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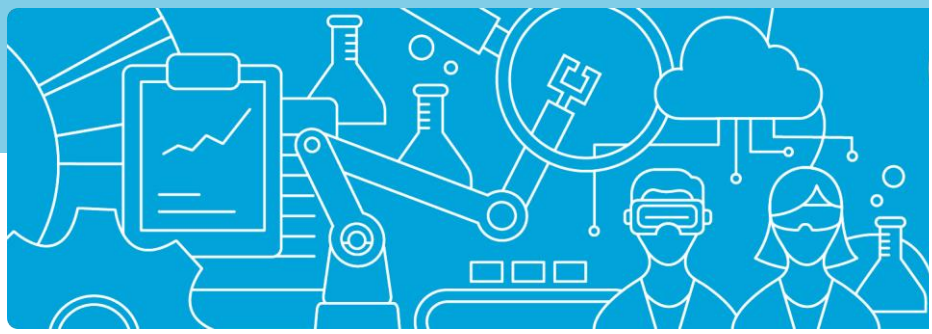

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Performance and Structures of the German Science System 2022

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Executive Summary

This study updates the annual comparative analysis of the performance and structures of the German science system against 22 selected countries. Bibliometric indicators are presented and discussed for the period 1995-2020, and citation-based indicators are presented for publications until 2018.

A notable theme in this report is the sustained presence of China[1] as a leading science system. Having overtaken the USA in 2018 and the Europe Union in 2019, China was the largest producer of scientific output in 2020, holding nearly a quarter (23.1%) of global publications. China's rapid growth has resulted in decreasing shares for most other well-established science systems over time. This includes Germany, which maintained its position behind China, the USA, and Great Britain as the fourth largest producer with 3.9% of global publications, down from 6.3% in 1995. Comparatively, alongside the Web of Science's (WoS) growing diversity of coverage of content outside the US and Europe, developing national science systems continued to increase their output and India narrowed the gap to rank fifth behind Germany with 3.8% of global publications according to the WoS.

In terms of impact, Switzerland, the Netherlands, Great Britain, and the USA continued to have the highest rates of excellent publications (>12%) among their publications, while Germany and Canada's Excellence Rates (9.8% and 9.5%) dipped slightly below the expected 10% level for the first time in 2018. This is part of a general trend of declining Excellence Rates for many European countries since the mid-2010s. However, when considering countries' contribution to the global corpus, Germany accounted for 4.2% of all excellent publications, behind only the USA and China, which accounted for over 20% each, and Great Britain (5.7%) in 2018. For the first time in 2018 China claimed a higher number of excellent publications than the 27 European Union countries combined. India too increased its share to 2.1% of all excellent publications, recently overtaking the contributions of the Netherlands, Spain, Korea and Japan to this specific corpus of leading publications. However, this still represents a low, although increasing Excellence Rate of 5.5% among India's growing publication corpus.

Regarding the visibility of scientific publications and journals, Germany continued to publish in highly visible journals, as shown by the above average citations received by these journsl (International Alignment). Compared with other publications within these journals, German publications attracted average citations (Scientific Regard). However, due to the higher expectations set by the highly visible journals, the Scientific Regard indicator values are decreasing. Notably, China further increased both its presence in highly visible journals and impact in theses journals beyond the above average levels first achieved in 2017. China's improved performance, taken in consideration with the rapidly growing contributions from India and the decline in indicator-based performance of historically strong systems such as the USA, Germany, and France, highlight profound structural changes in the global science system. Such developments represent a shift of the global system towards Asia and away from Europe and North America, respectively the fortification of a multipolar global system.

[1] China refers to Mainland China in the Web of Science.

Foreword

This report is the latest iteration in this series of bibliometric reports analysing the performance of Germany within the global science system. In this report, we present indicators to assess Germany's performance and compare it against 22 countries and the groups of the EU13, EU14, EU27, and OECD countries (see Appendix 1 for countries and groups). As indicators of the countries' scientific productivity, we present the national fractional count of global publications indexed in the Web of Science. To examine the countries' scientific impact we present the Scientific Regard and International Alignment indicators which, respectively, show whether the countries' publications were well-cited compared to other publications in the journals in which they were published, and whether they published in highly visible journals. We also present Excellence Rates, which are the percentage of a country's publications that were amongst the 10% most highly cited in each discipline, and each country's share of the global excellent publications, highlighting their contribution to this global corpus of excellent publications.

This report examines articles and reviews published in journals from the Web of Science's (WoS) Science Citation Index Expanded (SCIE), Social Science Citation Index (SSCI), and Arts and Humanities Citation Index (A&HCI) indices. The data is based on the KB WoS Snapshot 2021 provided by the German Competence Centre for Bibliometrics[2] as of April 2021. Fractional counting is used for all data. Fractional counting is conducted at the level of the author and aggregated to the country-level. As such, an equal proportion of each publication is attributed to each author which is then aggregated into the fractional count of publications for each author's country via the authors' respective affilliation.

We examine counts of publications over the period 1995 to 2020. A citation window of three years is applied for citation data, as such citation-based indicators include all citations of a publication which occurred within the year of its publication and the subsequent two years. Citation data are presented for the period 1995 to 2018. Self-citations have not been excluded from the data. See Appendix 2 for further details about the methodology used in this report.

In examining a time-series spanning more than 20 years, not only are changes in the national science systems relevant, but so too is the constantly-changing nature of the WoS database, which is regularly updated to expand its coverage of journals, both current and historical. As such, we refer readers to Section 2 of a previous report in this series [6], which provides a suite of contextual information relevant for the interpretation of the time-series for indicators presented in this report.

[2] http://www.bibliometrie.info

Country and Region-Level Indicators

This Section presents five indicators of productivity and impact for 23 countries between 1995 and 2020. As an indicator of productivity we present the national fractional shares of global publications. Impact is observable via the Scientific Regard, International Alignment, and Excellence Rates indicators, and the fractional share of excellent global publications. We provide these indicators with the aim of describing the performance of Germany's science system and evaluating it against the 22 countries selected for comparison (see Appendix 1).

National shares of global publications

National shares of global publications are a useful indicator of a country's standing in the international science system in terms of its level of scientific output. We present in Figure 1 the fractional share of global publications held by each of the selected countries. In this figure, the width of each country's band represents its share of global publications. The ordering of the bands in each group indicates the country's ranking from the largest share at the top to the smallest share at the bottom. Please note the panels have different scales on the y axis.

Having overtaken the USA in 2018, China was the largest producers of scientific output in 2020 with 23.1% of global publications. China has demonstrated a remarkable increase in productivity from 1.6% of global publications in 1995. In comparison the USA's current share of 17.1% represents nearly half of the 32.5% share it held in 1995. China's growth has resulted in decreased shares for many countries with well-established science systems, including Germany, France, and Great Britain. Germany produced 6.3% of global publications in 1995 but has held approximately 4% in recent years.

In contrast, India's share of global publications has more than doubled from 1.8% in 1995 to 3.8% in 2020. This places it as the fifth largest producer in 2020, just below Great Britain and Germany. Korea has also increased its share over this period, from 0.7% to 2.9%, as have Brazil (0.6% to 2.4%) and Poland (0.8% to 1.4%). These countries' growing shares of global publications reflect the ongoing development of these science systems, and also WoS' expansion to include increasingly diverse content beyond its traditional orientation toward English-language publications from North America and Europe [3].

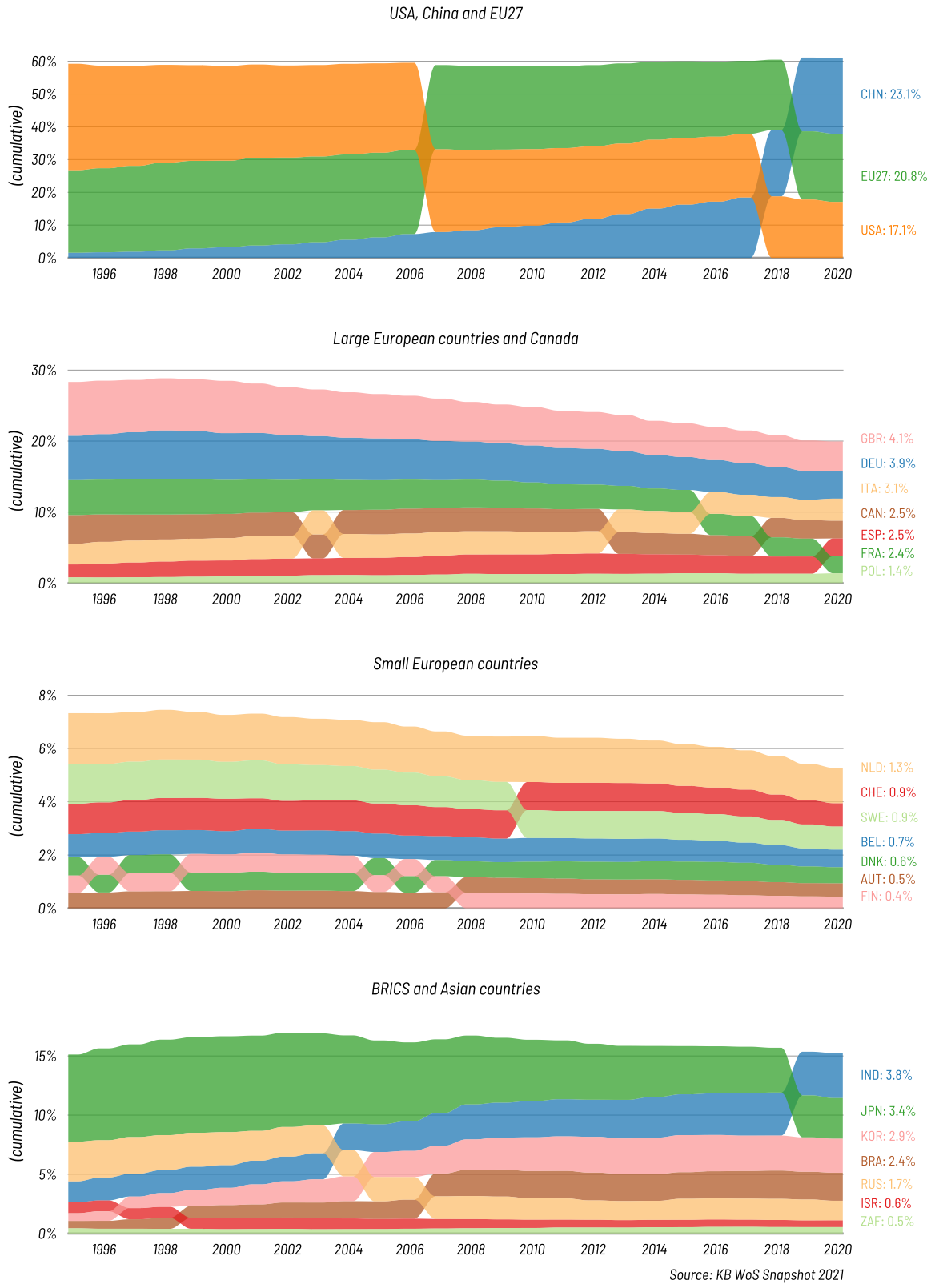

Figure 1: Countries' fractional shares of world publications, 1995-2020. Shares are presented cumulatively. The width of each country's band represents its fractional share of publications, and the ordering of the bands shows the country's ranking within its group with larger shares at the top.

National shares in 10% most cited publications

While productivity indicators demonstrate a country's level of output, impact indicators can provide insight into the reception of those publications by the scientific community as measured by citations. One such indicator is the fractional share of "excellent" global publications, as shown in Figure 2. Excellent publications are those constituting the globally 10% most highly cited in each discipline. Each country's share thus represents their relative contribution to the corpus of excellent publications. Data are shown up to 2018 to allow a 3-year citation window. This indicator can be considered in combination with the Excellence Rates (ERs) in Figure 3. ERs normalise a country's number of highly cited papers against its total publication output to show the relative share of the country's publications that are considered excellent. Figure 2 instead visualises the absolute contribution to this set of leading publications.

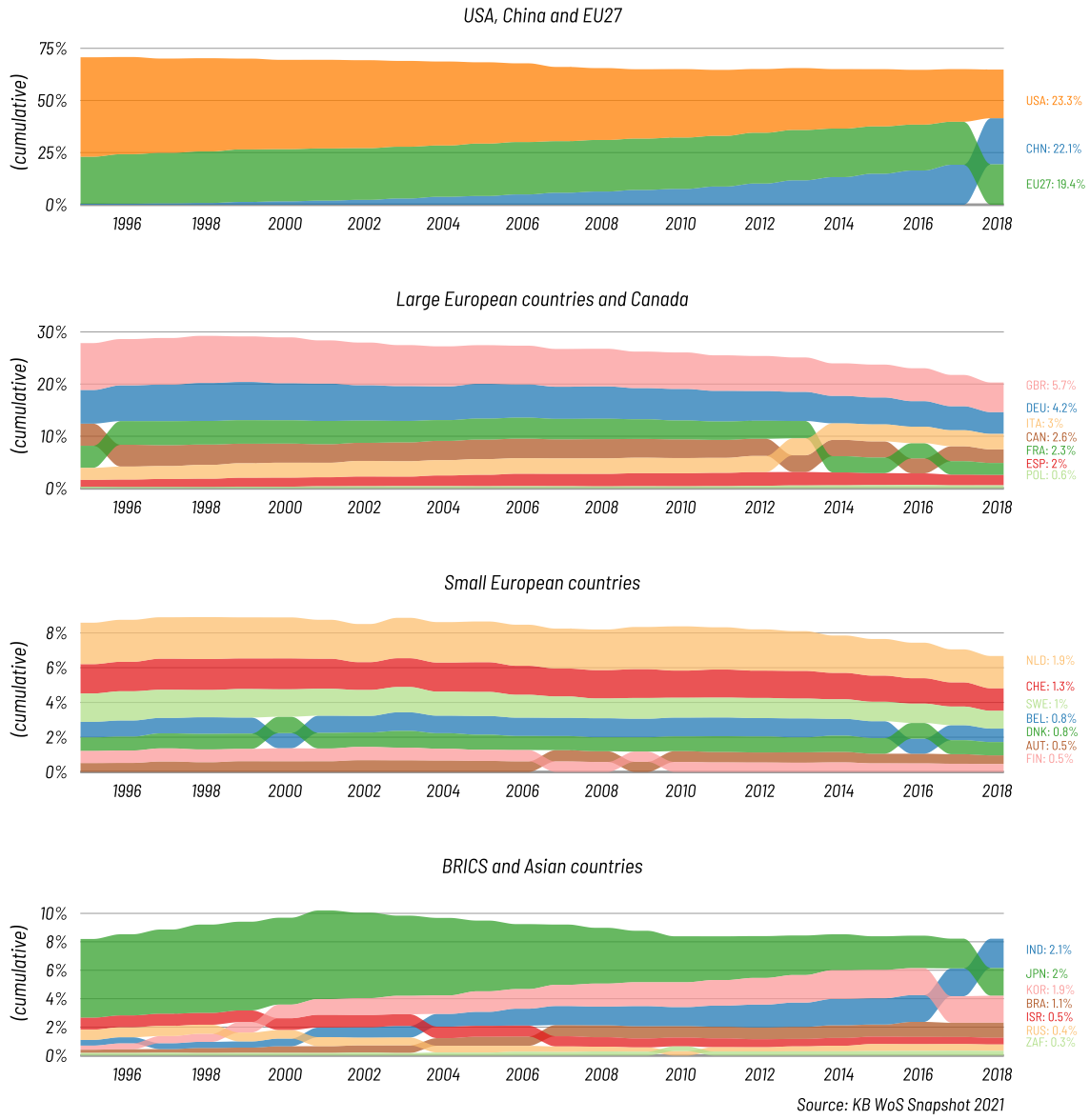

Figure 2: Fractional share of global publications in 10% most cited per discipline by country group, 1995-2018. Shares are presented cumulatively. The width of each country's band represents its fractional share of publications, and the ordering of the bands shows the country's ranking within each group.

The rankings of countries based on their contribution to the set of excellent publications in 2018 follow similar trends to their levels of overall scientific productivity in the same year. The USA contributed the largest share of excellent publications (23.3%), followed by China (22.1%), Great Britain (5.7%), and Germany (4.2%). China's share of excellent publications has grown alongside its overall output, increasing from 0.4% in 1995 to nearly a quarter of all excellent publications in 2018. For the first time in 2018 China claimed a higher number of excellent publications than the 27 European Union countries combined.

A country's overall scientific output, ER, and share of excellent publications can be considered together to develop a picture of its global contribution given the size of its science system. For instance, Switzerland, the Netherlands, Denmark, Sweden, and Belgium had amongst the highest ERs, indicating larger percentages of their publications were excellent. However, as each of these countries produced only approximately 1% of global publications, they each contributed approximately 1% of global excellent publications. In comparison, the larger scientific output of countries such as Germany, Spain, France, Canada, and Italy, meant that, although a smaller percentage of their publications were excellent, they contributed larger shares of excellent publications to the global corpus (2.0-4.2%). The USA, China, and Great Britain thus contributed the highest percentage of excellent publication as countries that accounted for large shares of global publications and had high rates of excellent publications.

India and Japan were exceptions to this trend. India and Japan were the 5th and 6th largest contributors of global publications at 3.8 and 3.4% respectively. However, only around 5% of their national publications were considered excellent. As such, their relative contribution to global excellent publications was 2%, or half of their overall contribution. Notably, India's share of excellent publications has quintupled over time from 0.4% in 1995 to 2.1% in 2018, recently overtaking the Netherlands, Spain, Korea, and Japan. However, Japan's contribution has declined from 5.5% of excellent publications in 1995. Japan's seeming underperformance given its position as leading global economy may reflect relatively low levels of international collaboration [5] and mobility, and preferences for publishing in national journals, which has reduced the visibility of Japanese publications [4].

Excellence Rates

Excellence Rates (ERs) are the percentage of national publications that were in the globally 10% most highly cited publications per discipline. The expected percentage is 10% so any percentage higher reflects performance that is better than expected. We show in Figure 3 the ERs for the country groups and individual countries up to 2018 to allow citations to occur in a 3-year citation window.

ERs tend to be relatively stable over time although the underlying content is constantly progressed. Switzerland, the USA, the Netherlands, Great Britain, Denmark, and Sweden recorded the highest ERs in 2018, retaining long-term trends of producing higher than expected percentages of excellent publications. Conversely, countries such as Korea, Japan, Poland, and the BRICS countries, except China, performed well below the expected level with ERs lower than 6.5%. Germany's ER declined continuously from its peak at 11.6% in the 2010s, dipping below the 10% threshold for the first time in 2018. This is part of a general trend of declining ERs for many European countries which began in the mid-2010s and has accelerated since 2016.

Some countries displayed particularly notable changes in performance. China's ER has steadily improved from 2.7% in 1995 to 10.9% in 2018, crossing the threshold to expected levels of performance in 2017. Both India and South Africa's ERs have also increased over time, although the performance of both remain under the expected 10% level. In contrast, the USA's ER began to slowly decline in the early 2000s from approximately 15% to 12.4% in 2018. Its ER remains amongst the highest of the examined countries, however. Finally, Japan's ER has decreased by more than 2 percentage points between 1995 and 2018.

Figure 3: Excellence Rates by country, based on fractional counting, 1995-2018

Scientific Regard and International Alignment

Scientific Regard (SR) conveys how well cited a country's publications were compared to other publications in the same journals. SR is centred on zero and so positive values indicate the country's publications were cited more often than is average for the journals in which they were published. Negative values indicate the converse. International Alignment (IA) complements SR as, while SR measures the citedness of publications in a journal, IA measures the citedness of the journals in which the country published compared to the average of all journals. IA too is centred on zero and so higher IA values reflect greater visibility and impact compared to the global average. We present in Figures 4 and 5 the SR and IA values for each country and country group. SR and IA are based on citations within 3 years of publication and so are presented up to 2018.

In examining SR and IA, and also the other indicators presented in this report, one should consider the influence of the variance in disciplinary coverage in the WoS on these indicators. We have previously observed the WoS to have good coverage of the natural and medical sciences and engineering and technology disciplines, but less complete coverage of the social sciences and humanities [6]. Poor coverage of a discipline results in under-representation of a country's citation counts, producing lower values in citation-based indicators. As such, countries with disciplinary profiles that align with the WoS' coverage have an advantage over countries with misaligned profiles.

Taking the complementary indicators together, in 2018 we observed three groups of countries. First, the countries that received higher than average citations in highly visible journals, as demonstrated by positive values for both indicators. These countries were Germany, Belgium, China, Denmark, Finland, Great

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ITA	-4	-3	-5	-3	-3	-3	-5	-1	-4	-4	-3	-3	-1	-2	-1	0	1	6	8	8	10	9	10	9
CHE	14	14	16	15	15	14	14	12	14	13	16	13	13	14	14	12	13	10	10	9	9	9	7	7
GBR	8	8	9	9	7	6	6	7	6	5	5	4	4	5	6	6	5	4	4	5	6	7	6	5
NLD	9	10	10	10	9	8	8	6	10	8	8	7	7	8	8	8	9	8	7	5	6	6	5	6
CHN	-24	-21	-16	-15	-8	-7	-5	-4	-1	1	0	-2	-1	0	0	0	1	2	1	2	2	3	5	6
BEL	7	6	9	7	4	5	5	8	9	3	7	8	9	10	10	9	12	8	9	8	7	2	5	1
DNK	12	12	14	14	10	13	12	11	15	11	13	11	10	12	12	12	12	12	8	9	8	7	3	2
USA	6	6	7	7	7	8	8	8	7	7	6	6	5	5	5	4	4	4	4	3	3	2	2	1
DEU	11	13	11	10	11	10	10	9	9	8	9	9	9	9	7	7	7	7	6	4	4	3	2	0
EU14	5	6	5	4	4	4	3	3	3	3	3	3	4	3	3	3	3	4	3	3	3	2	1	0
EU27	3	4	3	3	3	2	2	2	2	1	2	2	3	2	2	2	3	3	3	2	2	1	0	0
SWE	13	12	12	10	11	9	7	7	6	4	4	4	1	1	4	3	3	2	3	1	2	0	0	-1
AUT	6	8	4	4	4	4	5	6	8	8	8	6	8	4	5	5	4	5	1	4	2	3	0	0
OECD	4	4	4	4	4	4	3	3	3	3	2	2	2	2	2	2	1	1	1	1	1	0	-1	-1
FIN	10	11	9	6	8	6	7	6	5	2	0	3	1	0	2	1	2	2	1	0	-2	0	-1	0
IND	-28	-26	-25	-23	-23	-18	-16	-16	-13	-12	-11	-8	-7	-7	-6	-6	-6	-5	-3	-3	-2	-2	-2	0
ZAF	-9	-12	-7	-10	-8	-7	-9	-11	-7	-7	-5	-1	-4	0	-1	1	-2	-5	0	-3	-3	-2	-3	-1
RUS	-2	-1	-3	-4	-2	-2	-6	-3	-4	-6	-6	-5	-6	-6	-7	-5	-5	-5	-3	-1	-2	-1	-3	-5
POL	-12	-16	-15	-13	-10	-13	-9	-9	-8	-11	-12	-9	-10	-11	-11	-10	-6	-2	1	1	0	-1	-3	-5
CAN	2	0	0	2	2	2	2	0	2	3	1	0	0	1	-1	-1	-1	-1	-2	-2	-2	-2	-3	-4
EU13	-12	-13	-13	-9	-9	-10	-8	-8	-7	-9	-8	-5	-4	-4	-3	-3	-2	-1	0	-1	-2	-3	-5	-5
ESP	-9	-9	-10	-10	-9	-5	-9	-7	-7	-3	-2	-1	-1	-1	0	-1	-1	-1	-2	-2	-4	-4	-5	-4
FRA	2	3	3	2	1	1	1	-1	-1	-1	-1	0	2	0	0	0	0	-1	-2	-2	-4	-4	-6	-9
BRA	-19	-22	-20	-17	-21	-16	-19	-17	-16	-17	-14	-14	-9	-6	-6	-7	-7	-10	-10	-11	-10	-9	-11	-11
KOR	-20	-18	-15	-16	-13	-11	-12	-10	-11	-10	-8	-9	-9	-8	-8	-8	-9	-9	-9	-10	-12	-13	-14	-15
JPN	-5	-6	-5	-5	-5	-6	-5	-6	-7	-7	-8	-8	-9	-9	-11	-11	-12	-12	-13	-13	-14	-14	-15	-16
ISR	-10	-12	-11	-13	-12	-8	-7	-7	-12	-9	-12	-10	-11	-13	-13	-15	-13	-15	-17	-14	-15	-17	-16	-16

Source: KB WoS Snapshot 2021

Figure 4: Scientific Regard by country and group, based on fractional counting, 1995-2018.

Britain, Italy, Switzerland, the Netherlands, and the USA. However, the recent rapid improvement in Italy's SR should be considered in light of increasing intra-national citations subsequent to changes in Italy's national evaluation system in 2011 [1]. The second group, comprised of Brazil, India, Japan, Poland, Russia, and South Africa received below average citations and published in less visible journals, shown by their dual negative values. The third group, consisting of Austria, Canada, France, Israel, Korea, Spain, and Sweden, received below average citations for their publications but their publications appeared in well-cited journals.

Austria and Sweden appeared in this third group for the first time in 2018 after losing impact in the journals in which they publish. They both previously achieved positive values for both indicators. Alongside Austria and Sweden, Germany, France, Belgium, Denmark, and the Netherlands also demonstrated concurrently decreasing SR and increasing IA values. That is, their publications increasingly appeared in well-cited journals where there was greater difficulty in exceeding the journal's average citations, decreasing their SR. For example, Germany's SR declined from 10.9 in 1995 to 0.1 in 2018, while its IA climbed from 1.1 in 1995 to 13.7 in 2016. As such, the declining SR for these countries at least partially results from their publishing in increasingly visible journals rather than solely a decline in impact.

However, also of note is the decline in IA values for many European countries since 2017. Simultaneously, China began publishing in journals of average visibility in 2016 and its IA climbed to 7 by 2018. Given China now holds nearly a quarter of global publications, it may be that China directs its significant share of content and citations toward journals not typically amongst the core journals of many European countries. This may have shifted the set of journals that are most highly cited, resulting in a decline in IA values for European countries that continue to publish in their traditional journal set. Such changes resulting from China's growth have broad implications for the global science system and warrant further research.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
CHE	31	29	30	28	27	26	29	27	26	27	26	25	26	27	29	28	29	30	30	29	29	28	25	24
USA	31	32	31	31	30	29	30	30	29	28	27	26	28	29	28	27	27	26	25	23	22	20	18	15
NLD	16	12	16	14	18	20	18	19	21	21	22	23	24	25	25	27	26	24	23	21	20	19	17	15
GBR	7	7	8	10	9	10	11	14	13	13	14	14	16	19	18	18	17	17	16	17	16	15	13	12
DNK	8	8	9	10	13	14	13	12	16	15	14	15	17	19	19	19	17	17	17	17	15	15	13	12
SWE	7	9	9	7	8	10	10	10	9	10	11	10	14	14	14	15	13	11	12	13	13	12	10	9
DEU	1	1	2	1	3	4	4	6	7	6	8	9	10	13	14	15	16	15	15	14	14	14	10	8
FRA	-3	0	0	-1	-1	1	2	1	2	2	3	3	6	7	8	10	11	11	12	12	11	11	9	8
OECD	13	13	12	12	12	12	12	12	12	11	11	11	12	12	12	12	12	11	10	10	9	8	7	5
EU14	0	1	1	1	3	4	3	4	4	5	6	6	7	8	9	10	10	10	9	9	8	9	7	6
BEL	1	-4	1	-1	3	3	2	2	4	4	6	7	7	7	12	8	10	10	9	10	7	9	7	6
CAN	1	5	6	6	7	7	8	8	8	7	7	8	10	11	11	11	11	10	9	8	8	8	6	4
ISR	8	4	6	6	8	6	8	8	8	9	10	9	11	13	12	14	15	14	11	11	8	9	5	5
AUT	-8	-5	-2	-4	1	2	-2	3	2	4	5	6	7	6	5	7	7	5	6	7	5	5	5	4
CHN	-61	-60	-58	-56	-53	-49	-50	-45	-42	-40	-37	-35	-30	-26	-23	-19	-16	-12	-10	-7	-3	0	4	7
EU27	-4	-3	-3	-3	-1	0	-1	-1	0	0	2	2	2	2	2	4	4	3	3	4	3	3	2	1
ITA	-1	2	3	2	7	5	3	5	4	5	7	6	5	7	6	6	5	4	3	3	2	2	1	1
FIN	3	1	6	2	5	8	4	5	5	3	5	4	5	6	5	7	6	5	6	4	3	0	1	2
ESP	-9	-7	-9	-9	-8	-7	-8	-8	-6	-4	-3	-2	-2	-4	-2	0	1	1	0	2	0	1	1	0
KOR	-43	-39	-40	-37	-33	-26	-28	-26	-24	-24	-19	-20	-21	-21	-21	-19	-15	-13	-12	-9	-6	-5	-2	0
JPN	-6	-7	-4	-4	-3	-3	-3	-4	-3	-2	-3	-4	-2	0	1	0	2	1	0	-2	-3	-5	-7	-10
IND	-59	-59	-59	-59	-58	-55	-53	-51	-51	-46	-45	-39	-40	-42	-37	-38	-34	-30	-29	-24	-23	-20	-19	-18
POL	-48	-45	-47	-46	-44	-44	-47	-43	-42	-44	-40	-41	-45	-52	-49	-48	-47	-48	-42	-39	-36	-33	-32	-31
EU13	-52	-50	-49	-49	-46	-45	-46	-43	-42	-42	-40	-39	-46	-51	-49	-47	-47	-45	-42	-38	-37	-34	-33	-31
ZAF	-50	-51	-47	-48	-47	-44	-43	-44	-42	-40	-38	-38	-38	-37	-38	-33	-40	-37	-34	-35	-34	-36	-33	-31
BRA	-37	-36	-38	-41	-40	-36	-38	-36	-36	-37	-35	-35	-42	-47	-48	-48	-47	-46	-43	-40	-39	-35	-34	-31
RUS	-78	-78	-77	-77	-77	-77	-75	-74	-74	-74	-73	-72	-73	-75	-76	-75	-74	-70	-66	-64	-61	-60	-59	-59

Source: KB WoS Snapshot 2021

Figure 5: International Alignment by country and group, based on fractional counting, 1995-2018.

Appendix 1: Country code list

Table 1: Names and codes of countries in this report and the groups in which they are included.

Country	Code	EU13	EU14	EU27	OECD
Australia	AUS	-	-	-	Yes
Austria	AUT	-	Yes	Yes	Yes
Belgium	BEL	-	Yes	Yes	Yes
Brazil	BRA	-	-	-	-
Bulgaria	BGR	Yes	-	Yes	-
Canada	CAN	-	-	-	Yes
Chile	CHL	-	-	-	Yes
China	CHN	-	-	-	-
Colombia	COL	-	-	-	Yes
Costa Rica	CRI	-	-	-	Yes
Croatia	HRV	Yes	-	Yes	-
Cyprus	CYP	Yes	-	Yes	-
Czech Republic	CZE	Yes	-	Yes	Yes
Denmark	DNK	-	Yes	Yes	Yes
Estonia	EST	Yes	-	Yes	Yes
Finland	FIN	-	Yes	Yes	Yes
France	FRA	-	Yes	Yes	Yes
Germany	DEU	-	Yes	Yes	Yes
Greece	GRC	-	Yes	Yes	Yes
Hungary	HUN	Yes	-	Yes	Yes
Iceland	ISL	-	-	-	Yes
India	IND	-	-	-	-
Ireland	IRL	-	Yes	Yes	Yes
Israel	ISR	-	-	-	Yes
Italy	ITA	-	Yes	Yes	Yes
Japan	JPN	-	-	-	Yes
Latvia	LVA	Yes	-	Yes	Yes
Lithuania	LTU	Yes	-	Yes	Yes
Luxembourg	LUX	-	Yes	Yes	Yes
Malta	MLT	Yes	-	Yes	-
Mexico	MEX	-	-	-	Yes
New Zealand	NZL	-	-	-	Yes
Norway	NOR	-	-	-	Yes
Poland	POL	Yes	-	Yes	Yes
Portugal	PRT	-	Yes	Yes	Yes
Romania	ROU	Yes	-	Yes	-
Russia	RUS	-	-	-	-
Slovak Republic	SVK	Yes	-	Yes	Yes
Slovenia	SVN	Yes	-	Yes	Yes
South Africa	ZAF	-	-	-	-
South Korea	KOR	-	-	-	Yes
Spain	ESP	-	Yes	Yes	Yes
Sweden	SWE	-	Yes	Yes	Yes
Switzerland	CHE	-	-	-	Yes
The Netherlands	NLD	-	Yes	Yes	Yes
Turkey	TUR	-	-	-	Yes
United Kingdom	GBR	-	-	-	Yes
United States	USA	-	-	-	Yes

Appendix 2: Methodological details

This appendix discusses key methodological details to be considered in the interpretation of data from this report. This report is based on document types 'articles' and 'reviews' from the publication type 'journal'. Data are extracted from the Science Citation Index Expanded (SCIE), Social Science Citation Index (SSCI), and Arts and Humanities Citation Index (A&HCI) from the Web of Science (WoS). Fractional counting is used for all data disaggregated by country. Publications are examined for the period 1995 to 2020, in accordance with the availability of data to the German Competence Centre of Bibliometrics. Citation data are examined for the period 1995 to 2018 based on a 3-year citation window. The following sections describe key features of the methodology used in compiling this report and which should be considered when interpreting these data.

Whole versus fractional counting

There are two methods for counting publications that have more than one author – whole counting or fractional counting. Whole counting assigns a whole count of the publication to each author so one publication is considered as one contribution from each author and the country with which they are affiliated. Consider, for example, one publication with an author from Germany and an author from France. Using whole counting the publication would count as one publication each for Germany and France, for a total count of two publications. Evidently this method of counting inflates the overall number of publications. One method of remedying this inflation is to award each author a proportion of the publication, known as fractional counting. In this example, equal proportions of the publication would each be attributed to Germany and France and the total number of publications remains at one. Fractional counting can however disadvantage countries that regularly collaborate internationally as they lose a proportion of these publications from their totals, and this should be considered in interpreting the data here.

This report uses fractional counting for all data disaggregated by country. For the latter part of the WoS time-series, fractionalisation was applied at the level of the author. That is, a proportion of the publication was attributed to each of the author's affiliated institutions and these proportions are summed across the corpus of relevant publications for each country. This approach sufficiently captures the multiple international affiliations authors may have and provides the most accurate counts of each country's publications. However, the quality of the data linking authors with affiliations prior to 2008 in WoS was inadequate to support author-level fractional counting. As such, for years prior to 2008, fractional counting has been applied at the level of the organisation rather than the author. This would produce somewhat different counts than if author-level counting was applied throughout the time-series. For instance, Table 2 shows an example of a publication's authorship with four authors from 3 organisations in 2 countries. When fractional counting is applied to the authors, each author receives 0.25 of the publication which aggregates to 0.75 for country 1 and 0.25 for country 2. When the fractional counting is applied at the organisational level, each organisation receives 0.33 of the publication which aggregates to 0.66 for country 1 and 0.33 for country 2. In this way, fractional counts of countries' publications will differ between 2008 and later years. For further information, Waltman and Eck [7] provides a useful discussion on counting methods and their impacts on field-normalised indicators.

Table 2: An example of a publication's authorship

Author	Organisation	Country
Author 1	Organisation 1	Country 1
Author 2	Organisation 1	Country 1
Author 3	Organisation 2	Country 1
Author 4	Organisation 3	Country 2

Citation window

While counts of publications can be reliably calculated as early as the following year, a period of time must elapse during which publications were disseminated, read and accumulated citations before counts of the publications' citations can be calculated. As such, it is typical in bibliometric studies to analyse citations in a window of 3 to 5 years after the publishing year. Wang [9] determined that 3 years is required for most publications to reach their maximum number of citations per year, after which point the number of citations are likely representative of the publication's long-term impact. For this reason this report uses a 3 year citation window, which also ensures better relevancy of the data than the longer 5 year window. As such, any data and indicators pertaining to citations include all citations received within the year the publication was published and the subsequent two years. Consequently, items published at the end of a year have a slight disadvantage in that they have slightly shorter window in which to accrue citations.

Self-citations

Self-citations can either be included or excluded from citations counts. Self-citations have been retained in the data for this report on the basis that, first, self-citation is a standard means of scientific communication and of building upon one's own previous body of work, and secondly that the patterns of self-citation are likely to be similar with fields so will not present an advantage or disadvantage due to differing citation practices after field normalisation [2].

Excellence Rate

The Excellence Rate identifies the percentage of a country's publications that were in the 10% most highly cited publications from each discipline and thus could be considered of excellent quality. In this report, we employed the method described by Waltman and Schreiber [8] to calculate the 10% most frequently cited publications. Following this method, we identified the publications with citations above the 90th percentile. However, there may be a number of publications with citations on the threshold of the 10th percentile which, if included, would exceed the 10% required. As a secondary step then, we proportionally assigned the publications on the 90th percentile threshold to achieve exactly the top 10%. When interpreting Excellence Rates, the expected rate is 10%. Values higher than 10% then indicate the country had a higher than expected percentage of publications in the subset of 'excellent' publications and thus better performance.

Scientific Regard

The Scientific Regard (SR) indicator shows whether a country's publications are cited more or less than average compared to other publications from the same journals. SR is calculated by comparing the observed number of citations for a country's corpus of papers to the number of citations those papers could have been expected to receive, i.e. the average citations of papers in the journals the country published in, and then the scale is transformed to range between -100 and 100. As such, an SR of 0 indicates the countries' publications were cited at the average of the journals they were published in, while values over 0 indicate the country's publications are cited more frequently than average, and values below 0 indicate a lower than average citation rate compared to other publications from the same journals. The SR value for a country is calculated as:

$$SR_k = 100\, tanh\, ln\, (OBS_k / EXP_k)$$

where OBS_k is the observed rate of citations of country k's publications, and EXP_k is the expected citation rate based on the average citation rate of the journals in which country k published.

International Alignment

International Alignment (IA) is a measure of the international visibility of the journals in which a country publishes, based on citations. The IA value for a country is calculated as:

$$IA_k = 100\, tanh\, ln\, (EXP_k / OBS_w)$$

where OBS_w is the observed number of citations of all publications in the world, and EXP_k is the expected number of citations for country k based on the number of citations received by the journals country k published in. As such, positive IA values indicate the country's publications were published in journals that were cited more frequently than average, and so reflect higher visibility and impact. Conversely, negative IA values indicate the country published in journals that were cited less frequently than the world average.

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