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GLOBALIZATION OF SCIENCE: EVIDENCE FROM AUTHORS IN ACADEMIC JOURNALS BY COUNTRY OF ORIGIN

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Globalization of Science: Evidence from Authors in Academic Journals by Country of Origin

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Abstract:
The scientific community faces an everlasting pressure to publish internationally. This study measures the tendency to publish in globalized journals on a large dataset of journals indexed in the Scopus database. Based on data on 34 964 journals indexed in the Scopus Source List (Scopus 2018), we derived seven globalization indicators. These were subsequently scaled-up to the level of 174 countries and 27 disciplines between 2005 and 2017. The methodology draws from the pioneering work of Zitt and Bassecoulard (1998; 1999). The paper is accompanied by the interactive publication available at http://www.globalizationofscience.com.
Advanced countries tend to have high globalization that is not varying across disciplines. Social sciences and health sciences are less globalized than physical and life sciences. The globalization in the former Soviet bloc is lower, especially in social sciences or health sciences. China has profoundly globalized its science system; gradually moving from the lowest globalization rates to the world average. Contrary Russia was constantly among the least globalized during the whole period, with no upward trend.

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Introduction

The scientific community faces an everlasting pressure to publish internationally (Buela-Casal et al. 2006, Chavarro et al. 2017). Academic researchers are expected to present their results to their peers across the world and publish in journals contributed by researchers from the whole world (*globalized journals)*.

On the other hand, there are concerns about the side-effects of ever-growing globalization of scientific communication (Chavarro et al. 2014, Chavarro et al. 2017). Local journals may offer a platform for research that would be not be published in "mainstream" journals - publications of junior researchers, publications bridging the knowledge between international science and local communities or topics that are overlooked by the mainstream research (Evans et al. 2014).

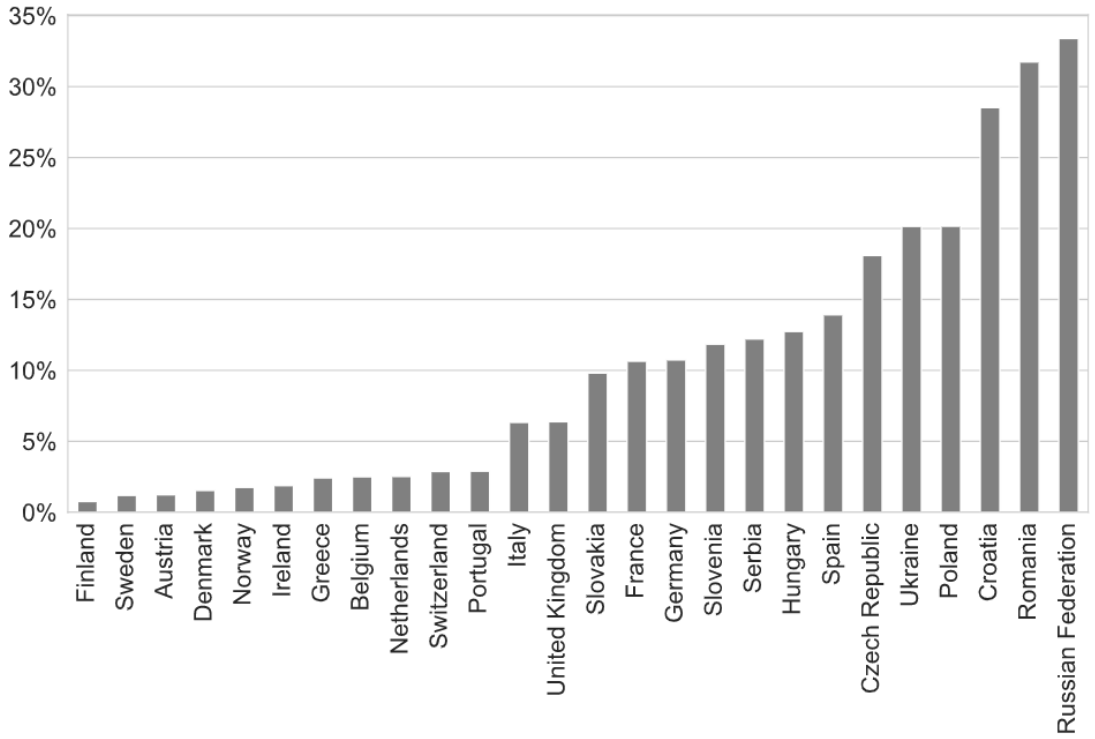
This paper perceives the globalization from the perspective of journals. The more researchers publish in the same journals as their peers abroad, the more globalized their research is. The global dimension of the audience is emphasized (hence globalization), but also alternative specifications based on language and institutional concentration are added to increase robustness of findings. Regardless the specification and underlying data, for simplicity we refer to journal globalization (from now on just *globalization*).

Comparably to citing patterns (Moed 2010, Garfield and Merton 1979) globalization can naturally differ across disciplines. In social sciences, the local research can be more important than in physics. However, the cross-country heterogeneity within a single discipline points towards the research evaluation in the country and the research culture in a broader context. Large differences between globalization in economics in the Netherlands and in Czechia cannot be easily explained by the research content. They point at the incentives provided by the research system of given countries.

The intuition suggests that the *globalized* journals will be disseminating science more efficiently than journals operating in only a handful of countries. Publishing in globalized journals may improve the researchers' visibility on the international scene. The more authors contribute to the journal, the higher competition may theoretically enforce higher quality. International publishing leads to higher competition faced by local researchers and to a larger emphasize on novelty. Simultaneously, international journals may help promoting international collaboration. The systemic tendency to publish in non-globalized journals indicates the local researchers' lack of motivation to open to the global stream of knowledge.

In performance-based research systems where journals are used as major evaluation tool journals can be prone to gaming practices (Rijcke et al. 2016, Good et al. 2015, Rafols et al. 2016, Macháček and Srholec (2017a)). Arguably, local journals are easier to "control". Good et al. (2015) for example describe practices of "establishing working paper series and promoting them as if they were refereed journals" (p. 97) in the Czech formula-based Evaluation Methodology.

Figure 1: Share of research output flowing into domestic* journals in Europe in 2015-2017



**domestic journals are defined as journals with at least 33% authors from the same country as the publisher of the journal. Only articles, reviews, and conference papers are included. Publisher country from Scopus Source List is used to identify the domicile of the journal*

Source: own calculaton, Scopus; Scopus Source List

In Western Europe and North America, research has undergone a transition from the national to the transnational model of publications already in the 1980s and the beginning of the 1990s (Zitt et al. 1998). Thirty years later, the non-globalized journals still play a substantial role in the countries from the former Soviet bloc (see Moed et al. 2018, Kirchik et al. 2012). For example, in Russia, Romania or Croatia more than 25 % of the national research output is published in journals from the country with at least a third of authors from the same country. The difference to the countries of the Western Europe is still very large (Figure 1).

Since the transition the global research landscape changed dramatically. It grows both in terms of size and interconnectedness (Wilsdon 2011). New countries incorporate their research into the global knowledge flows (Gazni et al. 2012; Wagner et al. 2015) and collaboration distances increase (Waltman et al. 2011). The international collaboration drives the growth of the research output (Adams 2013). Developing countries invest heavily to improve its research infrastructure (Wilsdon 2011) and international visibility (Zhou and Glanzel 2010).

The internationalization is driven by science policy, more efficient communication infrastructure, but also researchers' self-organization. However, it is not automatic as it meets adverse reaction from the scientific community - proximity effects anchored in infrastructural factors or inertia of personal and institutional networks (Zitt and Bassecoulard 2004). The different research landscape across countries will lead to different balance between the engine and the adverse effects to internationalization.

Zitt and Bassecoulard (1998 and 1999) suggested a methodology for determining journal globalization. It also allows to scale up from journal level to the national level. However, since then any systematic evidence is missing. This paper applies similar methodology to study the changes in the globalization landscape in the new millennium and apply it to much broader dataset. How are post-soviet countries integrating into the world knowledge flows? How is China globalizing its fast-growing research output (Zhou and Leyersdorf 2006, Moed 2002)? How about Russia and Eastern Europe?

Based on data on 34 964 journals indexed in the Scopus Source List (Scopus 2018), we derived 7 indicators of journal globalization. These were subsequently scaled-up to the level countries, disciplines and time. The final dataset consists of average globalization scores and distribution of research output into journals by globalization quartiles for 174 countries across 27 narrow, 5 broad disciplines and 1 all-embracing *All disciplines* between 2005 and 2017.

The following section describes used methodology and its main limitations; the second section describes data collection and its characteristics and the third describes results. The last section concludes. The paper is accompanied by an already released interactive study available at http://www.globalizationofscience.com (Macháček and Srholec 2019). Readers can spend their time with the interactive application, as it offers an intuitive way of exploring the results in detail.

Globalization Indicators

The academic journals are an essential platform for dissemination of scientific knowledge. They allow scientists across the world to keep up to date with the latest discoveries and to present their results to the global audience. Simultaneously they serve as a major research evaluation tool and researchers often face a significant pressure to publish "internationally".

There is no consensus on the definition of "internationality". Journal can be considered international based on the country of origin of authors, country of origin of editors, language of publication or even having "international" in its name. The journals publishing only Czech and Slovak authors are de facto international. Each definition of internationality can lead to different ranking in the degree of the internationality (Buela-Casal et al. 2006). Internationality is a very ambiguous term.

To ensure robustness the paper uses 7 *globalization indicators* assessing each country and discipline's globalization for each year. Most indicators are based on the geographical diversity of authors. The two-step methodology builds on the work of Zitt and Bassecoulard (1998) and (1999). First, we calculate the globalization indicators for each journal in our dataset in each year. Subsequently, the journal-level indicators are aggregated up to the level of countries and disciplines.

Journal-level Indicators

For each journal *j* in the dataset, a set of globalization indicators *i* was calculated for each year *y*. Calculation is derived separately for each discipline *d*. The journal globalization is denoted $g_{j,d,y,i}$.

The indicators are intentionally constructed diverse. They vary in terms of input data as well as the approach to globalization. The indicators are not perfect, but each is imperfect in a different way. When combined, they can yield a robust picture of development of globalization.

Three indicators – *euclid*, *cosine* and *top3* (see Table 1 for details) are designed to account for a strong concentration of research in a few countries[1]. They are based on the idea that globalized journals have a structure that closely resembles the global structure of the whole discipline. Researchers from the whole world have equal probability to be published regardless of their affiliation country. These indicators measure how the distribution of authors corresponds to the benchmark distribution of authors in the entire discipline (column *Bench.* in Table 1).

Two indicators are simple shares of documents in the journal fulfilling a simple condition. The *englishShare* is a share of documents written in English and the indicator *localShare* is the share of authors originating in the same country as the publisher of the journal. Last two indicators – *giniSimpson, instTOP3* – are diversity measures. The first is Gini-Simpson Index applied on country data. The second is a simple ratio of three largest affiliations on the total number of documents.

The indicators are based on three different data sources (column *Data* in Table 1). Five indicators employ affiliation countries of authors. These are complemented with one indicator based on language and one based on affiliation names. Three indicators are constructed using the whole distribution of the underlying data, i.e. each document enters the calculation (column *Dist.*). Two indicators analyze only documents by most important contributors (countries and affiliation).

$N_{c,j,y}$, $N_{c,d,y}$ and $N_{i,j,y}$ are the number of documents with authors affiliated to the country *c* or institution *i*, in journal *j* or discipline *d*, in year *y*. $N_{LOCAL,j,y}$ is the number of documents with authors from the same country as the publisher of journal *j* in the year *y*. $N_{ENG,j,y}$ is the number of English-written documents in the journal *j* in year *y*. $T_{j,y}$ denotes the total number of documents in the journal *j* in year *y*. Note that documents by authors from multiple countries are fully attributed to each country, i.e. $T_{j,y} \leq \sum_c N_{c,j,y}$.

The vectors $x_{j,y}$ and m_d represent the country distribution of authors of the journal j and the discipline d, in which $x_{c,j,y} = \frac{N_{c,j,y}}{T_{j,y}}$ and $m_{c,d} = \frac{\sum_y N_{c,d,y}}{\sum_y \sum_c N_{c,d,y}}$. While $x_{j,y}$ is calculated separately in each year *y*, m_d relates to the whole period. The benchmark distribution is always calculated from all available periods so that the development in time considers the world trend.

Aggregation

In the second stage, the journal-level indicators were aggregated to the level of countries and disciplines. The resulting globalization score $G^S_{c,d,y,i}$ is a weighted average of individual journals scaled between 0 and 1, where 0 is the lowest globalization across all years, countries and disciplines within the indicator and 1 is the highest.

Table 1: Globalization Indicators

Indicator (shortcut)	$g_{j,d,y,i}$ *calculation*	*Data*	*Bench.*	*Dist.*	*Source**
	Description				

[1] US alone accounts for 21 %, of the research output in 2017, China for additional 19 %. Scopus search: PUBYEAR = 2017 AND DOCTYPE (ar OR re OR cp) on January 24th 2020 .

Euclidian distance (*euclid)*	$\sqrt{\sum(x_{j,y} - m_d)^2}$	Country	Yes	Full	ZB (1998)
	Euclidian distance of journal and discipline country distribution				
Cosine distance (*cosine*)	$\frac{\sum(x_{j,y} m_d)}{\sqrt{\sum(x_{j,y}^2)\sum(m_d^2)}}$	Country	Yes	Full	ZB (1998)
	Cosine distance of journal and discipline country distribution				
GiniSimpson Index (*GiniSimpson*)	$1 - \sum \frac{N_{c,j,y}^2}{(\sum N_{c,j,y})^2}$	Country	No	Full	Aman (2016)
	Gini-Simpson diversity of journal country distribution				
Largest Contributors Surplus (*top3*)**	$\sum_{c=1}^{3}(x_{c,j,y} - m_{c,d})$	Country	Yes	Partial	Own
	Surplus of three largest contributing countries over its share in discipline				
Institutional Diversity (*instTOP3*)**	$\sum_{i=1}^{3}(N_{i,j,y}/T_{j,y})$	Institutional	No	Partial	Own
	Share of three largest institutions on all documents				
English Documents (*englishShare*)	$\frac{N_{ENG,j,y}}{T_{j,y}}$	Language	No	Share	BC et al. (2006)
	Share of English-written documents				
Local Authors (*localShare)*	$\frac{N_{LOCAL,j,y}}{T_{j,y}}$	Country	No	Share	ZB (1998)
	Share of documents from a journal's domicile				

* ZB is Zitt and Bassecoulard; BC is Buela-Casal

** the underlying data for these indicators are sorted by descending order. The computation algorithm only considers the three most important

To increase robustness and decrease volatility, the aggregation was only performed when the authors from the country published in at least 30 journals that in a given year published at least 30 documents. This leads to gaps in results, particularly in the small disciplines and small countries.

The globalization of science in country c, discipline d and year y expressed by an indicator i is calculated from the set of journals J assigned to discipline d as an average of individual journals globalization weighted by the share of documents flowing into the journal:

$$\mathrm{G_{c,d,y,i}} = \sum_{\mathrm{j=1}}^{\mathrm{J}} \mathrm{a_{c,d,y,j}}\, \mathrm{g_{j,d,y,i}}$$

$a_{c,d,y,j} = \frac{N_{c,j,y}}{N_{c,d,y}}$ is the share of documents with authors from country c in journal j on all documents from the country c, discipline d in year y, $g_{j,d,y,i}$ is the globalization indicator i of journal j in the discipline d and year y.

Subsequently, the aggregated globalization index was standardized between 0 and 1 and converted to an ascending scale to simplify the interpretation of the results:

$$\mathrm{G^S_{c,d,y,i}} = \frac{\mathrm{G_{c,d,y,i}} - \mathrm{G_i^{min}}}{\mathrm{G_i^{max}} - \mathrm{G_i^{min}}}\alpha_i$$

in which G_i^{min} and G_i^{max} is minimum and maximum value of the indicator *i* across all years, countries and disciplines and α_i equals -1 for the minimizing indicators (low values for high globalization) and 1 otherwise.

It is possible to compare globalizations between countries, discipline, and in time. However, the meaningful comparison between indicators is not possible due to large heterogeneity of underlying distributions. The same value from two indicators cannot be interpreted as corresponding levels of globalization.

Data

The analysis is based on Scopus data. Scopus indexes more journals than Web of Science (SCI-Expanded, SSCI and A&HCI combined; see Mongeon and Paul-Hus 2016). It is more likely to contain the more localized part of the scientific output in the country.

The data for all 34 964 journals indexed in the Scopus Source List (Scopus 2018) were downloaded using Scopus API in August 2018. For each journal in each year between 2005 – 2017, we downloaded the country and institutional distribution of authors and the distribution of languages. Data were limited to articles, reviews, and conference papers.

The Scopus Search API was requested with the following query:

ISSN(AAAA-BBBB) AND DOCTYPE(AR OR RE OR CP) AND PUBYEAR = YYYY

in which AAAA-BBBB is the journal's ISSN and YYYY is the year. Rather than publication-level data, the aggregate distribution is collected. For each journal in each year, we collect the number of articles affiliated to each country, language, and institution.

Scopus Journal Classification (see Scopus 2019) is used to assign journals to disciplines. Both narrower classification (*Major Subject Classification;* referred to as *narrow disciplines*) and broad classification on 4 disciplines (*Broad Subject Clusters* – life sciences, physical sciences, health sciences and social sciences; referred to as *broad disciplines*) is used, supplemented by all-encompassing discipline *All*. The most granular level of Scopus classification was neglected due to concerns to representativeness and threat of false identification (see Wang and Waltman 2016). In the rest of the paper, the broad classification will be stressed, but the narrow results are also available in both interactive application and the downloadable data.

Journal-based discipline classification is a rough brush as it is not possible to assign documents directly to disciplines. In our dataset large part of journals (20 % according to *broad* classification and 50 % of narrow) are assigned to more than one discipline. The used methodology fully attributes all journals documents to all assigned disciplines. This may cause distortion, especially due to large interdisciplinary journals that index research from various unrelated disciplines.

Only minor data cleaning was required after downloading the data. Approximately 5 % of publications are attributed to the *undefined* country. These were excluded from the analysis. Undefined publications were also subtracted from the total number of publications in the journal. The data for Russia and the Russian Federation and Yugoslavia and Serbia were merged.

The resulting database contains information on 22 million documents. The Scopus indexation grows relatively fast (by an average pace of 4 % per year). We track 1.29M documents published in 2005 up to 2.09M in 2017. The growth momentum was generally faster in the first half of analyzed period.

Limitations

The major drawback of globalization approach is the representativeness of the underlying data. We refer to the *Globalization of Science*, but it might be more convenient to refer to the *Globalization of Science in Journals then Indexed in Scopus*. Citation databases may index the research output across units unevenly. The representativeness issue is present in all major dimensions – countries, disciplines, and in time.

Bibliometric databases probably represent larger portion of the research output in the countries of scientific core than in those at the periphery (Rafols et al. 2014 shows an example of rice research, Chavarro 2017, Mongeon and Paul-Hus 2016). With a reasonable assumption that the under-representation is more affecting the non-globalized part of journals the results show the upper bound of globalization of the periphery countries.

The results are sensitive to Scopus journal-indexation decisions. For example, in 2009 Scopus reacted to criticism by increasing its coverage of social sciences and humanities journals by 39 % (Hicks and Wang 2010). Short-term changes must be interpreted with caution. Sudden year-by-year jumps are not necessarily caused by fundamental changes of the researchers' behavior but are often driven by adding (or removing) journals in the database. Also, long-term gradual changes may be partly driven by indexation decisions.

The bibliometric databases can cover disciplines unevenly as well. Mongeon and Paul-Hus (2016) report significant under-representation of social sciences and humanities in both Scopus and WoS. These concerns not only contain the coverage of journals within the database, but also use of journals as a publication platform. For disciplines relying on other publication venues such as books the results may be distorted.

Results

This section only captures the most fundamental world trends of globalization. The reader is encouraged to take advantage of the interactive application and supplementary data to understand the globalization in the full detail.

After excluding all dependent territories except Hong Kong, the computation algorithm yielded globalization scores $G^{S}_{c,d,y,i}$ in three major dimensions - 174 countries (c), 32 disciplines (d) and 13 years (y). Each score is calculated by one of 7 indicators i. Scores are normalized relative to all observations within a single indicator. $G^{S}_{c,d,y,i} = 0$ and 1 always refer to the least and most globalized country, discipline and the year within all results available within a single indicator.

The panel of results is not complete as the rule of publishing in at least 30 journals in given country, discipline and year is applied. Countries and discipline publishing in given year in less than 30 journals were excluded. In 2017, the data were available for 171 countries in the discipline *All*, 125 – 155 in broad disciplines and for less than 100 countries in 21 out of 27 narrow disciplines. Naturally, the larger the research production in the country and the discipline, the more globalization scores are computed. The data coverage also grows in time together with growth of research output.

Results robustness

Various indicators yield similar estimates of globalization. The various indicators are generally correlated (see Table A1 in the Appendix). 25 out of 28 coefficients exceed 0.5, and a half of coefficients is higher than 0.7. Also, visual check in the interactive application reveals that most globalization paths in time and relative rankings are similar across indicators. The most in-between indicator is Euclidian distance with a correlation coefficient higher than 0.75 in 8 out of 8 indicators. That's why by default, we refer to it when not stated otherwise.

Results are not excessively distorted by relying on journal-based discipline classification, although the documents in journals publishing in multiple disciplines are fully attributed to each of the discipline. To test it, globalization was recalculated using only journals with 1 broad discipline (80 % of journals) and with 1 narrow disciplines (50 % of journals). The distortion is acceptable. The correlation between original all globalization scores computed from all journals and one calculated from journals with only 1 broad discipline is 0.83. When counting only journals with 1 narrow discipline assigned the correlation is still high - 0.78.

Countries, disciplines or time?

At the beginning of the analysis we decompose the globalization variance into dimensions – countries *c*, disciplines *d* and years *y*. Table 2 shows explained variance ω^2 of ANOVA regression, on all globalization scores of a given indicator *i*, where c, d, y are treated as categorical variables. ω^2 allows to decompose R^2 across the factors used in the regression. The regression is run separately for broad and narrow disciplines. This simple regression already explains approximately 70 % of the variance in the data in case of broad disciplines and 60 % of variance in narrow disciplines.

Countries are by far the most important determinant of globalization as they systematically explain more than 50 % of all explained variance (in some cases even 90 %). The effect is stronger for broad disciplines. Disciplines are a weaker predictor of globalization, but it is still relatively important factor (especially in case of narrow disciplines). Perhaps surprisingly, the role of time is negligible.

Table 2: Variance decomposition (ω^2 and R^2) by countries *c*, disciplines *d* and years *y* by ANOVA

		Gini-Simpson	cosine	euclid	instTOP3	localShare	shareEnglish	top3
Broad disc.	*c*	55 %	67 %	58 %	64 %	37 %	47 %	53 %
	d	14 %	4 %	11 %	4 %	23 %	10 %	9 %
	y	2.6 %	0.3 %	0.2 %	0.9 %	4.2 %	1.7 %	0.3 %
	R^2	72 %	72 %	69 %	69 %	66 %	60 %	63 %
Narrow disc.	*c*	36 %	46 %	36 %	42 %	18 %	28 %	31 %
	d	20 %	16 %	23 %	18 %	34 %	14 %	24 %
	y	1.1 %	0.2 %	0.1 %	0.4 %	2.3 %	0.6 %	0.3 %
	R^2	57 %	62 %	58 %	60 %	56 %	43 %	56 %

Note: ANOVA based on regression $G^{S}_{c,d,y,i} = \alpha + \beta_0 c + \beta_1 d + \beta_2 y + \epsilon$ for all observations. Type II sum of squares are used.

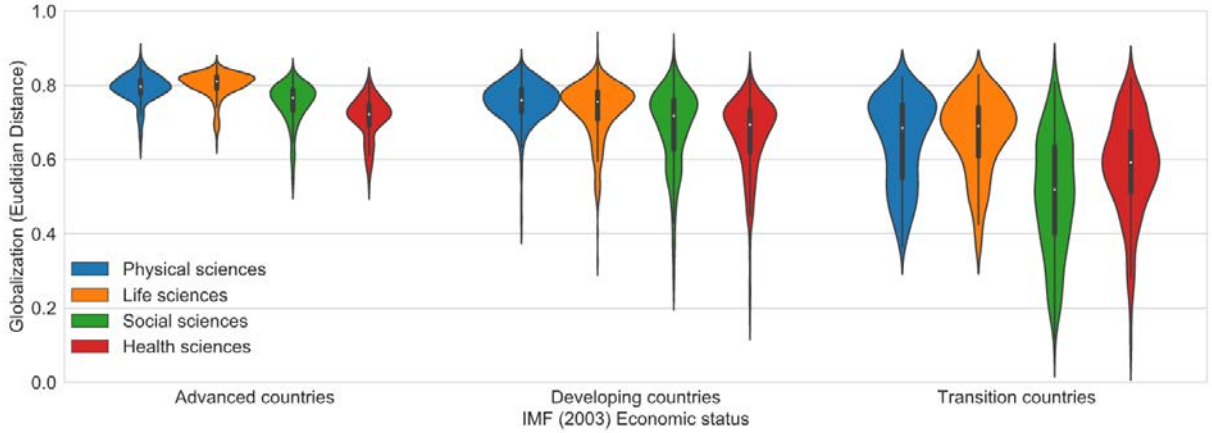
Globalization by country groups and broad disciplines

Although outdated, the country groups by IMF (2003) can serve as a good starting point for describing results. The countries are divided into three categories: (a) *Advanced countries* cover the richest countries in the world in the mainly in Western Europe, North America, and Eastern

Asia. This group should capture countries of the western core (31 countries). (b) *Transition countries* consist mainly of the post-soviet countries in Central and Eastern Europe. Central Asia. and Cuba. The group contains mainly countries of the former soviet bloc, including new EU member states (28 countries). (c) *Developing countries* – contain the rest of the World, including China (115 countries). Exact classification is available in the Appendix A4.

Figure 2 depicts a distribution of globalization across all countries and years calculated by Euclidian distance grouped by economic status and broad disciplines. Each "*violin*" represents an estimated density of all globalization scores within given country group (x axis) and discipline (color). Note that violins are symmetrical across its vertical axis. All the distributions are negatively skewed, meaning that globalization is more concentrated in the upper part of the distributions. Although Euclidian distance is reported here, the same patterns as described below are present in each of the indicators.

Figure 2: Density of globalization by IMF (2003) economic status and by broad disciplines



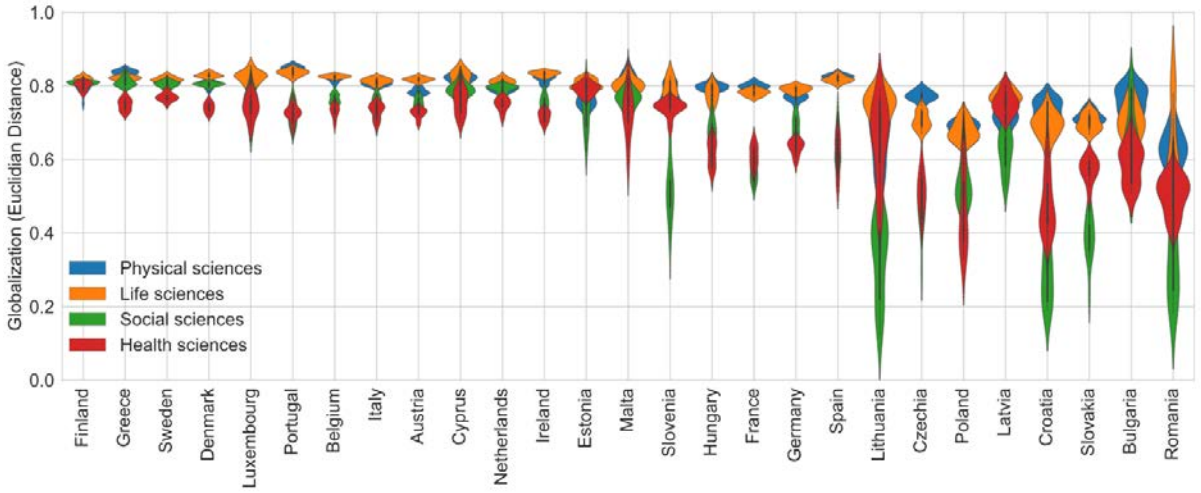
Source: own calculation, Scopus.

The cross-country data reveal that globalization in *Advanced countries* is high and relatively invariant. On the contrary, in *Transition countries*, the globalization is lower and much more heterogenous. The distribution is more spread across the whole spectrum. *Developing countries* are in between the groups.

Putting it all together in the *Advanced countries*, the globalization is relatively high and differences between disciplines are minor. In *Transition countries* the mean globalization is lower and the gap between disciplines is larger. The *life sciences* and *physical sciences* are less globalized especially in the former USSR countries. The *social sciences* and *health sciences* are less globalized across *Transition countries*, but outside of the former USSR, the globalization gradually increases in time.

Globalization in the European Union

Figure 3: Density of globalization in the European Union



Source: own calculation, Scopus. Each "violin" is symmetrical. Countries are sorted by $G^{S}_{c,All,euclid,2017}$

The differences between the *Advanced* and *Transition countries* can be depicted in the European Union, which has members from both country groups. The Advanced countries in the EU are referred to as the Western countries and the Transition countries as the Eastern. The figure 3 shows the estimated density of globalization measured by Euclidian distance in all member states of the EU in broad disciplines. Each density is calculated based on globalization scores between 2005 and 2017.

The *life sciences* and *physical sciences* are highly globalized in almost all EU members, although the mean globalization is higher in the Western countries. The globalization also tends to be relatively stable in time. Of course, there are exceptions – see Romania or Poland – but these are exclusively in the East.

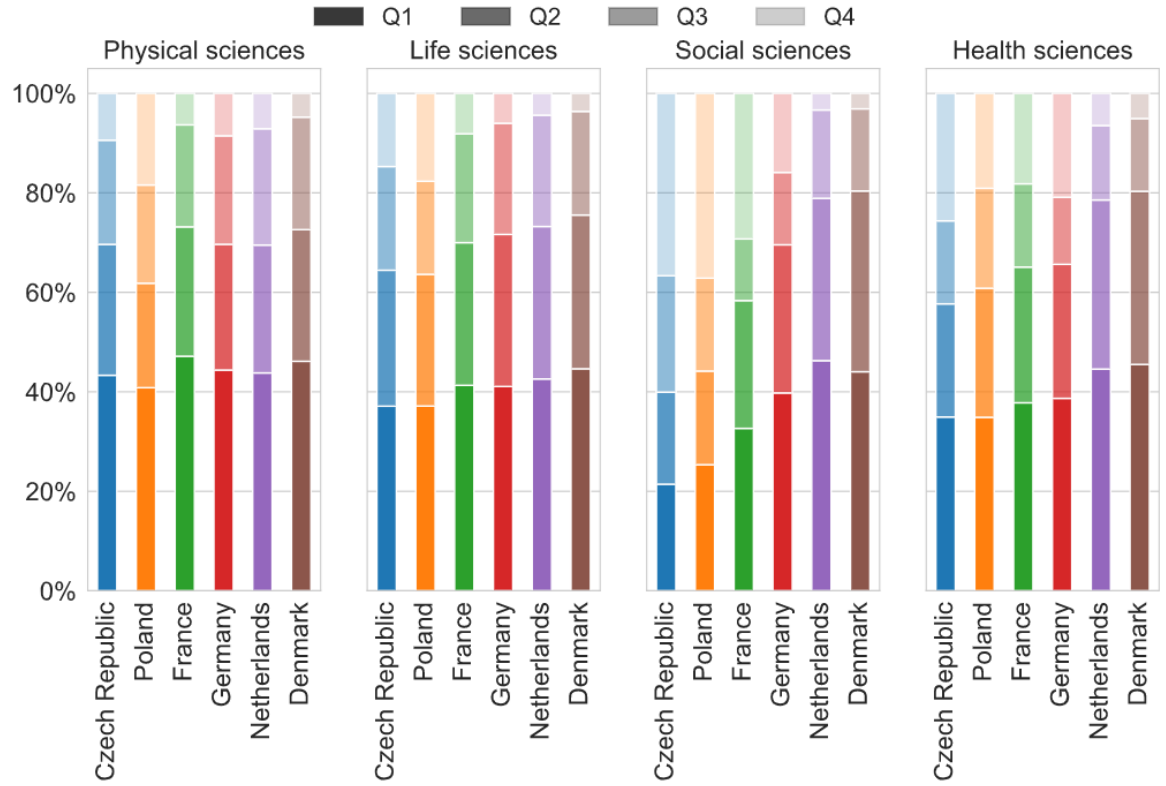
The differences between the East and the West seems to prevail in s*ocial sciences* and *health sciences*. They also tend to be globalized in western countries. The gap between these disciplines and the *life* and *physical* sciences are usually small. The only exception are countries speaking with important scientific languages, but not English - France, Germany and Spain. In these countries, *social* and *health sciences,* are less globalized.

In the East, *social sciences* and *health sciences* are significantly less globalized. The globalization tends to grow, especially after 2010, but the gap between these disciplines in the West and the East is still significant in 2017.

This gap between East and West is depicted on figure 4 that breaks down the research output of the Czech Republic, Denmark, France, Germany, Netherlands and Poland by globalization of journals. Czech Republic and Poland represent the *East* and the rest belongs to the *West*. Germany and France are included because of their important languages.

First, all journals were divided into quartiles by their Euclidian distance globalization in 2017. In the second step all documents from the given country and discipline published in journals with computed globalization were assigned to the quartiles. Quartiles are marked Q1 – Q4, where Q1 are 25% of journals with highest globalization and Q4 with smallest. The darker the color on the figure, the higher the globalization.

Figure 4: Research output of selected countries divided into journals by globalization (2017, Euclidian distance)



Source: own calculation. Scopus

The cross-country differences within *physical* and *life sciences* are relatively minor. Approximately 40 % of all documents is published in journals with highest globalization (*Q1*) and additional 25-30% in the second quartile. There is slightly higher share of Q4 in Czech Republic and Poland, especially in *life sciences*.

In Czech Republic and Poland almost 40 % of all documents is published in the Q4 journals in *social sciences*. The same figure is approx. 30 % in France and less than 20 % in Germany. In the Netherlands and Denmark only 3 % of all documents is published in Q4 journals. Not surprisingly, the larger portion of research is published in Q4, the less is published in the most globalized journals. Similar patterns can also be found in the *health sciences*.

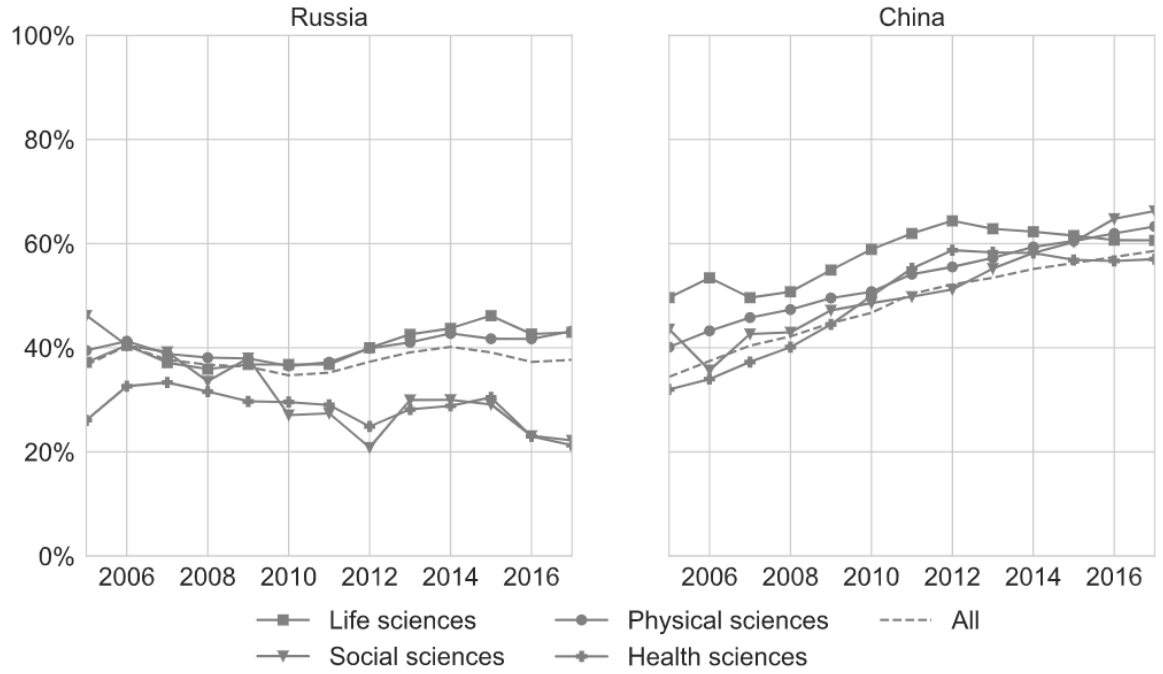
Globalization in Russia and China

Russia is a prime example of a strongly isolated research system (see figure 5). In 2017, Russia ranked as the first or second least globalized country in all broad disciplines. Even when extended to the narrow definition of disciplines. Russia is among the last 3 countries in 23 out of 25 disciplines where the data are available. Moreover, Russian science does not indicate any significant changes. More than 50 % of their research output is published in the Q4 journals in all broad disciplines. In *social sciences*, it is 74 %.

This is in sharp contrast with the case of China. Although at the beginning of the analyzed period, in 2005, China was the least globalized country in the world in *All disciplines* (Moed 2002), and among the 5 least globalized in all broad disciplines. Rapid transformation of the Chinese system resulted in the relatively fast growth of globalization. During the analyzed

period, the globalization grew fast across all broad disciplines. In 2017, almost 30 % of their research output in All disciplines was published in Q1 journals.

Figure 5: Globalization in broad disciplines in China and Russia in time (Euclidian distance)



Source: own calculation. Scopus

Discussion and conclusion

The most important outcome of this paper is a rich dataset measuring the globalization of journal publications of researchers across countries, disciplines and in time. Data calculated from more than 34 964 Scopus-indexed journals are available on 174 countries, 27 narrow and 4 broad disciplines and 13 years between 2005 and 2017. The globalization is measured using 7 different indicators of globalization. For each country, discipline, year and indicator we report average globalization score and the distribution of the research output across quartiles. Globalization indicators of individual journals are also provided. See the appendix A2 and A3 for details.

The average globalization scores can be inspected in full detail in an interactive application available at http://www.globalizationofscience.com/ (Macháček and Srholec 2019). The app can be used to analyse globalization development in various disciplines in a single country or to compare a single discipline in different countries.

It's (almost) all about incentives (Franzoni et al. 2011). Countries are the most important factor explaining the heterogeneity of globalization. Disciplines are much weaker predictor. The incentives provided by national research evaluation schemes and the country research culture in general have much higher impact on resulting globalization than the discipline in which the research is done.

The more research is needed to understand the results in more detail, focusing on some specific area or a discipline. Any detailed research must deal with the representativeness issue. The distortion is acceptable on a global scale that is described in this paper. However, Scopus might

contain country-specific or discipline-specific niches that can drive part of the results. Scopus might not cover substantial part of targeted research at all (Rafols et al. 2014) or besides purely academic journals it might cover also professional journals (Macháček and Srholec 2017b) . The more detail, the higher caution is needed (Waltman 2018).

The globalization is generally high (and the differences between disciplines small) in the countries of the "core" – in the Western Europe and North America. This finding is in line with Zitt et al. (1998) who announced "*almost complete transition from national to the transnational mode of communication*" already at the end of the last century.

The low globalization is symptomatic for the countries of the former soviet bloc, and especially for the former Soviet Union. The journals publishing researchers from only a handful of countries (or even just one) are an important publishing platform, especially in the social sciences and health sciences. For example, in Russia, Kazakhstan or Ukraine, the lack of globalization is present in almost all disciplines. The historical heritage of the old soviet system is one of the factors, but the attempts to game the research evaluation system are also commonly described (Moed et al. 2018, Rafols et al. 2016, Good et al. 2015, Kirchik et al. 2012).

The globalization of science gives information about a transformation of research outside the developed world. There is a striking difference between China, which gradually globalized almost all its broad disciplines and symptomatically low globalization in Russia,. In Brazil, the globalization grows from 2010 and in India, it is not. In Indonesia, the globalization even seems to decline throughout the analyzed period. However, especially in developing countries, the data can be very sensitive to the Scopus indexation decision.

The social sciences and health sciences are less globalized than life sciences and physical sciences. In combination with under-representation of socially scientific research in Scopus (Mongeon and Paul-Hus 2016) and an assumption that Scopus is more likely to index globalized than non-globalized journal, one might conclude that at least in case of social sciences, the true gap to life sciences can in many cases be even wider. However, the local journals often have strong incentives to get indexed in Scopus and sometimes they succeeded[2].

The policy study on the local journals in the Czech Republic (Macháček and Srholec 2017b, in Czech) shows examples of the least globalized journals that are indexed in Scopus. They can be very diverse – from journals with more than 100 years of history that have been traditional platform for science in the Czech Republic, through journals on the unclear boundary between academic and "professional" journals. Also, highly suspicious journals whose content is not even available online were marked.

Research internationalization is certainly beneficial. Both the international competition and cooperation can spur innovation and lead to scientific breakthroughs (Adams 2013). However, science policy must consider the potential benefits and disadvantages linked to the international publishing requirements. More effort is needed to understand the impact of globalization on scientific visibility, collaboration and impact as well as the link of globalized research to the societal needs (Glaser and Laudel 2016, Chavarro et al. 2016). Hopefully, the data on globalization can be of use for research on the role of globalized and national journals in the 21st century.

[2] Macháček and Srholec (2017b) describe on the Czech and Slovak journals cases of notoriously local journals, even though Scopus includes *International diversity of authors* within their indexation criteria.

References

Adams. J. (2013). Collaborations: The fourth age of research. Nature. 497(7451). 557.

Aman. V. (2016). Measuring internationality without bias against the periphery. In 21st International Conference on Science and Technology Indicators-STI 2016. Book of Proceedings.

Buela-Casal. G.. Perakakis. P.. Taylor. M.. & Checa. P. (2006). Measuring internationality: Reflections and perspectives on academic journals. Scientometrics. 67(1). 45-65.

Chavarro (2017). Universalism and Particularism: Explaining the Emergence and Growth of Regional Journal Indexing Systems. PhD Thesis. SPRU – Science and Technology Policy Research Unit, University of Sussex

Chavarro, D., Tang, P., & Rafols, I. (2014). Interdisciplinarity and research on local issues: evidence from a developing country. Research Evaluation, 23(3), 195-209.

Chavarro, D., Tang, P., & Ràfols, I. (2017). Why researchers publish in non-mainstream journals: Training, knowledge bridging, and gap filling. Research policy, 46(9), 1666-1680.

Evans, J. A., Shim, J. M., & Ioannidis, J. P. (2014). Attention to local health burden and the global disparity of health research. PloS one, 9(4).

Franzoni. C.. Scellato. G.. & Stephan. P. (2011). Changing incentives to publish. Science. 333(6043). 702-703.

Garfield, E., & Merton, R. K. (1979). Citation indexing: Its theory and application in science, technology, and humanities (Vol. 8). New York: Wiley.

Gazni. A.. Sugimoto. C. R.. & Didegah. F. (2012). Mapping world scientific collaboration: Authors. institutions. and countries. Journal of the American Society for Information Science and Technology. 63(2). 323-335.

Gläser, J., & Laudel, G. (2016). Governing science: How science policy shapes research content. European Journal of sociology/Archives Européennes de sociologie, 57(1), 117-168.

Good, B., Vermeulen, N., Tiefenthaler, B., & Arnold, E. (2015). Counting quality? The Czech performance-based research funding system. Research Evaluation, 24(2), 91-105.

Hicks, D., & Wang, J. (2011). Coverage and overlap of the new social sciences and humanities journal lists. Journal of the American Society for Information Science and Technology, 62(2), 284-294.

IMF (2003) World Economic Outlook (Statistical Appendix; pp. 163-169). Available at: https://www.imf.org/external/pubs/ft/weo/2003/02/

Kirchik. O.. Gingras. Y.. & Larivière. V. (2012). Changes in publication languages and citation practices and their effect on the scientific impact of Russian science (1993–2010). Journal of the American Society for Information Science and Technology. 63(7). 1411-1419.

Macháček. V. and Srholec. M. (2017a) Predatory Journals in Scopus. 2/2017. Institute for Democracy and Economic Analysis (IDEA).

Macháček. V. and Srholec. M. (2017b) Místní časopisy ve Scopusu (in Czech). 17/2017. Institute for Democracy and Economic Analysis (IDEA).

Macháček. V. and Srholec. M. (2019) Globalization of Science: Evidence from Authors in Academic Journals by Country of Origin. 6/2019. Institute for Democracy and Economic Analysis (IDEA).

Moed. H. (2002). Measuring China" s research performance using the Science Citation Index. Scientometrics. 53(3). 281-296.

Moed, H. F. (2010). Measuring contextual citation impact of scientific journals. Journal of informetrics, 4(3), 265-277.

Moed. H. F.. Markusova. V.. & Akoev. M. (2018). Trends in Russian research output indexed in Scopus and Web of Science. Scientometrics. 116(2). 1153-1180.

Mongeon. P.. & Paul-Hus. A. (2016). The journal coverage of Web of Science and Scopus: a comparative analysis. Scientometrics. 106(1). 213-228.

Ràfols, I., Molas-Gallart, J., Chavarro, D. A., & Robinson-Garcia, N. (2016). On the dominance of quantitative evaluation in 'peripheral'countries: Auditing research with technologies of distance. Available at SSRN 2818335.

Rijcke, S. D., Wouters, P. F., Rushforth, A. D., Franssen, T. P., & Hammarfelt, B. (2016). Evaluation practices and effects of indicator use—a literature review. Research Evaluation, 25(2), 161-169.

Scopus (2019) What is the complete list of Scopus Subject Areas and All Science Journal Classification Codes (ASJC)? Available at: https://service.elsevier.com/app/answers/detail/a_id/15181/supporthub/scopus/related/1/ [accessed May 28. 2019]

Scopus (2018) Scopus Source List (May 2018 version). Available at: https://www.scopus.com/sources

Wang, Q., & Waltman, L. (2016). Large-scale analysis of the accuracy of the journal classification systems of Web of Science and Scopus. Journal of Informetrics, 10(2), 347-364.

Waltman, L., Tijssen, R. J., & van Eck, N. J. (2011). Globalisation of science in kilometres. Journal of informetrics, 5(4), 574-582.

Waltman, L. (2018). Responsible metrics: One size doesn't fit all. CWTS Blog, March 29th 2018. Available at: https://www.cwts.nl/blog?article=n-r2s294. Downloaded on February 20th, 2020.

Wagner. C. S.. Park. H. W.. & Leydesdorff. L. (2015). The continuing growth of global cooperation networks in research: A conundrum for national governments. PLoS One. 10(7). e0131816.

Whitley, R., & Gläser, J. (2007). The changing governance of the sciences. Sociology of the sciences yearbook, 26.

Wilsdon. J. (2011). Knowledge. networks and nations: Global scientific collaboration in the 21st century.

Zitt. M.. & Bassecoulard. E. (1998). Internationalization of scientific journals: a measurement based on publication and citation scope. Scientometrics. 41(1-2). 255-271.

Zitt. M.. & Bassecoulard. E. (1999). Internationalization of communication a view on the evolution of scientific journals. Scientometrics. 46(3). 669-685.

Zitt. M.. & Bassecoulard. E. (2004). Internationalisation in science in the prism of bibliometric indicators. In Handbook of quantitative science and technology research (pp. 407-436). Springer. Dordrecht.

Zitt. M.. Perrot. F.. & Barré. R. (1998). The transition from "national" to "transnational" model and related measures of countries' performance. Journal of the American Society for Information Science. 49(1). 30-42.

Zhou. P.. & Glänzel. W. (2010). In-depth analysis on China's international cooperation in science. Scientometrics. 82(3). 597-612.

Zhou, P., & Leydesdorff, L. (2006). The emergence of China as a leading nation in science. Research policy, 35(1), 83-104.

Appendix

Table A1: Correlation matrix of Globalization measured by various indicators

Indicator	*euclid*	*cosine*	*GiniSimpson*	*top3*	*instTOP3*	*sEnglish*	*localShare*
euclid	**1.00**	**.83**	**.87**	**.93**	**.81**	**.61**	**.75**
cosine	.83	1.00	.64	.75	.69	.47	.41
GiniSimpson	.87	.64	1.00	.72	.67	.64	.78
top3	.93	.75	.72	1.00	.79	.51	.67
instTOP3	.81	.69	.67	.79	1.00	.43	.57

sEnglish	.61	.47	.64	.51	.43	1.00	.61
localShare	.75	.41	.78	.67	.57	.61	1.00

Pearson correlation coefficients of all available data for each indicator; Source: Scopus; own calculation

Supplementary file Appendix A2: Average globalization scores and research output distribution for countries, disciplines, indicators and years

The CSV file is available at: XXX

Supplementary file Appendix A3: Journal globalizations for years, indicators and disciplines

Note that journals with multiple disciplines are computed for each discipline. The results will differ for benchmark-based indicators that take into account the distribution of authors in the discipline.
The CSV file is available at: XXX

Appendix A4: IMF (2003) country classification

Advanced countries: Andorra, Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Israel, Italy, Japan, Liechtenstein, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Portugal, San Marino, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, United Kingdom, United States

Developing countries: Afghanistan, Algeria, Angola, Antigua and Barbuda, Argentina, Bahamas, Bahrain, Bangladesh, Barbados, Belize, Benin, Bhutan, Bolivia, Botswana, Brazil, Brunei, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Central African Republic, Chad, Chile, China, Colombia, Comoros, Congo, Costa Rica, Cote d'Ivoire, Cuba, Democratic Republic Congo, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Ethiopia, Fiji, Gabon, Gambia, Ghana, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kenya, Kiribati, Kuwait, Laos, Lebanon, Lesotho, Liberia, Libya, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Mexico, Micronesia, Morocco, Mozambique, Myanmar, Namibia, Nauru, Nepal, Nicaragua, Niger, Nigeria, North Korea, Oman, Pakistan, Palau, Palestine, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Qatar, Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Solomon Islands, Somalia, South Africa, Sri Lanka, Sudan, Suriname, Swaziland, Syria, Tanzania, Thailand, Timor-Leste, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Tuvalu, Uganda, United Arab Emirates, Uruguay, Vanuatu, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe

Transition countries: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czechia, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Moldova, Mongolia, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan

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