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Performance and Structures of the German Science System 2017

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0 Executive Summary

This study provides an overview of bibliometric indicators for Germany and its international position compared with 23 countries and the EU for the period 2001-2016.

The trend of increasing total publications in the observation period continued in 2016. In many Western countries, however stagnation or at least a smaller growth can be found. Also Germany remains constant at the same publication level between 2013 and 2016. The majority of the worldwide growth is driven by China which is still the country with the highest growth, but also Brazil, India, South Africa and South Korea are able to increase their output. Some countries like Japan, Israel, Great Britain, France, Finland, Canada or Sweden also stagnate. In consequence, the shares in worldwide publications continue to decrease for these countries. The USA still have an annual publication output far higher than those of the other countries, but it also stagnates recently in absolute term, also resulting in further decreasing shares of worldwide publication output. The USA accounts for 20.2% of worldwide publications – a decline from 29.7% in 2001. China reached 17% and Germany 4.5% in 2016. In a longer-term perspective Japan is the only country that – in absolute numbers - publishes fewer articles in the Web of Science in 2016 than in 2001.

The citation-based indicators – meant to indicate the quality of the scientific publications – show a slightly increasing performance of Germany. German authors are able to publish more and more of their papers in higher ranked journals. The Excellence Rate – an indicator that addresses the share of top 10% highly cited papers – also increases for Germany in a longer perspective and recently kept a high level of 15%. Chinese authors have also been able to not only increase their absolute publication output, but also their quality – at least reflected by citations. China is still below the world average, but approaching it. The USA are – together with Switzerland and a number of smaller European countries like Denmark or the Netherlands – at the top in terms of the quality of their scientific output, but they also show slightly decreasing trends in all of these indicators.

The trend to more co-publications continues in almost all countries – an indication of higher international cooperation. Germany has a rather high share of international co-publications, given the size of its science system. The highest co-publication share can be observed for Switzerland. The USA are the most attractive partner for most countries, but they only reach a co-publication level of 40.3% – a strong increase since 2001.

1 Introduction to this issue

A continuous monitoring of the research and innovation system allows assessments of the present and future competitiveness of an economy. Scientific publications instantiate such developments and build the foundation for a fluctuant and adaptable knowledge system. Their analysis can shed light on frontier research, co-operations, structures, changes and the role of institutions in science systems.

This year, the study focuses on the core indicators and the updating of the data and illustrations describing the basic output of science systems in an international comparison, their trends and their visibility/quality in terms of citations as well as international co-publication structures. The bibliometric performance of a set of 23 countries and three regions (EU-28, EU-15 and EU-13)[1] (see Appendix p. 25) is analyzed in this report. The focus lies on Germany's performance in this global context.

In particular, we will analyze seven indicators in this study. The number of publications of the selected industrialized countries and regions provides a first comparison among countries over time. The publication share of the world also shows the size relationships between countries. The number and percentage of international co-publications of the countries and regions depicts the extent to which a country or region is internationally oriented. The International Alignment (IA) indicates whether the authors of a country frequently publish – compared to the world average – in internationally more or less respected journals. The Scientific Regard (SR) indicates whether publications of one country are more or less often cited compared to publications of the same research field. These two indicators should be considered and interpreted together. The Excellence Rate (ER) indicates how many of the publications of a country or a region belong to the worldwide most "excellent" publications – in our case to the 10% most cited publications.

A final analysis focuses on the German science system. We provide the number of publications and citations from German universities and non-university research institutions per full time equivalent (FTE).

The journal publications are retrieved from the Science Citation Index Expanded (SCIE) and the Social Science Citation Index (SSCI), which are both sub-products of the database Web of Science (WoS). The analysis covers "articles", "letters", "notes" and "reviews" for journal papers. Most analyses use fractional counting of the publications. By this, each publication is weighted according to the relative share of a country. Whole

1 EU-28 includes all EU countries, EU-15 includes countries which acceded up to April 2004 and EU-13 countries which acceded later.

count is used for the co-publication analysis, where a fractional counting is less intriguing. As external citations are the most relevant for evaluative purposes, this study follows the recommendation of CWTS to exclude self-citations (Nederhof, 1993). Whenever the period of analysis are not explicitly specified, publication-based indicators are presented for the period 2001 to 2016 and citation-based indicators for the period 2001 until 2014. For citation-based indicators we employ a three-year citation window, which means that we count all citations that a publication receives in the year of publication and the two subsequent years. A more detailed description of the underlying methods is provided in Michels et al. (2013).

2 Journal publications in an international comparison

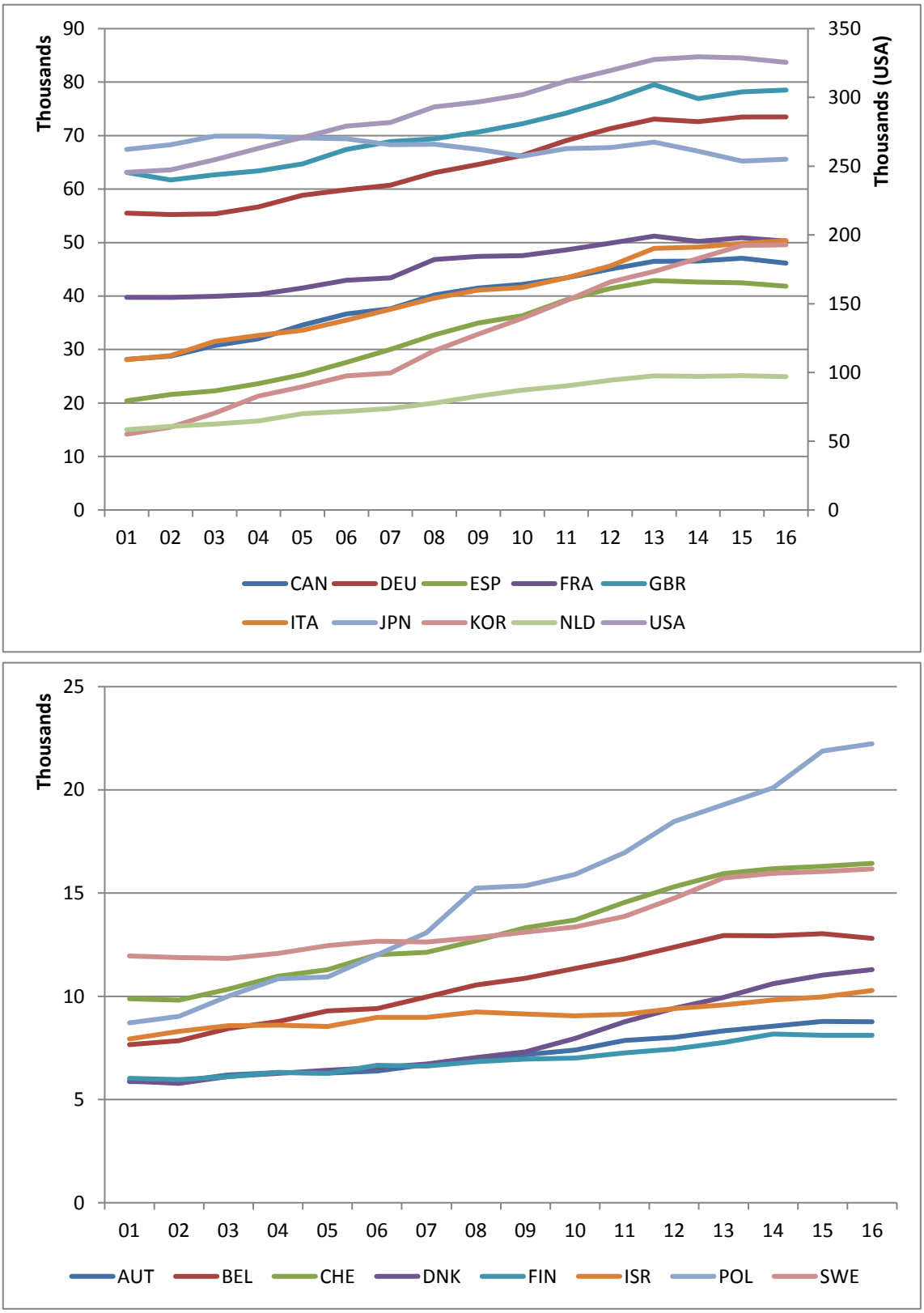
2.1 Number of publications and share of publications

Due to increases of the scientific output, of the science orientation of emerging countries, and also of the database coverage (see e.g. Michels and Schmoch, 2012), publication numbers worldwide steadily grow in the observation period 2001-2016.

Figure 1 shows the publication output until 2016 of the selected industrialized countries in the WoS. Since the countries work on very different output levels, the graph was split up into two groups of countries. The upper panel shows ten countries that publish the most: Japan, Germany, The United Kingdom, France, Canada, Italy, Netherlands, South Korea, Spain and the USA (see right hand scale). The lower panel shows the publications of some other industrialized countries like: Switzerland, Sweden, Finland, Austria, Belgium, Denmark, Israel and Poland. This separation of countries into two groups is used throughout the whole report.

As the different scales show, the USA still have a yearly publication output far higher than those of the other countries. Regarding only the industrialized countries, the United Kingdom has the second highest publication number, even if the number of publications decreased considerably in 2014, for the years 2015 and 2016, the trend is again rising. Germany also has a high number of publications of about 73500 publications in 2016. South Korea shows a dynamic development of publications and overtakes Italy and France in 2016. For Poland and Denmark, we find a noticeable increase of publications in the last years. Belgium is the only country with lower publication numbers that has a decreased number of publications in recent years.

Figure 1: Publication numbers of the selected industrialized countries in the SCIE and the SSCI (fractional counting)

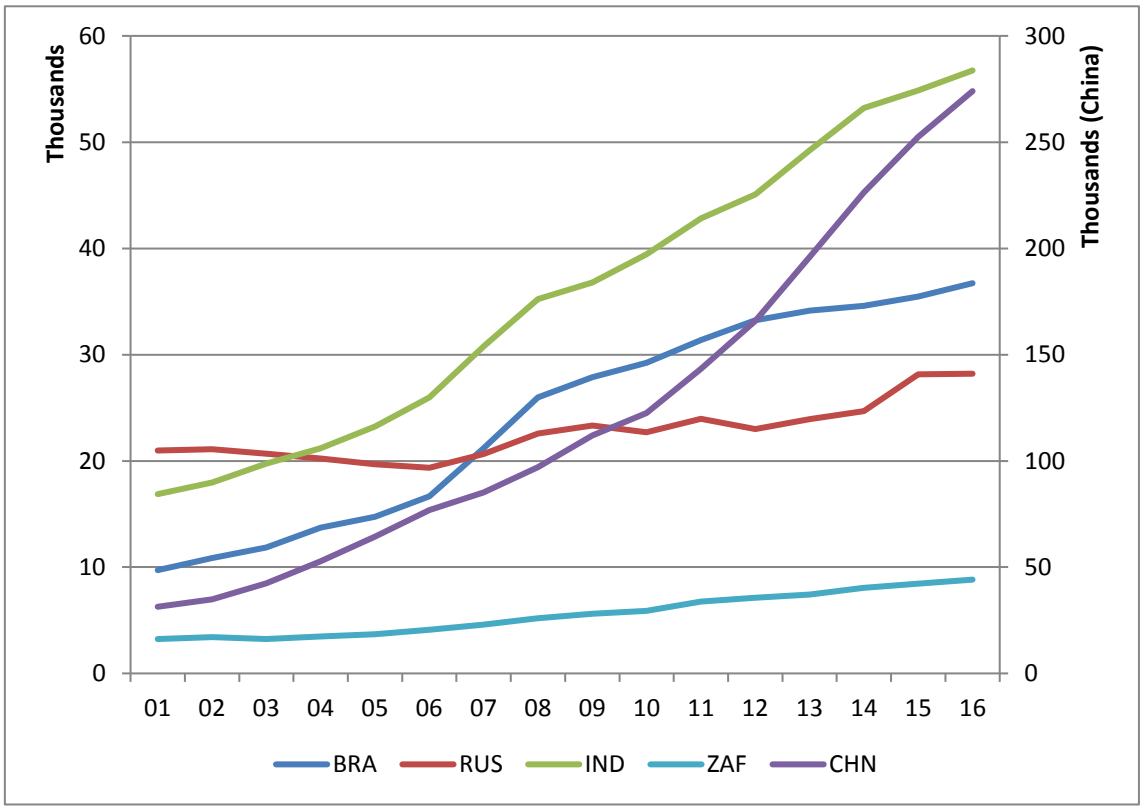


Source: Web of Science, queries and calculations by Fraunhofer ISI

Figure 2 shows the publication numbers for the BRICS countries. China is still the country with the highest growth. Compared to 2015, the number of publications has increased by 8% up to 274,009 publications and still approaches the top-ranked USA. Thus, China has almost four times as much publication as Germany in 2016; ten years before, Germany and China accounted for almost the same number of publications.

The other BRICS countries were also able to increase their absolute annual publication output. India increased the number of publications by 3 % up to more than 56.000. South Africa was also able to increase the absolute number of publications by 5% between 2015 and 2016. The average growth rates (CAGR) per year between 2006 and 2016 are 8.1% for India and 7.9% for South Africa. However, they are considerably outperformed by China with a compound annual growth rate of 13.6% in this period – and it is still growing at this pace. Brazil stagnated recently, but also reached an average growth rate between 2006 and 2016 of 8.2%.

Figure 2: Publication numbers of the BRICS countries in the SCIE and the SSCI (fractional counting)



Source: Web of Science, queries and calculations by Fraunhofer ISI

Table 1 shows a publication index per year in relation to the number in 2006. The worldwide increase accounts for 57% between 2006 and 2016 and a compound annual growth rate of 4.6% heavily affected by the trends in China, Brazil or India. Compared to the worldwide total most of the Western industrialized countries had a lower growth of publications in 10 years. Denmark and Poland are the only European countries which reached a higher growth than the world average. Spain and Italy are very close to the world average. Especially the more recently acceded countries of the EU (EU-13) also published above the world average; they reached 74% more publication in 2016 than in 2006. Germany was able to increase its publication numbers by 23%, but compared to 2015, the numbers remained constant. Japan is still the only country here that publishes fewer articles in Web of Science in 2016 than in 2006.

Table 1: Development of the publication numbers of the selected countries and regions in the SCIE and the SSCI according to fractional counting (Index 2001=100)

Country/ region	06	07	08	09	10	11	12	13	14	15	16
AUT	100	105	109	112	116	123	125	131	134	138	137
BEL	100	106	112	116	121	126	132	138	137	138	136
BRA	100	127	156	167	175	188	199	205	207	213	220
CAN	100	103	110	113	115	118	123	127	127	128	126
CHE	100	101	106	111	114	121	127	133	135	136	137
CHN	100	111	126	146	160	186	216	255	295	329	357
DEU	100	101	105	108	111	115	119	122	121	123	123
DNK	100	103	107	112	122	134	144	152	162	169	173
ESP	100	109	119	127	132	142	150	156	155	154	152
FIN	100	99	103	104	105	109	112	116	123	122	122
FRA	100	101	109	110	111	113	116	119	117	118	117
GBR	100	102	103	105	107	110	114	118	114	116	116
IND	100	119	136	142	152	165	174	190	205	211	219
ISR	100	100	103	102	101	102	105	107	109	111	115
ITA	100	106	112	116	117	122	129	138	138	140	142
JPN	100	98	99	97	95	97	98	99	97	94	95
KOR	100	102	119	131	143	156	170	178	187	197	198
NLD	100	103	108	115	121	126	132	136	135	136	135
POL	100	109	127	128	133	141	154	161	167	182	185
RUS	100	107	117	121	117	124	119	124	127	145	146
SWE	100	100	101	103	105	109	116	124	126	127	128
USA	100	101	105	106	108	112	114	117	118	118	117
ZAF	100	112	126	136	143	164	173	180	196	205	215
EU13	100	116	135	139	144	150	158	165	166	175	174
EU15	100	103	108	112	114	119	124	129	128	129	129
EU28	100	104	111	114	117	122	127	132	131	133	133
WORLD	100	105	113	118	123	130	137	145	149	154	157

Source: Web of Science, queries and calculations by Fraunhofer ISI

Table 2 shows the shares of the countries of the worldwide publication output. The USA is still holding the highest share in 2016, with a slight decrease compared to the previous year. The influence of China continues to increase. In 2016 China already held 17% of the worlds' publications. Germany's share has decreased in the observation period from 5.8% in 2006 to 4.5% in 2016, despite its growth in absolute terms in this period. All the EU regions show the same slightly declining trend, which occurs due to the higher growth rates in China, India and South Korea.

Table 2: Shares (in percent) of the selected countries and regions in percent in the SCIE and the SSCI within all publications (fractional counting)

Countr region	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
AUT	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5
BEL	0.9	0.9	1.0	0.9	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8
BRA	1.2	1.3	1.3	1.5	1.5	1.6	2.0	2.2	2.3	2.3	2.3	2.4	2.3	2.2	2.2	2.3
CAN	3.4	3.4	3.5	3.4	3.5	3.6	3.5	3.4	3.4	3.3	3.2	3.2	3.1	3.0	3.0	2.9
CHE	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0
CHN	3.8	4.1	4.8	5.7	6.6	7.4	7.9	8.3	9.2	9.7	10.6	11.7	13.1	14.7	15.9	17.0
DEU	6.7	6.5	6.3	6.1	6.0	5.8	5.6	5.4	5.3	5.2	5.1	5.0	4.9	4.7	4.6	4.5
DNK	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7
ESP	2.5	2.6	2.5	2.5	2.6	2.7	2.8	2.8	2.9	2.9	2.9	2.9	2.9	2.8	2.7	2.6
FIN	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
FRA	4.8	4.7	4.5	4.3	4.3	4.2	4.0	4.0	3.9	3.8	3.6	3.5	3.4	3.3	3.2	3.1
GBR	7.6	7.3	7.1	6.8	6.6	6.5	6.4	6.0	5.8	5.7	5.5	5.4	5.3	5.0	4.9	4.9
IND	2.0	2.1	2.2	2.3	2.4	2.5	2.8	3.0	3.0	3.1	3.2	3.2	3.3	3.5	3.5	3.5
ISR	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6
ITA	3.4	3.4	3.6	3.5	3.4	3.4	3.5	3.4	3.4	3.3	3.2	3.2	3.3	3.2	3.1	3.1
JPN	8.2	8.1	7.9	7.5	7.1	6.7	6.3	5.9	5.5	5.2	5.0	4.8	4.6	4.4	4.1	4.1
KOR	1.7	1.8	2.1	2.3	2.4	2.4	2.4	2.6	2.7	2.8	2.9	3.0	3.0	3.1	3.1	3.1
NLD	1.8	1.9	1.8	1.8	1.8	1.8	1.8	1.7	1.7	1.8	1.7	1.7	1.7	1.6	1.6	1.5
POL	1.1	1.1	1.1	1.2	1.1	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.4
RUS	2.5	2.5	2.3	2.2	2.0	1.9	1.9	1.9	1.9	1.8	1.8	1.6	1.6	1.6	1.8	1.7
SWE	1.4	1.4	1.3	1.3	1.3	1.2	1.2	1.1	1.1	1.1	1.0	1.0	1.1	1.0	1.0	1.0
USA	29.7	29.3	28.8	28.3	27.8	27.1	26.0	25.1	24.3	23.9	23.2	22.6	22.0	21.4	20.7	20.2
ZAF	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
EU13	2.7	2.8	2.9	2.9	2.9	3.0	3.3	3.6	3.5	3.5	3.4	3.4	3.4	3.3	3.4	3.3
EU15	32.5	32.0	31.4	30.8	30.4	30.0	29.4	28.7	28.3	28.0	27.4	27.1	26.7	25.7	25.2	24.7
EU28	35.3	34.8	34.3	33.7	33.3	33.0	32.7	32.2	31.8	31.5	30.9	30.5	30.1	29.0	28.6	28.0
WOR LD	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Source: Web of Science, queries and calculations by Fraunhofer ISI

2.2 International Co-Publications

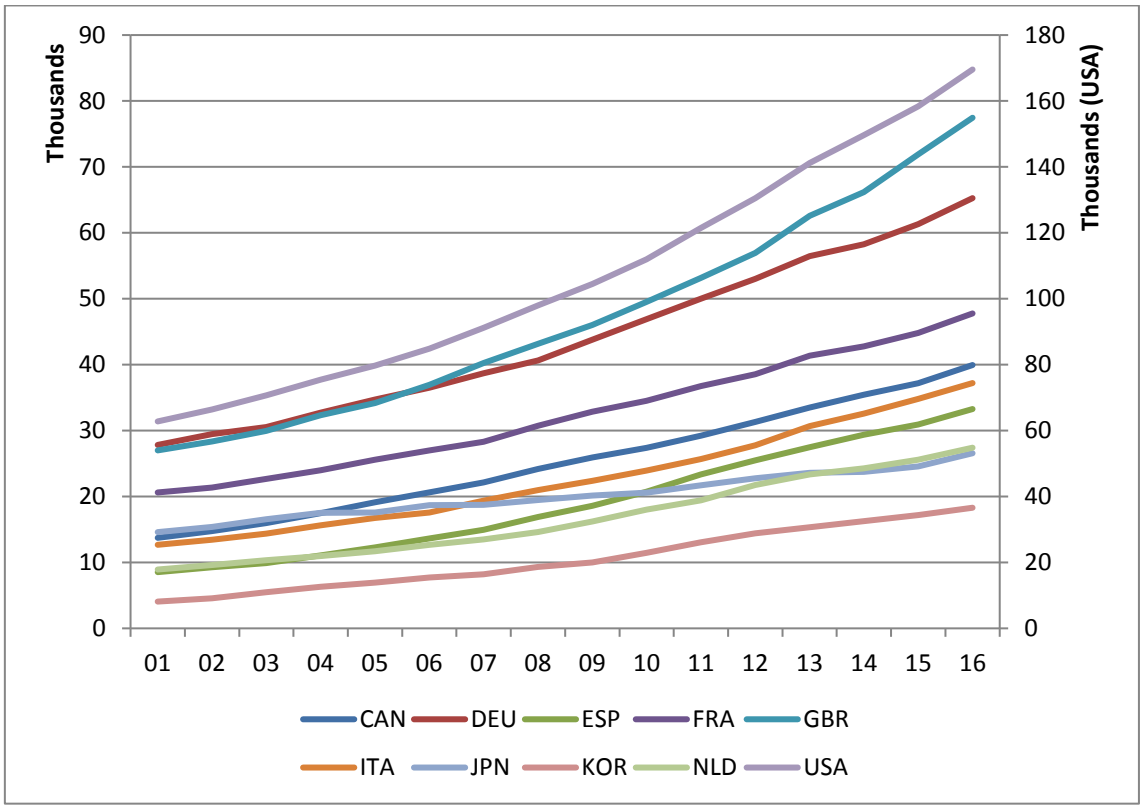
Co-publications can be divided into international and national co-publications. International co-publications are defined as publications that have at least one partner from

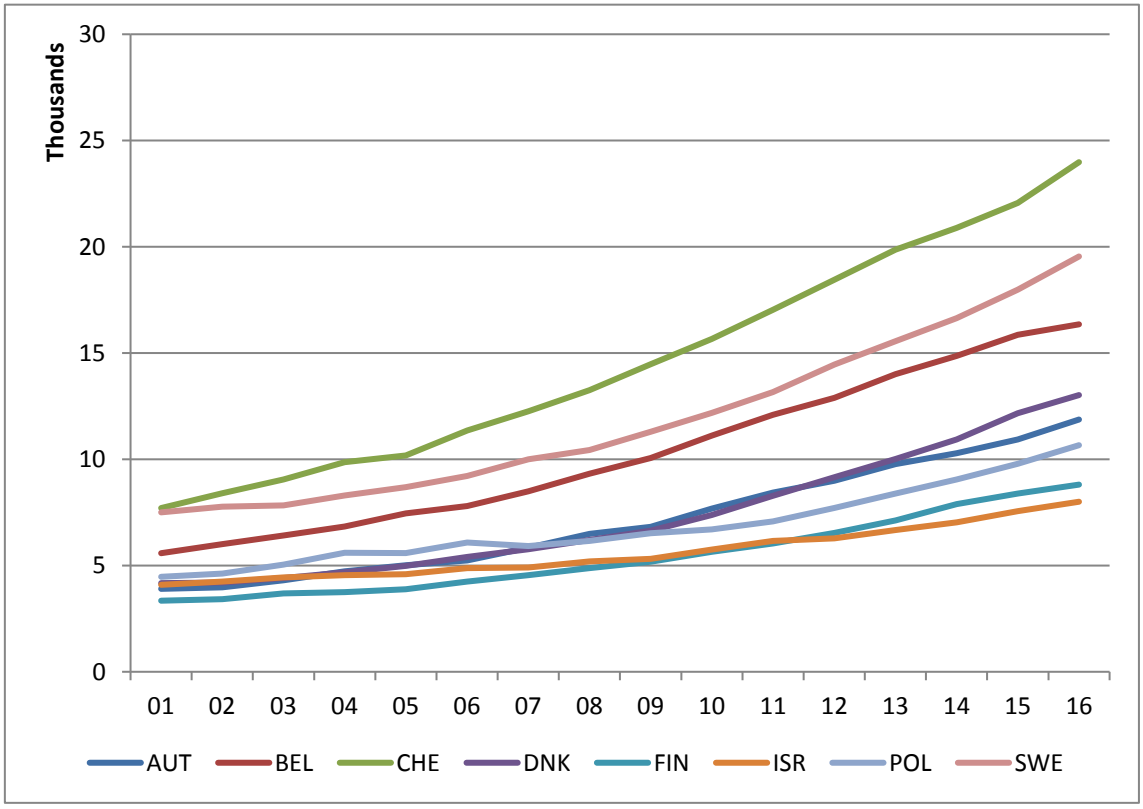
abroad. By contrast, purely national co-publications are defined as publications with at least one cooperation partner from the same country, but who do not belong to the same organization. In this section the focus lies on international co-publications which are an indicator for scientific collaborations.

Figure 3 and Figure 4 show the number of international co-publications of the industrialized countries and the BRICS countries. The analyses depict the overall development of Germany's (and other countries') behaviour in collaborations over time by comparing the absolute as well as relative numbers of co-publications.

In all of the countries there is a visible trend to more international cooperation. This is not a surprising trend, because the number of publications has risen in the same period as well. It should be noted that China's international publications have risen as much in recent years that most of the industrialized countries are surpassed. The US remains far ahead (see secondary axis in Figure 3).

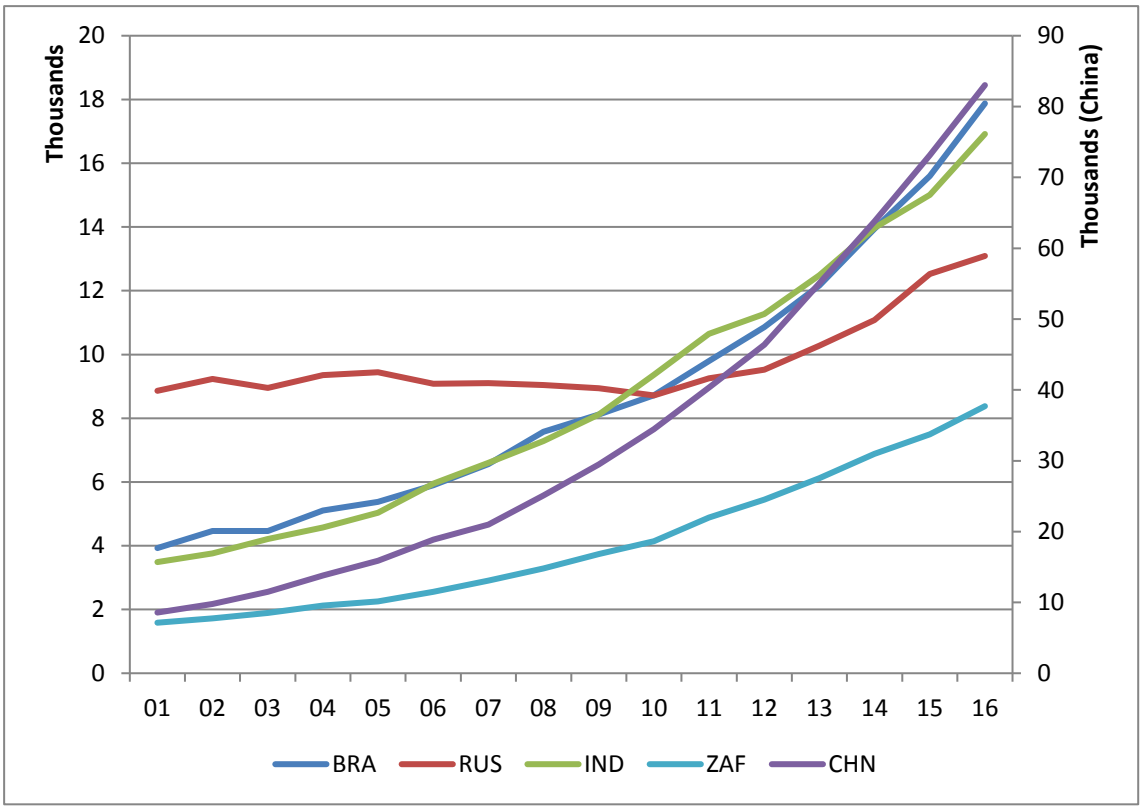
Figure 3: Number of international co-publications of the selected countries (whole counting)





Source: Web of Science, queries and calculations by Fraunhofer ISI

Figure 4: Number of international Co-Publications for the BRICS countries (whole counting)



Source: Web of Science, queries and calculations by Fraunhofer ISI

Even though the absolute number of co-publications increased for all collaboration partners, the relative share of co-publications with the individual countries changed substantially in several countries in the period between 2001 and 2016. Table 3 shows the relative share of all countries under analysis here, the EU regions and the world.

In comparison to other countries, Germany has a relatively high share of international co-publications, given its size in terms of inhabitants and also in terms of researchers. In 2016, more than every second German publication was written in collaboration with a foreign author. This co-publication share is exceeded by 10 other countries in our set (CHE, AUT, BEL, SWE, DNK, NLD, FIN, GBR, FRA and ZAF). The highest co-publication share can be observed for Switzerland with 74%. Except for South Africa all BRICS countries had a relatively low share of international co-publications in the whole time period. It is impressive that China was able to keep its level of international co-publications (about 26% in 2016), given its enormous growth of scientific publications in absolute terms. South Korea, Japan and Poland also show low shares of international co-publications (less than 40% in 2016). The relative share of international co-publications of the USA increased from 23% in 2001 to 40% in 2016. The highest increase of the shares of international co-publications between 2001 and 2016 can be observed for United Kingdom (27 percentage points), Austria (24 percentage points) and

Finland (22 percentage points). Poland is the only country in the set which has lower shares of international co-publications in 2016 compared to 2001.

Table 3: Shares of the selected countries and regions in the CPCI of international co-publications relative to their total number of publications (whole counting)

Country/region	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
AUT	47.7	48.2	49.2	51.5	53.7	54.6	56.8	58.9	59.5	62.5	63.4	64.9	66.5	67.2	68.4	71.2
BEL	50.8	52.5	52.2	53.0	54.1	55.1	55.9	57.3	58.8	60.6	62.1	62.8	64.2	66.3	68.0	69.7
BRA	33.1	33.6	31.2	30.9	30.4	29.6	26.6	25.2	25.2	25.7	26.7	27.7	29.7	32.9	35.2	38.2
CAN	38.3	39.8	40.2	41.6	42.0	42.4	43.8	44.5	45.7	46.8	48.1	49.1	50.2	52.0	53.3	56.4
CHE	53.0	56.5	57.0	57.9	58.0	59.7	62.0	63.2	64.7	66.4	67.1	67.9	69.2	70.3	71.8	74.3
CHN	23.8	24.4	23.7	23.0	21.8	21.7	21.8	22.8	23.2	24.5	24.5	24.4	24.5	24.6	25.2	26.3
DEU	39.1	41.0	42.1	43.4	44.1	45.2	46.6	47.0	48.6	50.1	50.8	51.6	53.0	54.2	55.6	57.8
DNK	49.9	50.7	50.4	51.5	52.8	54.9	56.1	57.1	58.0	58.5	59.0	59.9	61.2	61.8	64.2	65.7
ESP	33.8	34.6	35.5	36.8	37.8	38.6	38.7	39.8	40.6	42.8	44.1	45.2	46.5	49.0	51.0	54.0
FIN	41.9	43.1	44.7	44.2	45.4	46.4	48.7	50.0	51.4	54.1	55.0	56.9	58.5	60.2	62.5	64.1
FRA	40.3	41.4	43.1	44.6	45.7	46.4	47.6	47.9	49.8	51.3	52.8	53.6	55.2	57.1	58.3	61.0
GBR	34.5	36.4	37.6	39.4	40.5	41.6	43.5	45.5	46.9	48.6	50.0	51.2	53.2	56.2	58.5	61.0
IND	18.6	18.8	19.1	19.3	19.4	20.4	19.2	18.6	19.7	21.0	21.9	22.0	22.2	22.9	23.7	25.5
ISR	39.9	39.6	39.9	40.6	41.0	41.3	41.5	42.2	43.3	46.0	48.0	47.4	48.8	49.6	51.5	52.3
ITA	36.2	37.2	36.4	37.9	39.0	38.8	40.0	40.8	41.5	43.2	44.1	45.0	46.0	47.8	49.6	51.5
JPN	19.5	20.2	21.1	22.1	22.3	23.5	23.9	24.7	25.7	26.6	27.3	28.3	28.8	29.5	31.0	32.8
KOR	24.8	25.4	26.1	25.5	25.8	26.5	27.3	26.8	26.2	27.3	28.2	28.5	29.0	29.0	29.2	30.6
NLD	44.0	45.2	46.6	47.2	46.8	48.6	49.7	50.6	51.9	53.7	55.1	57.4	58.7	60.1	61.8	64.4
POL	39.6	39.5	38.9	39.7	39.3	39.0	35.7	32.5	33.8	33.5	33.1	33.1	34.2	35.1	34.9	36.8
RUS	34.0	35.0	34.7	36.5	37.5	36.8	35.0	32.4	31.3	31.3	31.4	33.2	34.2	35.5	35.4	36.5
SWE	46.0	47.5	47.8	48.9	49.4	50.8	53.6	54.5	56.4	58.1	59.5	60.4	60.7	62.5	65.0	67.5
USA	22.6	23.5	24.2	24.9	25.5	26.2	27.6	28.4	29.6	30.9	32.2	33.4	34.9	36.3	38.0	40.3
ZAF	38.3	39.1	43.8	45.1	45.2	45.6	46.2	46.1	47.8	49.5	50.3	51.9	54.5	55.5	56.8	58.9

Source: Web of Science, queries and calculations by Fraunhofer ISI

2.3 Journal-specific Scientific Regard (SR) and International Alignment (IA)

The Scientific Regard (SR) and the International Alignment (IA) put the citation rate in perspective with the reputation – in terms of average citation rates per journal – of the publishing journals. While the IA shows whether a country publishes in more or less cited journals (compared to the world average), the SR relates the citation rate of a publication to the average citation rate in each journal and indexes the average for all publications.

Table 4: Index of the journal-specific Scientific Regard (SR) for the selected countries and regions in the SCIE and the SSCIE according to fractional counting

Country/ region	01	02	03	04	05	06	07	08	09	10	11	12	13	14
AUT	4	1	7	6	3	4	6	1	3	3	0	1	-1	0
BEL	0	5	4	0	4	4	4	5	4	4	5	4	5	4
BRA	-29	-25	-24	-24	-20	-20	-15	-13	-11	-11	-12	-14	-15	-14
CAN	1	0	1	2	0	0	1	0	1	0	0	0	-2	-1
CHE	18	14	13	12	17	14	12	14	12	10	11	8	7	8
CHN	-10	-8	-3	1	1	0	3	4	3	3	5	6	6	6
DEU	9	9	9	7	8	7	6	5	3	5	4	4	4	2
DNK	9	11	15	11	11	12	8	13	9	9	9	9	6	6
ESP	-15	-14	-13	-9	-9	-7	-6	-7	-6	-7	-5	-6	-7	-6
FIN	2	1	1	0	-2	1	-2	-2	-1	-1	0	-1	-3	-1
FRA	2	-1	0	-2	-1	-1	0	-1	-1	-1	-2	-2	-2	-3
GBR	7	7	5	7	6	5	4	5	6	6	6	5	4	6
IND	-21	-21	-17	-18	-14	-10	-9	-8	-6	-6	-5	-4	-4	-3
ISR	-11	-11	-13	-10	-13	-11	-12	-14	-13	-14	-13	-14	-18	-15
ITA	-11	-7	-7	-8	-6	-7	-6	-6	-3	-3	-4	-1	-1	0
JPN	-10	-10	-12	-11	-12	-11	-12	-12	-13	-14	-14	-14	-15	-16
KOR	-11	-8	-8	-6	-7	-7	-8	-6	-6	-7	-8	-8	-8	-9
NLD	9	5	12	9	6	7	5	7	6	7	7	7	5	3
POL	-22	-23	-19	-22	-20	-21	-18	-20	-16	-17	-14	-10	-8	-7
RUS	-10	-8	-10	-11	-11	-11	-9	-10	-11	-10	-10	-12	-11	-11
SWE	9	8	6	5	3	3	1	1	3	2	1	0	1	0
USA	10	10	10	9	9	8	8	7	7	6	6	6	6	5
ZAF	-14	-14	-12	-14	-10	-7	-8	-4	-6	-3	-7	-8	-3	-6
EU13	-20	-18	-15	-18	-17	-14	-12	-12	-10	-9	-8	-7	-7	-8
EU15	3	2	2	2	2	2	2	2	1	2	1	1	1	1
EU28	1	1	1	1	1	0	0	0	0	1	0	1	0	0

Source: Web of Science, queries and calculations by Fraunhofer ISI

Table 4 shows the SR values for the countries under observation here for the years 2001 to 2014. The German index has been decreasing from 9 in 2001 to 2 in 2016. In general, we find that countries with a rather low SR show an increasing trend while countries with a high SR report declining SR index values over the years. Against this trend, Japan and Israel decrease their SR of about -10 in 2001 to about -15 in 2016. Russia (about -10) and the United Kingdom (about 6) maintain a stable SR over the years. For India, China, Brazil, Poland, Italy, Spain, South Africa, Belgium and South Korea, we find a higher SR in 2014 than in 2001. While China shows a negative SR index value (-10) in 2001, it increased its SR in 2014 to a positive value (6), which means that the increasing absolute numbers of scientific publications in the Web of Science are also more frequently cited compared to the journals where they are published. To some extent this might be explained by the fact that authors tend to cite authors from their own

countries more frequently than foreigners. This is partly explainable by collaboration, interaction, similar national research priorities as well as cultural overlaps. In consequence of the absolute increase of publications also the citations increase.

Table 5: Index of the International Alignment (IA) for the selected countries and regions in the SCIE and the SSCI according to fractional counting

Country region	01	02	03	04	05	06	07	08	09	10	11	12	13	14
AUT	-9	-4	-5	-2	0	-1	1	0	-3	1	-1	-2	1	0
BEL	-5	-7	-2	-1	1	2	1	3	5	2	4	4	4	4
BRA	-50	-47	-47	-47	-44	-44	-50	-55	-55	-56	-55	-54	-51	-48
CAN	3	3	4	3	4	5	6	5	5	5	5	4	4	3
CHE	25	23	22	24	23	22	23	24	24	24	24	26	26	23
CHN	-65	-60	-55	-55	-52	-48	-41	-36	-32	-28	-25	-21	-16	-13
DEU	-3	-2	0	0	3	3	4	6	8	8	9	9	9	8
DNK	7	8	12	12	11	13	13	14	15	14	11	12	12	12
ESP	-20	-20	-19	-15	-13	-11	-10	-13	-11	-9	-9	-7	-8	-6
FIN	-3	-1	-1	-2	-1	-1	0	1	0	1	-1	-1	-1	-3
FRA	-6	-7	-5	-5	-3	-3	0	1	1	3	4	5	6	6
GBR	2	6	7	7	9	8	10	12	10	10	10	10	9	9
IND	-66	-64	-63	-57	-55	-50	-50	-53	-48	-48	-45	-41	-39	-35
ISR	3	3	3	5	6	6	7	8	7	9	11	9	7	6
ITA	-6	-3	-4	-3	0	0	-2	-1	-2	-2	-4	-4	-5	-5
JPN	-13	-14	-13	-10	-11	-11	-10	-7	-6	-7	-6	-6	-7	-9
KOR	-41	-40	-39	-41	-38	-37	-29	-30	-29	-26	-23	-19	-17	-14
NLD	13	14	16	18	19	20	21	21	21	22	20	19	18	15
POL	-63	-58	-56	-58	-52	-52	-55	-61	-58	-57	-56	-56	-50	-47
RUS	-85	-85	-84	-84	-83	-82	-83	-84	-84	-83	-83	-80	-77	-74
SWE	4	4	5	6	8	8	11	9	10	10	8	6	6	7
USA	28	28	27	27	26	26	26	26	25	24	23	23	21	19
ZAF	-54	-54	-51	-47	-43	-44	-45	-44	-46	-40	-48	-45	-41	-41
EU13	-60	-57	-54	-54	-51	-50	-55	-59	-57	-55	-55	-53	-50	-46
EU15	-3	-2	-1	0	2	2	3	4	4	5	4	4	4	4
EU28	-7	-6	-5	-4	-2	-2	-2	-2	-2	-1	-1	-1	-1	-1

Source: Web of Science, queries and calculations by Fraunhofer ISI

Table 5 shows the IA values for the selected countries and regions, as a supplement to the SR values. This index indicates if the journals are high or low cited – on average. In general, the IA values are more dispersed than the SR values, i.e. there are countries with relatively low values (e.g. Russia, Brazil, Poland and South Africa), but also with high values (e.g. Switzerland, the USA, Netherlands and Denmark). Such a high disparity could not be observed for the SR values. Part of the reasoning of this diverse picture is the fact that the IA does not account for scientific fields. As the profiles of the countries considerably differ and as the citation rates of some disciplines also considerably differ, the dispersion of the countries is affected. As the profiles within the coun-

tries are rather stable over time, the strength of the IA is the analysis of the trends within the countries. For example, it is interesting to note that the US-American index decreases over time from a level of 28 in 2001 to a level of 19 in 2014.

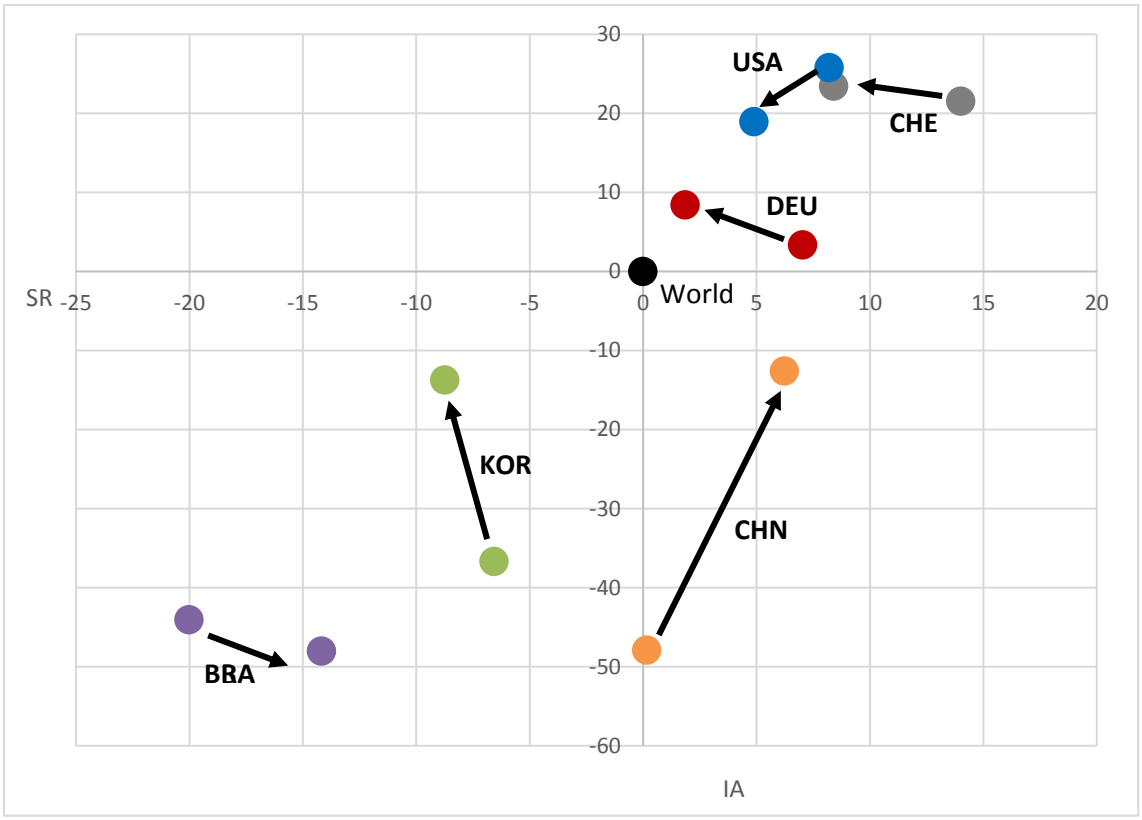
The IA index of the EU15 countries is only slightly positive, which indicates a publication behaviour that targets – on average – journals which are cited on a worldwide average. The Eastern European countries (EU13) are not yet on this same level. They only achieve to publish in journals that are less frequently cited than the world average. Their index level is considerably negative. Over the last 13 years, it only increased by 14, so that in 2014, the EU13 countries still show one of the lowest index values of all investigated countries.

Germany is able to considerably increase its IA index from -3 to a level of 8, which brings it to the level of the United Kingdom and even beyond Sweden, which recently shows a slightly decreasing trend of this indicator.

China, India and South Korea were able to publish their research findings in higher ranked journals since 2001. Their IA index considerably increases over time; however, it is still negative.

Figure 5 shows the SR and the IA in comparison for six selected countries and the world. The initial situation in 2006 as well as in 2014 – different to the absolute publication numbers, the citation based indicators only reach until 2014 due to the citation window of three years – are depicted for each country. Their development over time is indicated by arrows. Both indicators have a value of 0 for the world average, which is used as a reference level for the comparison.

Figure 5: Index of the journal-specific Scientific Regard (SR) and the International Alignment (IA) for six selected countries in 2006 and 2014 in the SCIE and the SSCI according to fractional counting



Source: Web of Science, queries and calculations by Fraunhofer ISI

At the top level (upper right quadrant) an approximation of the countries can be detected. The leading countries in terms of citation-based indicators – the USA and Switzerland – show decreasing trends, while Germany is able to improve its position in the International Alignment index. Thus, Germany now targets journals with a higher international reputation. It increases its visibility, aiming for journals with a higher international standing. In turn, its relative citation rate in comparison with other articles in its journals slightly decreases. The absolute citation rates in these journals are higher – also resulting in higher absolute citation numbers. On the other hand, Germany cannot maintain its level in the SR, which means that within these – on average – higher cited journals, German authors cannot keep their relative position like in the lower ranked journals. Thus, Germany's citation rates are comparable to average citation rates of articles in its journals in recent years.

The three countries in the lower panel were selected to show their development over time. While Brazil is hardly able to catch up with the worldwide scientific activities, South Korea is able to considerably increase its performance over time. Authors from South Korea are still cited below the average of the journals they publish in. However, their International Alignment strongly increases and approached the worldwide average.

Chinese authors, on the other hand, are already cited more frequently than the average of the authors in their journals and they even increase their SR values over time. They clearly direct their attention to internationally more visible (and more highly cited) journals as they are moving towards the worldwide average.

2.4 Share in top cited publications (Excellence Rate)

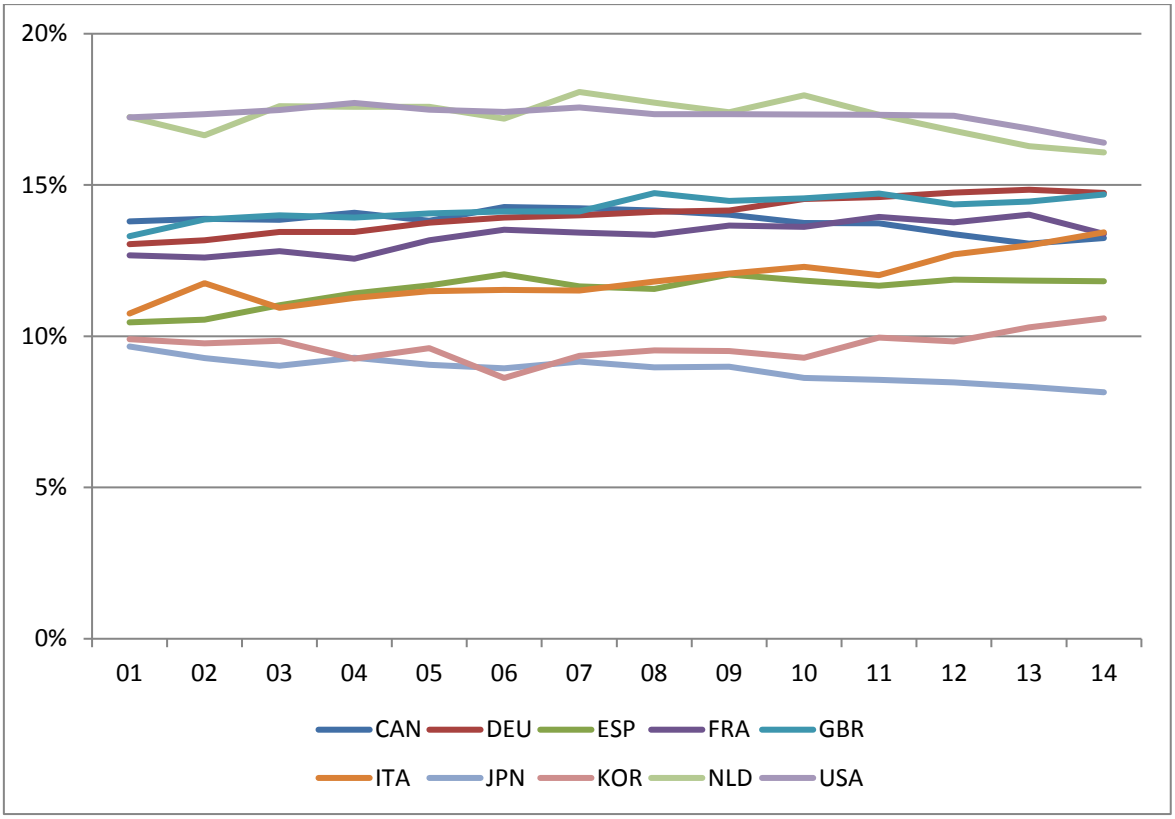
The focus of this section lies on the share of publications that belong to the worldwide top cited publications. The 10% top cited publications per field are selected (to account for varying citation rates in the scientific fields). For each country, the number of publications belonging to the top 10% in at least one field is calculated and set in relation to the total number of its publications. In that way, its share of highly cited publications is derived, that is also denoted as Excellence Rate (Bornmann et al. 2012; Waltmann and Schreiber 2013).

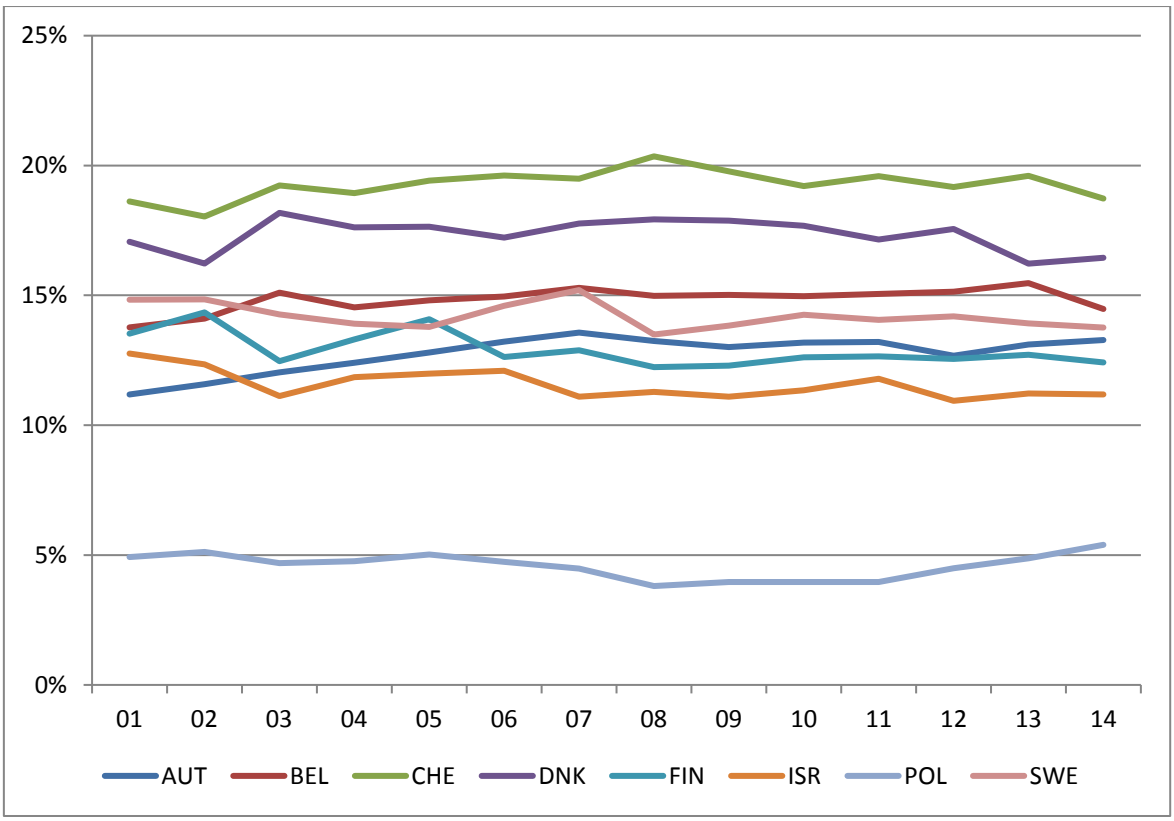
Figure 6 shows the Excellence Rate for a selected set of industrialized countries. Only three of them (Poland, Japan and South Korea) do not reach the reference value of 10%, which we would expect if the quality of publications (indicated by the citations they receive) is evenly distributed across all countries. Only about 4-5% of the Polish publications belong to the most highly cited publications in the world. Japan is close to the 10% mark. However, South Korea managed to surpass the 10% hurdle in 2013 and increased in 2014 to 11%. Switzerland is at the top also in this indicator (see lower panel). More than 19-20% of their publications belong to the top 10% cited publications. The Netherlands, Denmark and the US also perform very well in this indicator, reaching levels of 16% in 2014, however, the value is slightly declining.

Germany reaches a level of 15% in 2014, which remains constant. The overall positive trend that was also found based on the citation indicator International Alignment which targets the total range of publication activities can also be confirmed when we look at the top cited publications in the world. Germany is well beyond the 10% we would expect by an equal distribution of quality. In addition, the German Excellence Rate even increased slightly in the past 11 years.

In comparison, the BRICS countries have – again with the exception of China - relatively low Excellence Rates (Figure 7). China achieves shares far higher than the other BRICS countries and shows a steep increase after 2006 up to 15% in 2014 and is thereby on the same level as Germany.

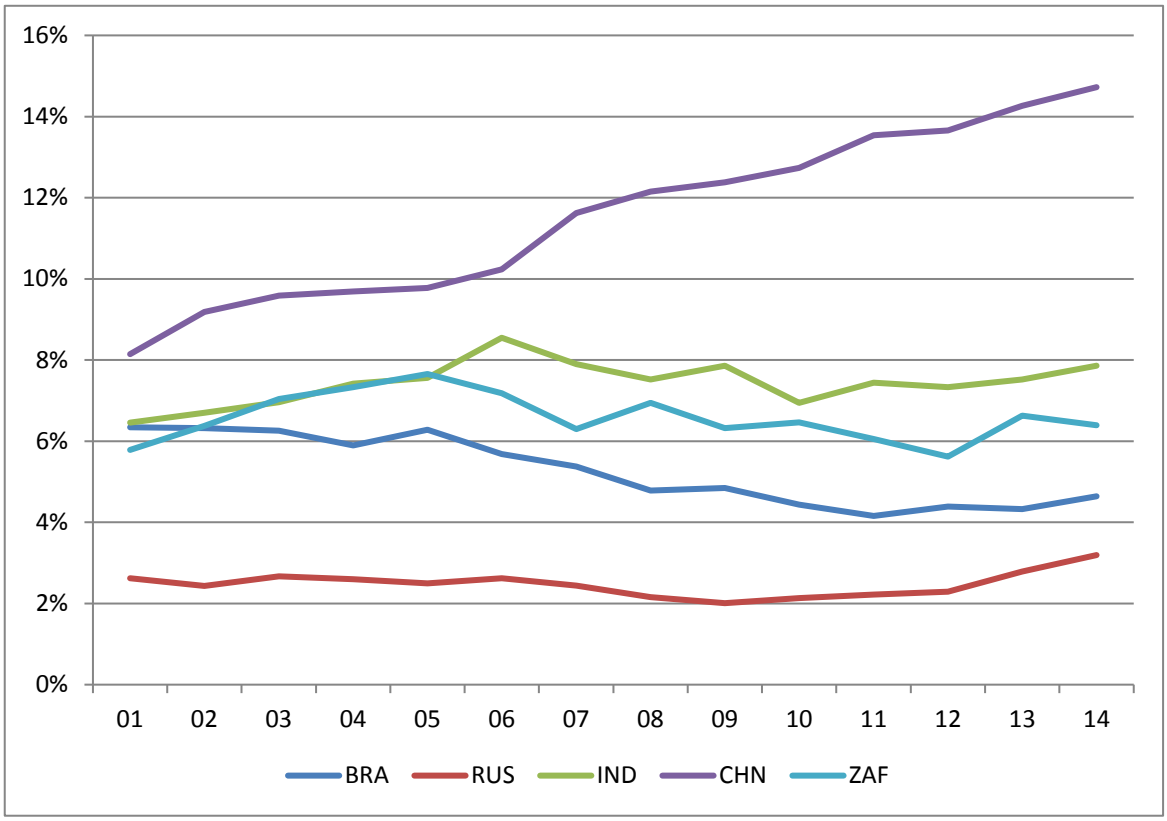
Figure 6: Excellence Rate for the industrialized countries according to fractional counting for the years 2001 to 2014





Source: Web of Science, queries and calculations by Fraunhofer ISI

Figure 7: Excellence Rate for the BRICS countries according to fractional counting for the years 2001 to 2014



Source: Web of Science, queries and calculations by Fraunhofer ISI

2.5 Number of publications and citations per FTE of German Universities and non-university research institutions

The German research landscape is differentiated following a mission orientation. While the large number of German universities is responsible for both, research and education, the large public research organizations (PROs) usually only conduct research. Their teaching obligations are restricted and mainly result from co-affiliations or individual career paths. However, the role in doctoral students' education is considerable. Many research institutes employ doctoral students and these students considerably contribute to the publication output of the research institutes. It needs to be stressed that in Germany, students can only graduate from universities and not from research institutes. Only the universities have the right to grant a PhD diploma. Essentially, all doctoral students at PROs are also somehow affiliated to a university.

The PROs have very different missions, which can, first of all, be characterized by basic research (Max Planck) and applied research (Fraunhofer). In addition, several missions like energy and large-scale research (Helmholtz) occur. Both the Helmholtz Association and the Leibniz Association conduct applied research as well as basic research. The Helmholtz Association developed its profile in medical research, running medical cen-

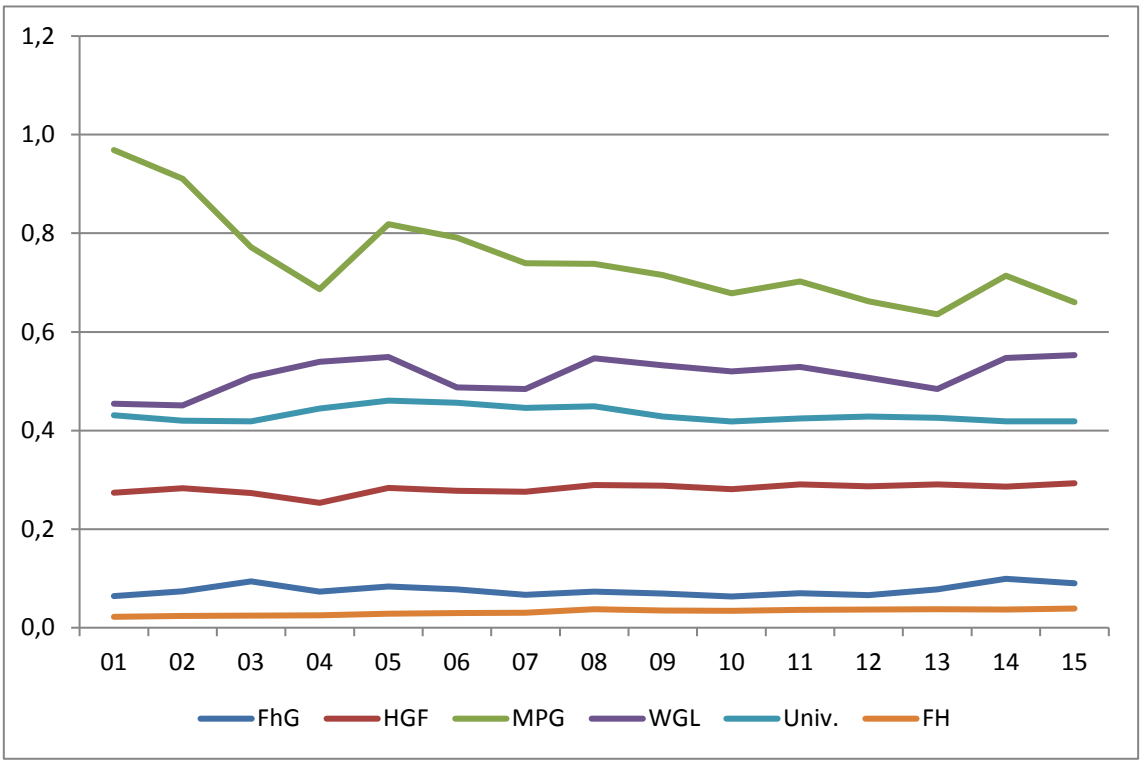
ters in collaboration with universities, in different locations in Germany. The Leibniz Association covers research at museums and also several particular topics (e.g. marine research), but also a number of institutes of the social sciences.

These are very different conditions for a comparison of the publication output of the universities and the public research organizations. In the following we will only report a small number of indicators that will not allow to show a complete picture of the publication activities and their assessment. We focus on the absolute number of publications and the absolute number of citations per full-time equivalent (FTE) researcher.

As Figure 8 shows, the largest publication output per FTE researcher is achieved by Max Planck. Each researcher – on average – publishes 0.7 papers per year, with a decreasing trend since 2001. It has to be mentioned here that the absolute number of researchers does not take into account the large number of scholarship and external visitors. This group, however, is taken into account in the case of publication output, if they put their Max Planck affiliation on the paper. This also holds for all the other PROs and also the universities, but the effect is largest in case of Max Planck due to large numbers of external and visiting scholars.

In the Leibniz Association each researcher publishes about 0.5 papers per year, with an increasing trend. The other groups are rather stable in their publication output. A researcher at a German university publishes about 0.4 papers per year and at Helmholtz it is about 0.3 papers. The lowest publication intensity can be found in Fraunhofer (0.1 papers) and in the universities of applied sciences (0.04 papers).

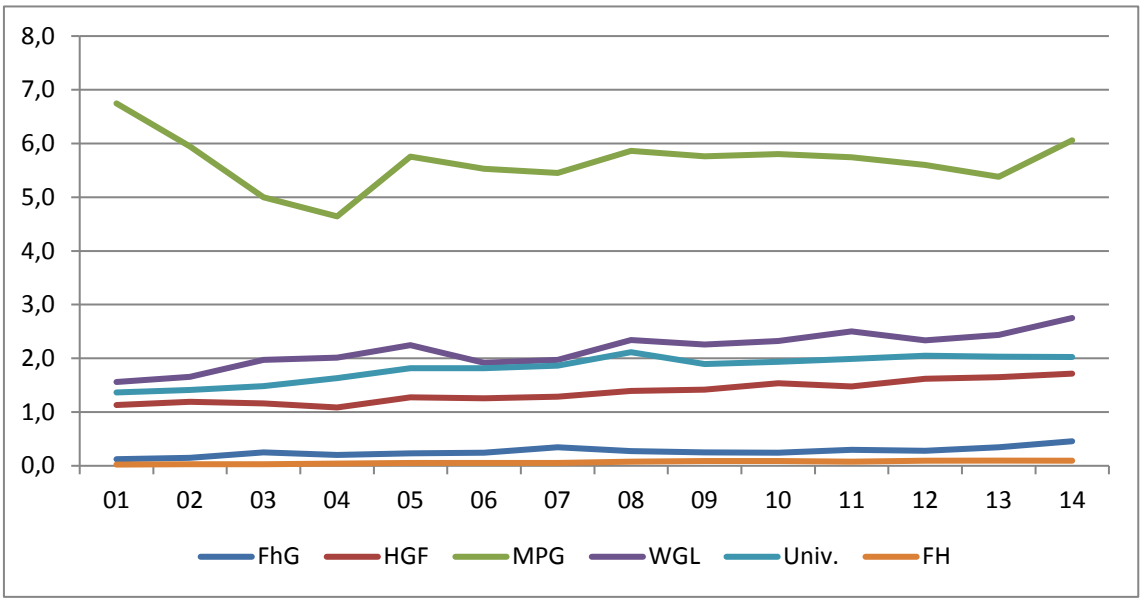
Figure 8: Number of publications per FTE of German Universities and non-university research institutions for the period 2001-2015



Source: Web of Science, queries and calculations by Fraunhofer ISI

As Figure 9 shows, Max Planck also receives the most citations per FTE – about 6 citations per researcher. Researchers from the Leibniz Association increased their citations in the last year to almost 3 citations and from universities to about 2 citations. Helmholtz reaches a value of 1.7 in 2014, Fraunhofer of about 0.5 and the universities of applied sciences of about 0.1.

Figure 9: Number of citations per FTE of German universities and non-university research institutions for the period 2001-2014



Source: Web of Science, queries and calculations by Fraunhofer ISI

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Appendix: Country Code list

Country	Country code
Austria	AUT
Belgium	BEL
Brazil	BRA
Canada	CAN
China	CHN
Denmark	DNK
Finland	FIN
France	FRA
Germany	DEU
The United Kingdom/United Kingdom	GBR
India	IND
Israel	ISR
Italy	ITA
Japan	JPN
Netherlands	NDL
Poland	POL
Russian Federation	RUS
South Africa	ZAF
South Korea	KOR
Spain	ESP
Sweden	SWE
Switzerland	CHE
United States	USA

Region EU-28	Country code
Austria	AUT
Belgium	BEL
Bulgaria	BGR
Croatia	HRV
Cyprus	CYP
Czech Republic	CZE
Denmark	DNK
Estonia	EST
Finland	FIN
France	FRA
Germany	DEU
The United Kingdom/United Kingdom	GBR
Greece	GRC
Hungary	HUN
Ireland	IRL
Italy	ITA
Latvia	LVA
Lithuania	LTU
Luxembourg	LUX
Malta	MLT
Netherlands	NLD
Poland	POL

Region EU-28	Country code
Portugal	PRT
Romania	ROU
Slovak Republic	SVK
Slovenia	SVN
Spain	ESP
Sweden	SWE

Region EU-15	Country code
Austria	AUT
Belgium	BEL
Denmark	DNK
Finland	FIN
France	FRA
Germany	DEU
The United Kingdom/United Kingdom	GBR
Greece	GRC
Ireland	IRL
Italy	ITA
Luxembourg	LUX
Netherlands	NLD
Portugal	PRT
Spain	ESP
Sweden	SWE

Region EU-13	Country code
Bulgaria	BGR
Croatia	HRV
Cyprus	CYP
Czech Republic	CZE
Estonia	EST
Hungary	HUN
Latvia	LVA
Latvia	LTU
Malta	MLT
Poland	POL
Romania	ROU
Slovak Republic	SVK
Slovenia	SVN