52.8 |
| Universite de Cergy-Pontoise | | 801+ | 701+ | 318 | 1.22 | 45.0 |
| Ecole Centrale de Lyon | | 601-800 | | 204 | 0.89 | 51.5 |
| Ecole Normale Superieure de Cachan | | 401-500 | 264 | 195 | 1.26 | 59.0 |
| Universite Paris Dauphine | 301-400 | | 356 | 189 | 1.22 | 39.2 |
| Universite Lumiere - Lyon 2 | | | 701+ | 171 | 0.59 | 27.5 |
| Universite Paris X Nanterre | | | 701+ | 162 | 0.93 | 33.3 |
| Universite Charles de Gaulle Lille 3 | | | 701+ | 125 | 0.29 | 27.2 |
| Paul Valery University of Montpellier | | | 701+ | 112 | 0.77 | 30.4 |
| Universite de Toulouse II - Le Mirail | | | 701+ | 90 | 1.09 | 45.6 |
| Sciences Po | | | 220 | 84 | 2.30 | 35.7 |
| ESPCI | 301-400 | | | 79 | 1.24 | 50.6 |
| Universite Toulouse 1 Capitole | | | 701+ | 69 | 1.01 | 43.5 |
| Universite Jean Moulin Lyon 3 | | | 701+ | 33 | 0.39 | 21.2 |
| Universit? Panth?on-Assas (Paris 2) | | | 601-650 | 23 | 0.76 | 34.8 |
| **Average mean** | | | | 1 270 | 1.39 | 46.5 |
| **Stand. Dev** | | | | 1 500 | 0.45 | 9.9 |
| **Stand, dev/average** | | | | 1.18 | 0.33 | 0.21 |
| **Max** | | | | 6 379 | 2.30 | 61.1 |
| **Min** | | | | 23 | 0.29 | 21.2 |
| **variation coiefficient** | | | | 7.834 | 2.159 | 1.413 |
| **Root-mean-square deviation** | | | | 9950.8 | 3.0 | 65.7 |

Note: ARWU (Academic Ranking of World Universities) THE WUR (Times Higher Education World University Rankings); QS WUR (Quacquarelli Symonds World University Rankings); N of Pubs – Number of Publications in Scopus for 2015: FWCI – Field-weighted citation impact in 2015; Int collab - Share of publications in international collaboration in 2015.

**Table B.2**
Universities of Germany that are indexed in ARWU and/or THE WUR and/or QS WUR in 2016–2017 and their key bibliometric indicators in 2015.

| Scopus ScVal name | ARWU 2016 | THE WUR 2017-2017 | QS WUR 2016-2017 | N of Pubbs | FWCI | Int collab |
|---|---|---|---|---|---|---|
| Technische Universitat Munchen | 47 | 46 | 60 | 6 025 | 1.72 | 50.2 |
| University of Heidelberg | 47 | 43 | 72 | 5 423 | 2.08 | 53.3 |
| Ludwig-Maximilians-University Munchen | 51 | 30 | 68 | 5 286 | 1.92 | 53.8 |
| RWTH Aachen University | 201-300 | 78 | 146 | 4 309 | 1.48 | 41.7 |
| Technische Universitat Dresden | 151-200 | 164 | 210 | 4 068 | 1.69 | 48.7 |
| Karlsruhe Institute of Technology KIT | 201-300 | 144 | 98 | 3 945 | 1.58 | 51.6 |
| University of Erlangen-Nuremberg | 151-200 | 160 | 272 | 3 874 | 1.66 | 48.6 |
| University of Freiburg | 101-150 | 95 | 163 | 3 444 | 1.68 | 51.8 |
| University of Bonn | 101-150 | 113 | 231 | 3 433 | 1.88 | 56.8 |
| University of Tubingen | 151-200 | 89 | 167 | 3 306 | 1.70 | 54.5 |
| University of Gottingen | 101-150 | 112 | 177 | 3 234 | 1.97 | 54.9 |
| Goethe University Frankfurt | 101-150 | 201-250 | 264 | 3 109 | 1.72 | 50.1 |
| University of Munster | 101-150 | 161 | 294 | 2 853 | 1.59 | 47.7 |
| University of Cologne | 201-300 | 170 | 347 | 2 754 | 1.86 | 52.7 |
| University of Mainz | 201-300 | 251-300 | 401-410 | 2 706 | 1.84 | 55.5 |
| Ruhr-Universitat Bochum | 201-300 | 251-300 | 451-460 | 2 691 | 1.42 | 45.4 |
| University of Duisburg-Essen | | 197 | 601-650 | 2 652 | 2.17 | 46.3 |
| University of Wurzburg | 151-200 | 186 | 421-430 | 2 590 | 1.96 | 55.2 |
| Friedrich-Schiller-Universitat Jena | 301-400 | | 363 | 2 528 | 1.52 | 46.6 |
| University of Leipzig | 151-200 | | 501-550 | 2 399 | 1.52 | 45.0 |
| Technische Universitat Berlin | 301-400 | 82 | 164 | 2 357 | 1.61 | 46.0 |
| University of Hamburg | 201-300 | 180 | 232 | 2 230 | 1.66 | 57.5 |
| University of Ulm | 201-300 | 135 | 347 | 2 111 | 2.10 | 50.0 |
| Technische Universitat Darmstadt | 401-500 | 201-250 | 247 | 2 109 | 1.33 | 46.0 |
| University of Kiel | 151-200 | 201-250 | 421-430 | 2 100 | 1.93 | 49.4 |
| Freie Universitat Berlin | | 75 | 123 | 2 092 | 1.47 | 49.1 |
| Humboldt-Universitat zu Berlin | | 57 | 121 | 2 077 | 1.77 | 53.5 |
| Heinrich-Heine-University Dusseldorf | 401-500 | | 601-650 | 2 051 | 1.76 | 48.2 |
| Universitat Stuttgart | 401-500 | 201-250 | 263 | 1 998 | 1.30 | 39.1 |
| Hannover Medical School | 301-400 | | | 1 896 | 1.82 | 47.5 |
| Saarland University | | | 501-550 | 1 728 | 1.46 | 42.2 |
| University of Regensburg | 401-500 | | 501-550 | 1 661 | 1.53 | 43.7 |
| University of Bremen | 401-500 | 301-350 | 441-450 | 1 635 | 1.56 | 48.1 |
| Universitat Hannover | 401-500 | 351-400 | 400 | 1 519 | 1.35 | 41.8 |
| University of Rostock | 401-500 | | 651-700 | 1 441 | 1.37 | 45.6 |
| Philipps-Universitat Marburg | 301-400 | 251-300 | 551-600 | 1 435 | 1.92 | 47.9 |
| Otto-von-Guericke University Magdeburg | | 501-600 | | 1 370 | 1.41 | 40.6 |
| University of Potsdam | 401-500 | | | 1 330 | 1.58 | 60.5 |
| Universitat Dortmund | | 301-350 | 551-600 | 1 297 | 1.57 | 44.6 |
| Martin-Luther-Universitat Halle-Wittenberg | 301-400 | | 501-550 | 1 257 | 1.47 | 47.1 |
| Technische Universitat Braunschweig | | | 471-480 | 1 213 | 1.76 | 46.7 |
| Universitat Bielefeld | 401-500 | 251-300 | 601-650 | 1 056 | 1.53 | 45.6 |
| Universitat Bayreuth | 401-500 | 251-300 | 501-550 | 965 | 1.65 | 52.7 |
| University of Konstanz | 401-500 | 194 | 352 | 940 | 1.49 | 56.0 |
| University of Kaiserslautern | | 351-400 | | 838 | 1.25 | 40.5 |
| University of Greifswald | | 401-500 | | 733 | 1.34 | 49.4 |
| University of Paderborn | | 501-600 | | 713 | 1.46 | 40.3 |
| University of Hohenheim | | 251-300 | | 692 | 1.61 | 47.7 |
| Universitat Siegen | | 401-500 | | 662 | 1.58 | 57.7 |
| University of Mannheim | | 102 | 411-420 | 441 | 1.81 | 38.3 |
| **Average mean** | | | | 2 292 | 1.63 | 48.6 |
| **Stand. Dev** | | | | 1 286 | 0.22 | 5.3 |
| **Stand, dev/average** | | | | 0.56 | 0.13 | 0.11 |
| **Max** | | | | 3 945 | 2.17 | 60.5 |
| **Min** | | | | 441 | 1.25 | 38.3 |

Note: ARWU (Academic Ranking of World Universities) THE WUR (Times Higher Education World University Rankings); QS WUR (Quacquarelli Symonds World University Rankings); N of Pubs – Number of Publications in Scopus for 2015: FWCI – Field-weighted citation impact in 2015; Int collab - Share of publications in international collaboration in 2015.

**Table B.3**
Universities of Italy that are indexed in ARWU and/or THE WUR and/or QS WUR in 2016–2017 and their key bibliometric indicators in 2015.

| Scopus ScVal name | ARWU 2016 | THE WUR 2017-2017 | QS WUR 2016-2017 | N of Pubbs | FWCI | Int collab |
|---|---|---|---|---|---|---|
| University of Rome La Sapienza | 151-200 | 251-300 | 223 | 6 839 | 1.72 | 43.9 |
| University of Padova | 151-200 | 301-350 | 338 | 5 084 | 1.79 | 48.8 |
| University of Bologna | 201-300 | 201-250 | 208 | 5 019 | 1.95 | 46.7 |
| University of Milan | 201-300 | 301-350 | 370 | 4 960 | 1.64 | 45.9 |
| University of Naples Federico II | 301-400 | 401-500 | 481-490 | 4 623 | 1.82 | 42.7 |
| Politecnico di Milano | 201-300 | 201-250 | 183 | 3 578 | 1.60 | 46.7 |
| University of Turin | 201-300 | 351-400 | 551-600 | 3 500 | 1.62 | 47.1 |
| University of Florence | 201-300 | 401-500 | 451-460 | 3 385 | 1.63 | 45.0 |
| University of Pisa | 201-300 | 401-500 | 431-440 | 3 234 | 2.01 | 44.2 |
| Universita Degli Studi Di Genova | | 401-500 | 701+ | 2 710 | 1.89 | 45.5 |
| University of Rome Tor Vergata | 401-500 | 401-500 | 481-490 | 2 567 | 1.62 | 48.5 |
| Politecnico di Torino | | 351-400 | 305 | 2 181 | 1.56 | 40.6 |
| University of Pavia | 301-400 | 301-350 | 551-600 | 2 128 | 1.84 | 49.2 |
| University of Catania | | 501-600 | 701+ | 2 072 | 1.84 | 37.0 |
| Universita di Palermo | 401-500 | 501-600 | 701+ | 1 940 | 1.66 | 34.7 |
| University of Bari | | 401-500 | 701+ | 1 922 | 1.76 | 42.1 |
| University of Perugia | 401-500 | | 701+ | 1 833 | 2.29 | 45.3 |
| University of Milan - Bicocca | 301-400 | 351-400 | 651-700 | 1 815 | 1.77 | 50.7 |
| Universita Cattolica del Sacro Cuore, Rome | | 501-600 | 491-500 | 1 723 | 1.50 | 37.4 |
| Universita di Salerno | | 401-500 | 701+ | 1 598 | 2.29 | 38.4 |
| University of Trento | | 201-250 | 441-450 | 1 589 | 1.91 | 54.8 |
| University of Modena and Reggio Emilia | | 401-500 | 651-700 | 1 485 | 1.60 | 42.0 |
| University of Parma | 401-500 | 501-600 | | 1 481 | 1.45 | 42.3 |
| University of Cagliari | | 501-600 | | 1 425 | 1.43 | 43.0 |
| University of Trieste | | 351-400 | 701+ | 1 385 | 1.74 | 51.6 |
| University of Siena | | 501-600 | | 1 338 | 1.63 | 45.7 |
| University of Ferrara | 401-500 | 401-500 | 701+ | 1 319 | 1.81 | 50.6 |
| University of Calabria | | 351-400 | | 1 312 | 2.02 | 47.2 |
| Universita Politecnica delle Marche | | 401-500 | | 1 288 | 1.85 | 35.0 |
| University of Verona | | 401-500 | | 1 223 | 1.56 | 45.3 |
| Universita Vita-Salute San Raffaele | 401-500 | | 701+ | 1 218 | 2.02 | 53.0 |
| Universita Roma Tre | | 401-500 | 701+ | 1 132 | 1.61 | 49.3 |
| University of Brescia | | 401-500 | 701+ | 1 064 | 1.69 | 42.2 |
| University of Salento | 401-500 | 351-400 | | 906 | 2.00 | 39.2 |
| Scuola Superiore Sant'Anna di Studi Universitari e di Perfezionamento | | 190 | | 606 | 1.80 | 38.6 |
| Scuola Normale Superiore di Pisa | 401-500 | 137 | | 522 | 2.00 | 64.9 |
| University of Venice | | 501-600 | 701+ | 453 | 1.14 | 41.3 |
| University of Urbino | | 501-600 | | 342 | 1.77 | 49.4 |
| Universita di Bergamo | | 401-500 | | 335 | 1.78 | 32.5 |
| Libera Universita di Bolzano | | 251-300 | | 331 | 2.15 | 51.7 |
| **Average mean** | | | | 2 087 | 1.77 | 45.0 |
| **Stand. Dev** | | | | 1 510 | 0.23 | 6.2 |
| **Stand, dev/average** | | | | 0.72 | 0.13 | 0.14 |
| **Max** | | | | 6 839 | 2.29 | 64.9 |
| **Min** | | | | 331 | 1.14 | 32.5 |

Note: ARWU (Academic Ranking of World Universities) THE WUR (Times Higher Education World University Rankings); QS WUR (Quacquarelli Symonds World University Rankings); N of Pubs – Number of Publications in Scopus for 2015: FWCI – Field-weighted citation impact in 2015; Int collab - Share of publications in international collaboration in 2015.

**Table B.4**
Universities of the United Kingdom that are indexed in ARWU and/or THE WUR and/or QS WUR in 2016–2017 and their key bibliometric indicators in 2015.

| Scopus ScVal name | ARWU 2016 | THE WUR 2017-2017 | QS WUR 2016-2017 | N of Pubbs | FWCI | Int collab |
|---|---|---|---|---|---|---|
| University College London | 17 | 15 | 7 | 11379 | 2.03 | 56.5 |
| University of Oxford | 7 | 1 | 6 | 10592 | 2.36 | 61.4 |
| Imperial College London | 22 | 8 | 9 | 9242 | 2.12 | 62.2 |
| University of Cambridge | 4 | 4 | 4 | 9135 | 2.22 | 60.9 |
| University of Manchester | 35 | 55 | 29 | 6488 | 1.83 | 52.5 |
| University of Edinburgh | 41 | 27 | 19 | 5471 | 2.08 | 56.1 |
| King's College London | 50 | 36 | 21 | 5029 | 1.98 | 56.3 |
| University of Southampton | 101-150 | 121 | 87 | 4426 | 1.78 | 57.6 |
| University of Bristol | 57 | 71 | 41 | 4228 | 2.05 | 52.9 |
| University of Birmingham | 101-150 | 130 | 82 | 3972 | 1.98 | 54.3 |
| University of Nottingham | 101-150 | 147 | 75 | 3885 | 1.62 | 49.5 |
| University of Sheffield | 101-150 | 109 | 84 | 3837 | 1.64 | 49.9 |
| University of Glasgow | 151-200 | 88 | 63 | 3515 | 1.85 | 58.5 |
| University of Leeds | 101-150 | 133 | 93 | 3489 | 1.67 | 52.6 |
| University of Liverpool | 101-150 | 158 | 157 | 3268 | 1.81 | 57.9 |
| University of Warwick | 151-200 | 82 | 51 | 3192 | 1.78 | 55.7 |
| Newcastle University | 301-400 | 190 | 168 | 2881 | 1.72 | 50.8 |
| Cardiff University | 101-150 | 182 | 140 | 2826 | 1.62 | 50 |
| Queen Mary University of London | 151-200 | 113 | 123 | 2812 | 2.30 | 58.2 |
| University of Exeter | 151-200 | 126 | 164 | 2304 | 1.99 | 56.6 |
| Queen's University Belfast | 301-400 | 201-250 | 195 | 2227 | 1.92 | 58.2 |
| University of York | 201-300 | 129 | 127 | 2156 | 1.91 | 49.9 |
| University of Durham | 201-300 | 96 | 74 | 2124 | 1.79 | 54.7 |
| London School of Hygiene and Tropical Medicine | 151-200 | | | 1935 | 2.68 | 75.8 |
| University of Aberdeen | 201-300 | 188 | 141 | 1897 | 1.62 | 59.1 |
| University of Leicester | 201-300 | 172 | 239 | 1816 | 2.15 | 55.1 |
| Lancaster University | | 137 | 129 | 1694 | 1.73 | 55.5 |
| University of Strathclyde | | 401-500 | 272 | 1689 | 1.51 | 50.5 |
| University of St. Andrews | 301-400 | 110 | 77 | 1635 | 1.68 | 61.3 |
| University of Surrey | 401-500 | 251-300 | 261 | 1623 | 1.60 | 52.6 |
| Loughborough University | | 301-350 | 237 | 1577 | 1.55 | 45.5 |
| University of Bath | 301-400 | 251-300 | 159 | 1501 | 1.65 | 47.1 |
| University of Sussex | 201-300 | 149 | 187 | 1449 | 1.86 | 55.5 |
| University of Reading | 301-400 | 192 | 175 | 1422 | 1.68 | 53.7 |
| University of Dundee | 201-300 | 180 | 244 | 1244 | 2.20 | 54.5 |
| University of East Anglia | 201-300 | 165 | 252 | 1224 | 1.72 | 51.7 |
| Brunel University | | 301-350 | 345 | 1185 | 1.82 | 53.8 |
| Swansea University | | 301-350 | 390 | 1160 | 2.03 | 50.7 |
| Heriot-Watt University | | 401-500 | 327 | 1142 | 1.69 | 50.5 |
| London School of Economics | 151-200 | 25 | 37 | 1049 | 1.86 | 42.3 |
| University of Kent | | 301-350 | 366 | 1012 | 1.77 | 50.2 |
| University of Plymouth | | 351-400 | 651-700 | 1003 | 1.51 | 52.7 |

| Scopus ScVal name | ARWU 2016 | THE WUR 2017-2017 | QS WUR 2016-2017 | N of Pubbs | FWCI | Int collab |
|---|---|---|---|---|---|---|
| City University London | | 351-400 | 314 | 972 | 1.13 | 50.4 |
| Open University Milton Keynes | | 401-500 | | 943 | 1.36 | 51.4 |
| Royal Holloway University of London | | 173 | 235 | 902 | 1.80 | 59.5 |
| Liverpool John Moores University | | 501-600 | | 837 | 1.68 | 64.2 |
| University of Hull | | 501-600 | 551-600 | 809 | 1.50 | 49.1 |
| Ulster University | | 501-600 | 601-650 | 796 | 1.29 | 52 |
| Northumbria University | | 601-800 | 701+ | 784 | 1.44 | 52.6 |
| Aston University | | 351-400 | 358 | 741 | 1.26 | 59.2 |
| University of Portsmouth | | 401-500 | 601-650 | 736 | 1.63 | 55.3 |
| University of Essex | | 301-350 | 330 | 724 | 1.49 | 55.4 |
| Bangor University | 401-500 | 301-350 | 411-420 | 674 | 1.41 | 54.7 |
| University of Stirling | | 301-350 | 385 | 642 | 1.67 | 46.4 |
| St. George's University of London | | 201-250 | | 636 | 2.93 | 60.4 |
| Keele University | | 401-500 | 551-600 | 614 | 1.39 | 52.1 |
| University of Hertfordshire | | 501-600 | 701+ | 584 | 1.52 | 54.8 |
| University of the West of England | | 601-800 | | 571 | 1.42 | 37.8 |
| Manchester Metropolitan University | | 601-800 | 701+ | 568 | 1.13 | 46.3 |
| University of Huddersfield | | 601-800 | 701+ | 516 | 1.22 | 43.8 |
| University of Central Lancashire | | 601-800 | 701+ | 504 | 1.25 | 44 |
| University of Salford | | 601-800 | 701+ | 504 | 1.23 | 46.8 |
| Coventry University | | 601-800 | | 503 | 1.23 | 50.5 |
| Birkbeck University of London | 401-500 | 201-250 | 280 | 498 | 1.50 | 44.4 |
| University of Greenwich | | 601-800 | 701+ | 488 | 1.37 | 50 |
| Aberystwyth University | | 301-350 | 491-500 | 483 | 1.59 | 55.9 |
| Bournemouth University | | 601-800 | | 482 | 1.13 | 48.5 |
| University of Bradford | | 601-800 | 551-600 | 455 | 0.95 | 54.9 |
| Middlesex University | | 501-600 | 601-650 | 453 | 1.15 | 44.6 |
| Nottingham Trent University | | 601-800 | 701+ | 436 | 1.17 | 39 |
| Sheffield Hallam University | | 801+ | | 422 | 1.09 | 35.5 |
| Royal Veterinary College University of London | | 301-350 | | 421 | 1.30 | 58.2 |
| University of Brighton | | 601-800 | | 406 | 1.56 | 45.3 |
| Kingston University | | 601-800 | 501-550 | 390 | 0.94 | 42.1 |
| Glasgow Caledonian University | | 601-800 | | 370 | 1.31 | 43.8 |
| Oxford Brookes University | | 401-500 | 359 | 361 | 1.50 | 46.3 |
| De Montfort University | | 601-800 | 651-700 | 354 | 1.10 | 37.3 |
| University of Lincoln | | 601-800 | | 327 | 1.14 | 42.5 |
| University of Westminster | | 601-800 | | 312 | 1.27 | 42.3 |
| University of the West of Scotland | | 601-800 | | 303 | 1.49 | 55.8 |
| Anglia Ruskin University | | 301-350 | | 299 | 2.82 | 40.8 |
| Goldsmiths, University of London | | 301-350 | 421-430 | 294 | 1.31 | 36.7 |
| Leeds Beckett University | | 601-800 | | 272 | 1.33 | 32.4 |
| University of Bedfordshire | | 601-800 | | 240 | 0.98 | 36.3 |
| London South Bank University | | 801+ | | 236 | 0.93 | 34.7 |
| Napier University | | 601-800 | | 231 | 0.73 | 45.5 |
| Robert Gordon University | | 801+ | 701+ | 223 | 1.02 | 42.6 |
| University of East London | | 601-800 | 701+ | 218 | 0.74 | 41.7 |
| University of Teesside | | 601-800 | | 204 | 1.88 | 35.3 |
| SOAS University of London | | 401-500 | 252 | 183 | 1.09 | 29.5 |
| Roehampton University | | 601-800 | | 156 | 1.18 | 42.9 |
| London Metropolitan University | | 601-800 | 651-700 | 139 | 1.09 | 55.4 |
| **Average mean** | | | | 1 739 | 1.59 | 50.4 |
| **Stand. Dev** | | | | 2 240 | 0.42 | 8.0 |
| **Stand, dev/average** | | | | 1.29 | 0.27 | 0.16 |
| **Max** | | | | 11 379 | 2.93 | 75.8 |
| **Min** | | | | 139 | 0.73 | 29.5 |

Note: ARWU (Academic Ranking of World Universities) THE WUR (Times Higher Education World University Rankings); QS WUR (Quacquarelli Symonds World University Rankings); N of Pubs – Number of Publications in Scopus for 2015: FWCI – Field-weighted citation impact in 2015; Int collab - Share of publications in international collaboration in 2015.

**Table B.5**
Universities of Russian Federation that are indexed in ARWU and/or THE WUR and/or QS WUR in 2016–2017 and their key bibliometric indicators in 2015.

| Scopus ScVal name | ARWU 2016 | THE WUR 2017-2017 | QS WUR 2016-2017 | N of Pubbs | FWCI | Int collab |
|---|---|---|---|---|---|---|
| Moscow State University | 87 | 188 | 108 | 5651 | 0.86 | 34 |
| St. Petersburg State University | 301-400 | 401-500 | 258 | 2894 | 1.13 | 33.8 |
| Kazan Volga Region Federal University | | 401-500 | 501-550 | 2205 | 1.49 | 20.7 |
| Novosibirsk State University | | 401-500 | 291 | 2069 | 0.98 | 34.8 |
| Moscow Engineering Physics Institute | | 401-500 | 401-410 | 1963 | 1.03 | 32.3 |
| Tomsk State University | | 501-600 | 377 | 1819 | 1.00 | 35.5 |
| St. Petersburg National Research University of Information Technologies, Mechanics and Optics (ITMO) | | 351-400 | | 1591 | 1.41 | 43.6 |
| Tomsk Polytechnic University | | 501-600 | 400 | 1578 | 1.26 | 21.7 |
| St. Petersburg State Polytechnical University | | 601-800 | 411-420 | 1432 | 1.68 | 38.6 |
| Ural Federal University | | 801+ | 601-650 | 1415 | 0.62 | 25.4 |
| Moscow Institute of Physics and Technology | | 301-350 | 350 | 1385 | 1.32 | 43.9 |
| Higher School of Economics | | 401-500 | 411-420 | 1019 | 1.39 | 34.3 |
| Nizhni Novgorod State University | | 801+ | 701+ | 887 | 0.71 | 29.4 |
| Southern Federal University | | 801+ | 551-600 | 740 | 0.85 | 20.8 |
| National University of Science and Technology MISIS | | 801+ | 601-650 | 739 | 0.67 | 35.6 |
| Far Eastern Federal University | | | 551-600 | 665 | 0.70 | 25.1 |
| Samara State Aerospace University | | 801+ | | 571 | 0.65 | 9.3 |
| Moscow State Technical University | | 601-800 | 306 | 570 | 0.71 | 11.4 |
| Siberian Federal University | | 801+ | | 475 | 0.80 | 18.5 |
| Novosibirsk State Technical University | 401-500 | 801+ | 701+ | 442 | 0.50 | 18.6 |
| National Research University of Electronic Technology (MIET) | | 801+ | | 388 | 0.70 | 31.7 |
| Saratov State University | | 801+ | 551-600 | 367 | 1.22 | 34.9 |
| Voronezh State University | | 801+ | 701+ | 331 | 0.40 | 15.7 |
| Sechenov First Moscow State Medical University | | 801+ | | 309 | 0.33 | 14.9 |
| Russian University of Peoples' Friendship | | 801+ | 601-650 | 270 | 0.40 | 25.6 |
| Plekhanov Russian University of Economics | | | 701+ | 149 | 0.99 | 6.7 |
| Moscow State Institute of International Relations (MGIMO-University) | | | 350 | 17 | 0.93 | 23.5 |
| Average mean | | | | 1 183 | 0.92 | 26.7 |
| Stand. Dev | | | | 1 158 | 0.36 | 10.2 |
| Stand, dev/average | | | | 0.98 | 0.39 | 0.38 |
| Max | | | | 5 651 | 1.68 | 43.9 |
| Min | | | | 17 | 0.33 | 6.7 |

Note: ARWU (Academic Ranking of World Universities) THE WUR (Times Higher Education World University Rankings); QS WUR (Quacquarelli Symonds World University Rankings); N of Pubs – Number of Publications in Scopus for 2015: FWCI – Field-weighted citation impact in 2015; Int collab - Share of publications in international collaboration in 2015.

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