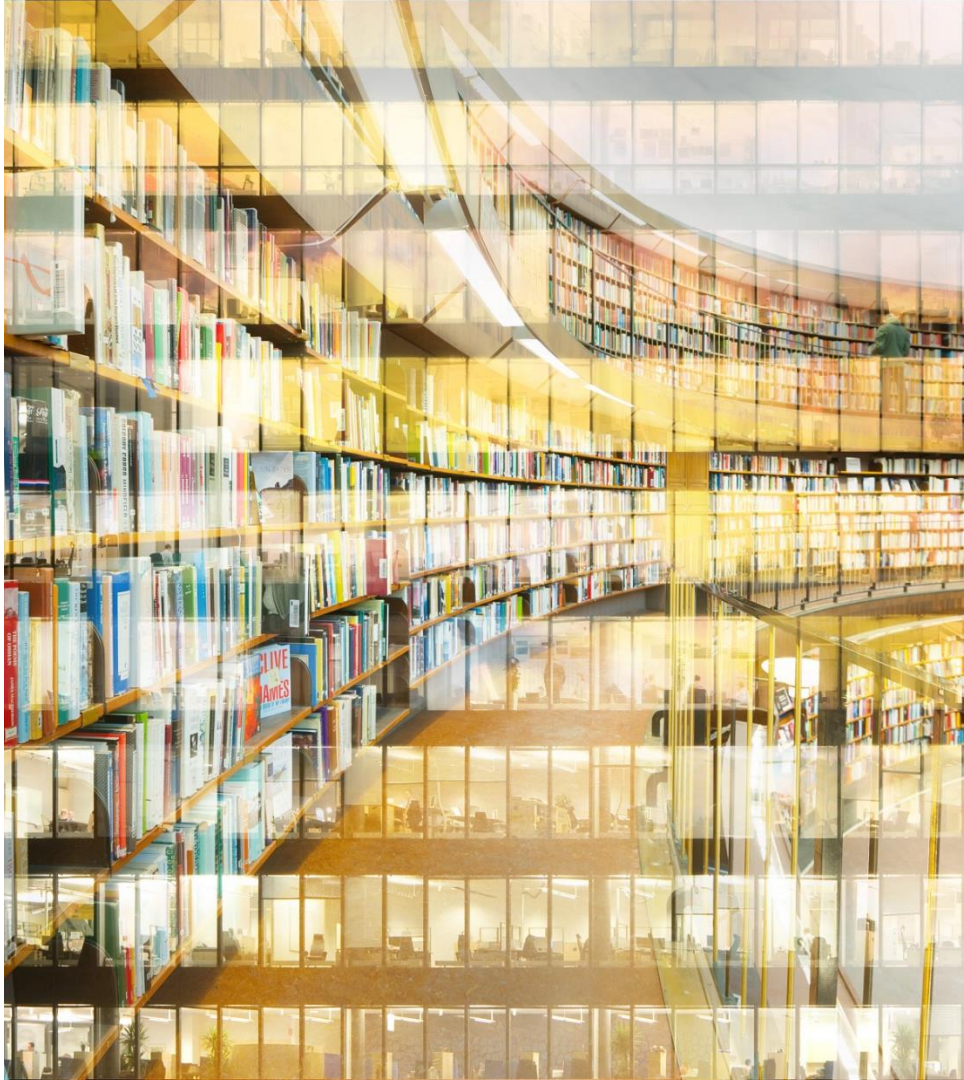
Infection Resilient Environments

Research capability review

June, 2022

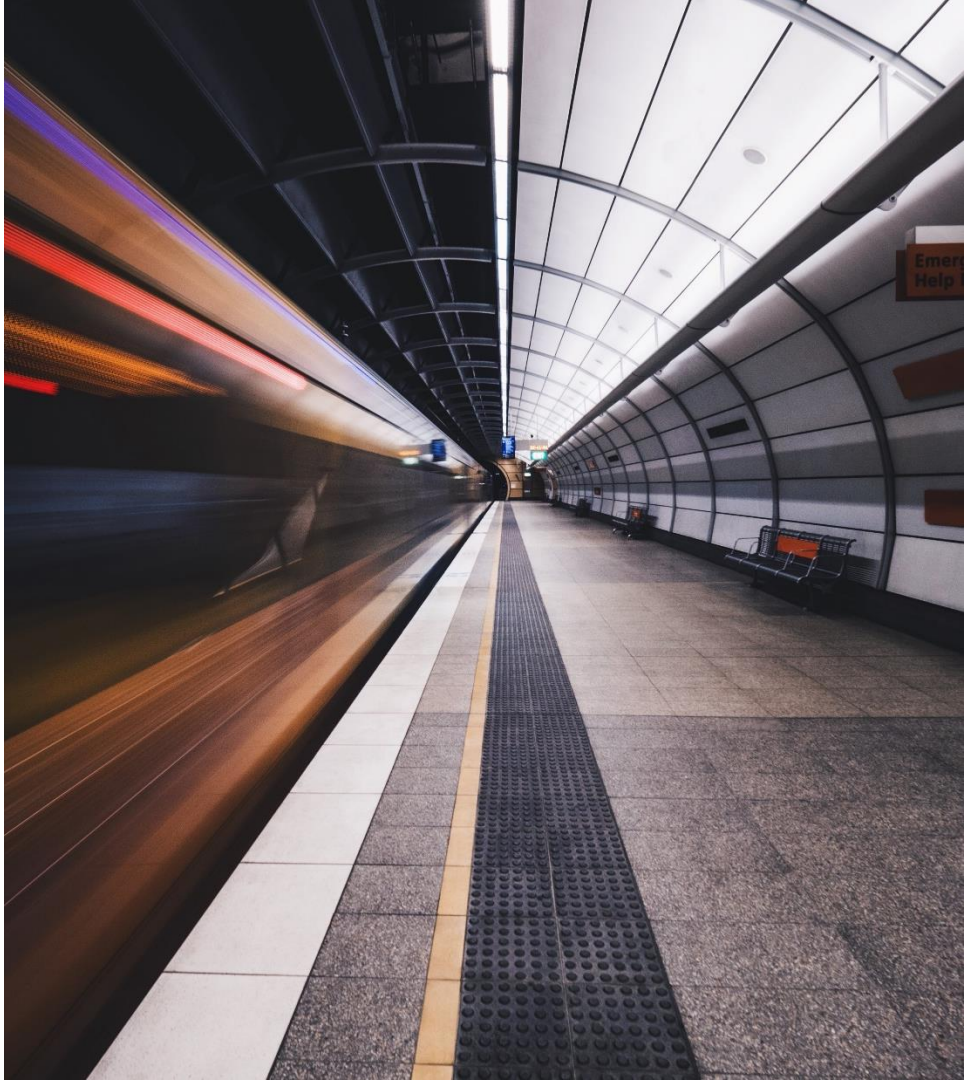
Introduction - Objectives

1. To understand who are the key stakeholders in the UK
2. To define the volume of research in the field completed in the UK and how this compares internationally
3. To determine the UK strengths by understanding the quantity and quality of UK research
4. To identify existing multidisciplinary links within the UK
5. To understand how this research has been funded including, if possible, by research councils, industry, and other sources
6. To understand where growth is happening in the field and trends over time



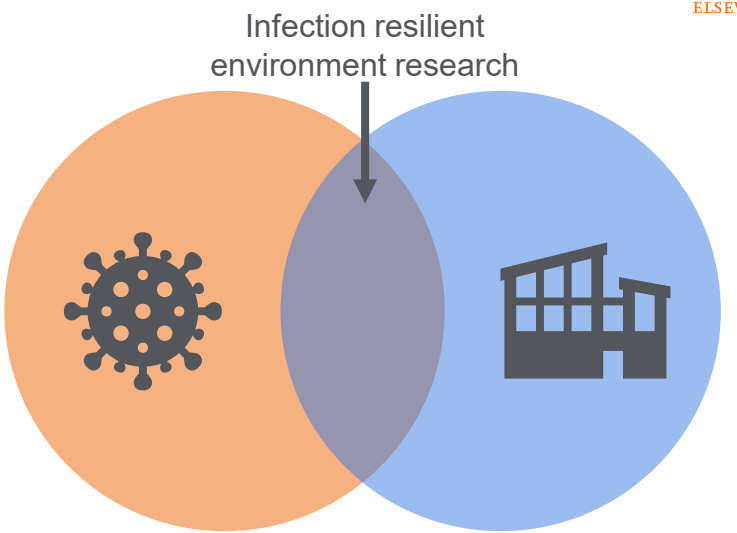
Definition of the field

- Infection resilient environment research concerns designing the built environment to prevent the spread of infectious diseases
- Covers many aspects, such as:
  - Ventilation methods
  - Environmental quality monitoring
  - Infection-resilient surfaces
  - Contactless technologies
  - Tools to facilitate physical distancing
  - Plumbing and drainage systems
- Task 1 was to find peer-reviewed publications relevant to the field
  - Proved challenging, as terms like “COVID-19” are now frequently used in unrelated publications



Defining the publication set

- The infection resilient environment publication set was built from a Scopus query containing over 300 key phrases.
- Designed as the intersection of documents captured from
  - Terms related to communicable diseases
  - Terms related to the built environment



9,099 Number of documents captured in all of Scopus

95% Precision rate of the publication set, following expert feedback

87% Recall rate of the full dataset, based on a verified set of articles

2021 Year with the largest publication volume

USA Country with the largest publication volume

Notes

- Overall period is 2001–2021, but most of the analyses focus on the 2011–2021 period to assess the most recent and relevant period (given the small impact over publication output).
- When it added insights, the period was split to take the steep increase with beginning of the pandemic into account. It needs to be noted that this leads to periods of different length (2011–2019 and 2020–2021). Impact indicators for the most current period may be influenced heavily by outliers.
- The publication set on Infection Resilient Environment is abbreviated throughout the presentation with “IRE”.
- Comparator regions and countries are for visual design sometimes abbreviated by ISO 3 codes, except the United Kingdom (‘UK’).

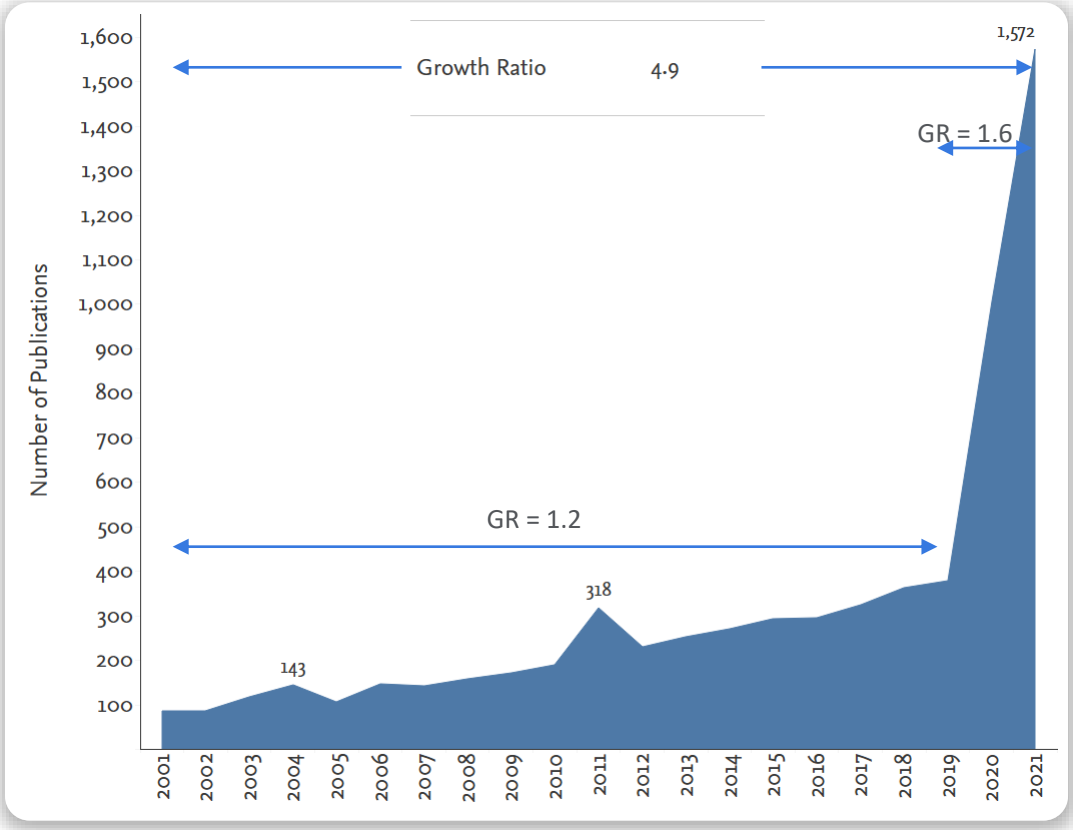
Development of the field “Infection Resilient Environment”

Globally, the field developed slowly with a small peak in 2011.

Due to the COVID-19 pandemic, the field saw a strong rise in 2020 and 2021, with a five-fold increase.

Between 2011 and 2021, the field grew by a factor of 4.9 (Growth Ratio).

GR for the subperiods do not add up because the major increase was between 2019 and 2020 (GR = 2.6).

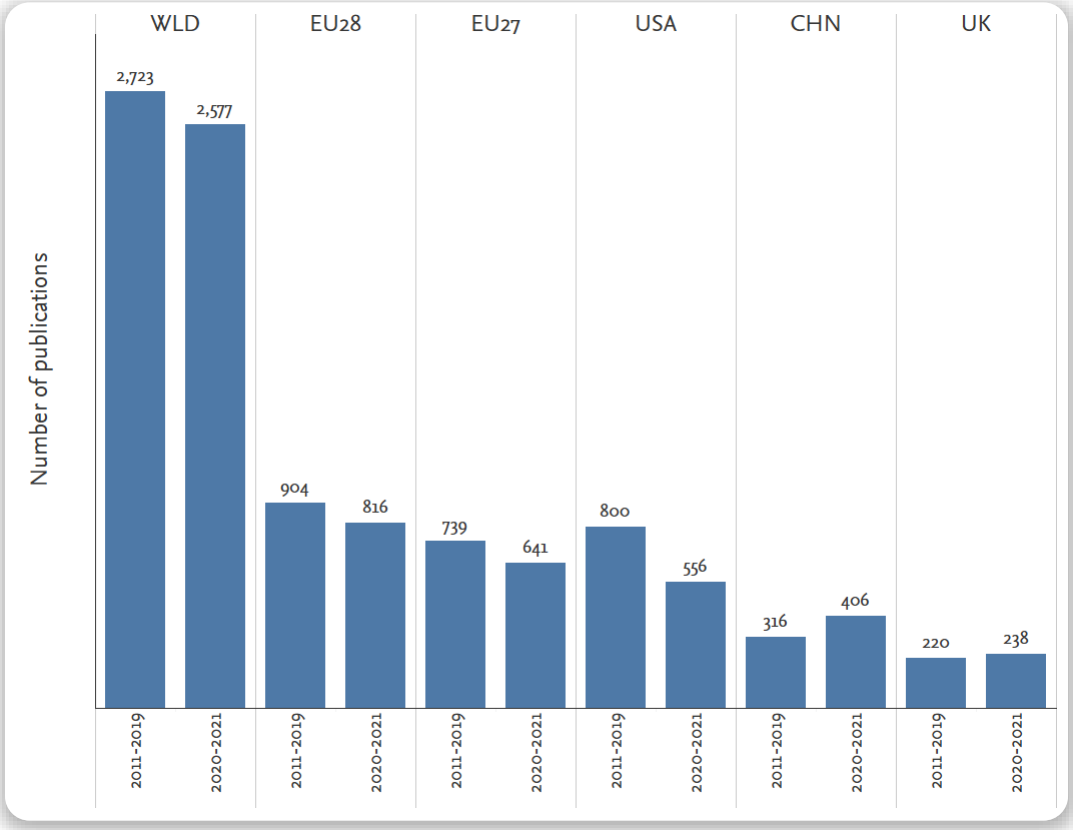


Total global output in IRE 2001-2021, growth rate is calculated as annual growth from first year to last year.
Source: Scopus

Development of the field “Infection Resilient Environment”

Globally, both periods (despite the first being 9 years long and the second being 2 years long) showed similar output volumes.

Only the UK and China had higher output in the second period.



Output in IRE for the periods 2011-2019 and 2020-2021 for selected comparators.
Source: Scopus

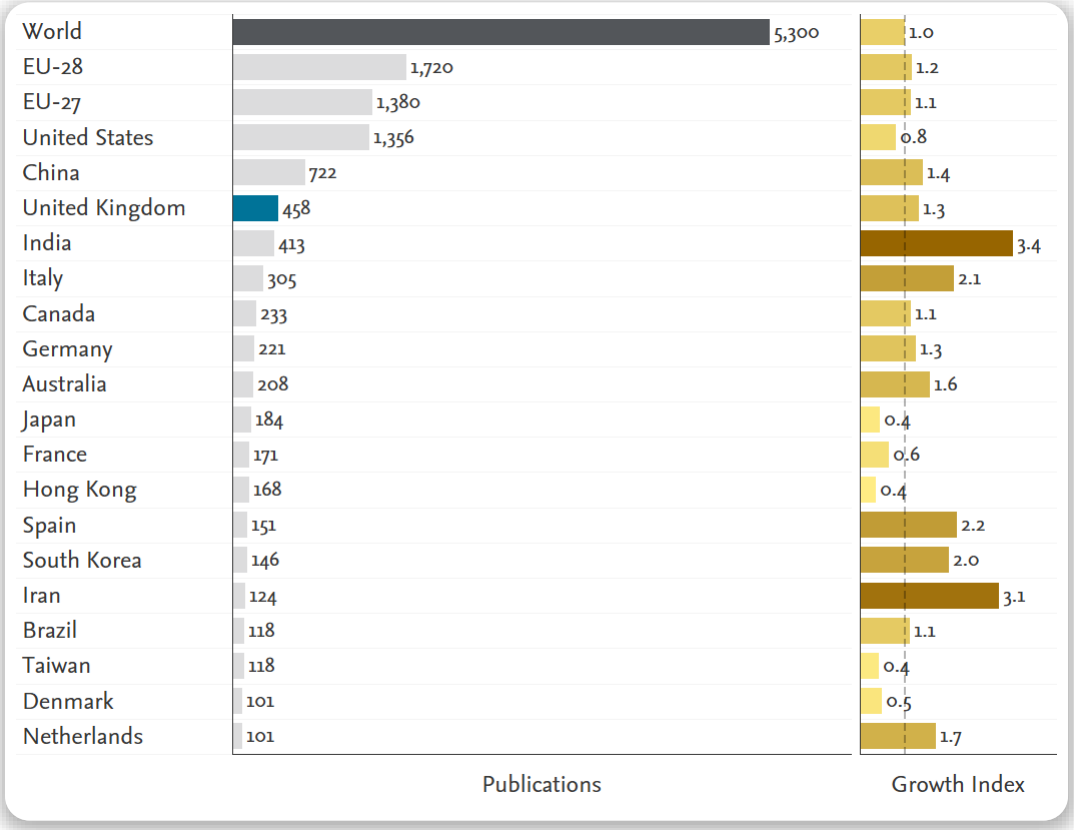
USA biggest single contributor from 2011 to 2021

The Growth Index indicates the growth normalized with the global growth across the period.

The EU-28 as a region is the biggest contributor, but the US is the largest single contributor (with a growth slightly slower than the world average).

India shows the highest growth, ranking at 4th in total output.

UK ranked 3rd in output across the period, with growth slightly faster than the World average.

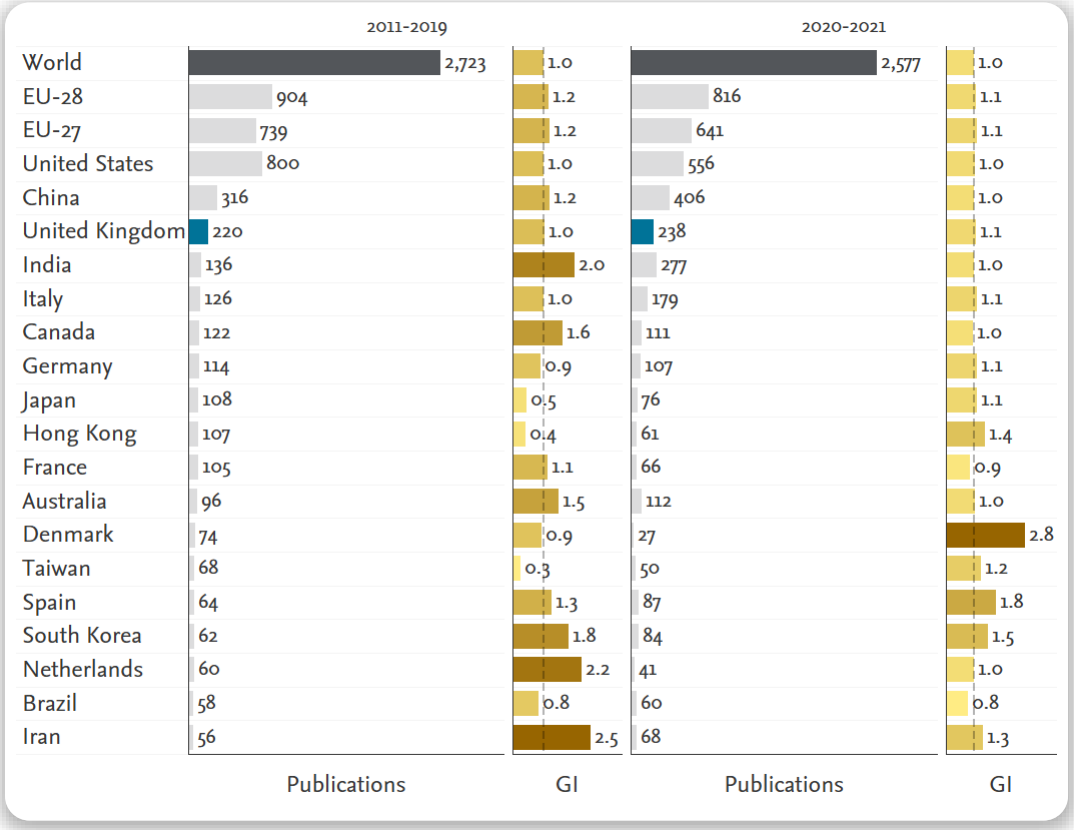


Total output in IRE 2011-2021 for top 20 regions and countries, growth index is calculated as growth rate for entity divided by global growth rate.
Source: Scopus

Different growth pattern before and after pandemic started

While Iran, Netherlands, India and South Korea had the largest growth in the first period, Denmark and Spain grew fastest in the second period.

The UK grew at the same pace as the world level in both periods, possibly indicating its strong position in global research.



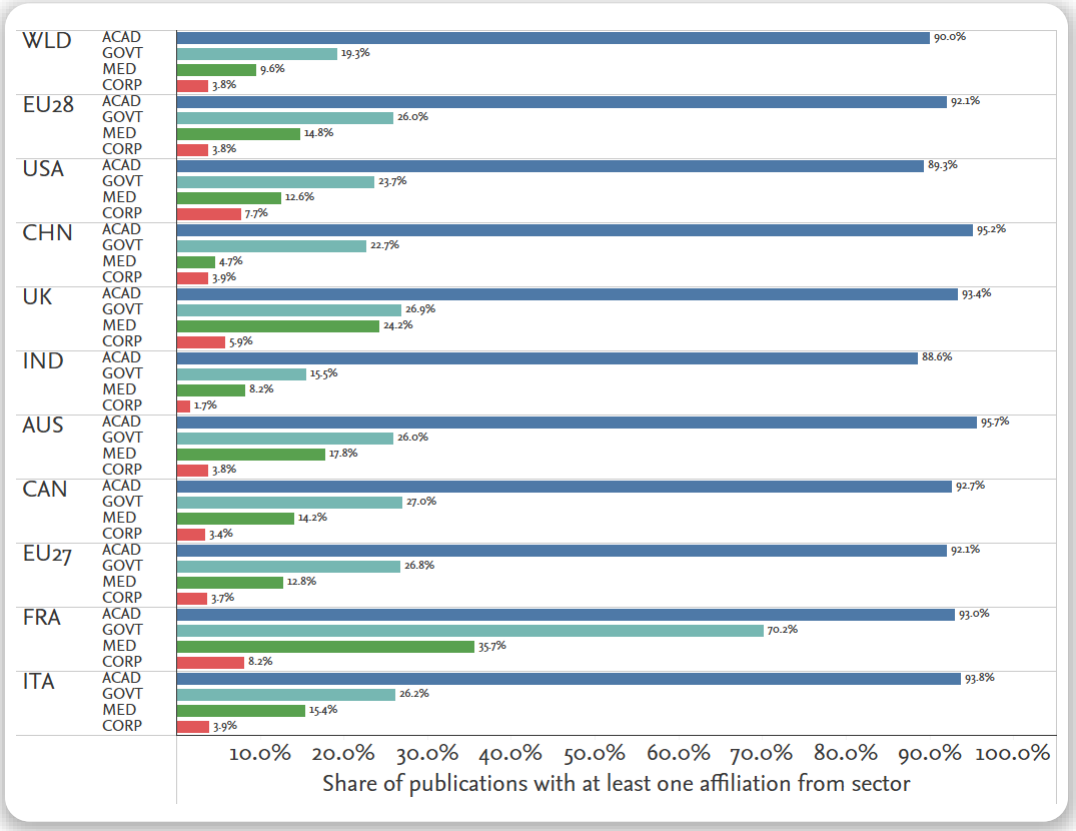
Total output and growth index in IRE for periods 2011-2019 and 2020-2021 for top 20 regions and countries, growth index is calculated as growth rate for entity divided by global growth rate. Entities are sorted by output in first period.
Source: Scopus

The academic sector is the largest contributor of knowledge in the field

At the world level, the Academic sector is the main producer of publications in the field, followed by the Government, Medical and Corporate sectors.

The same trend holds true for most individual countries as well as the UK.

In France, the Government sector is much more present than in other countries, mainly due to the involvement of governmental bodies such as INSERM and CNRS in research.



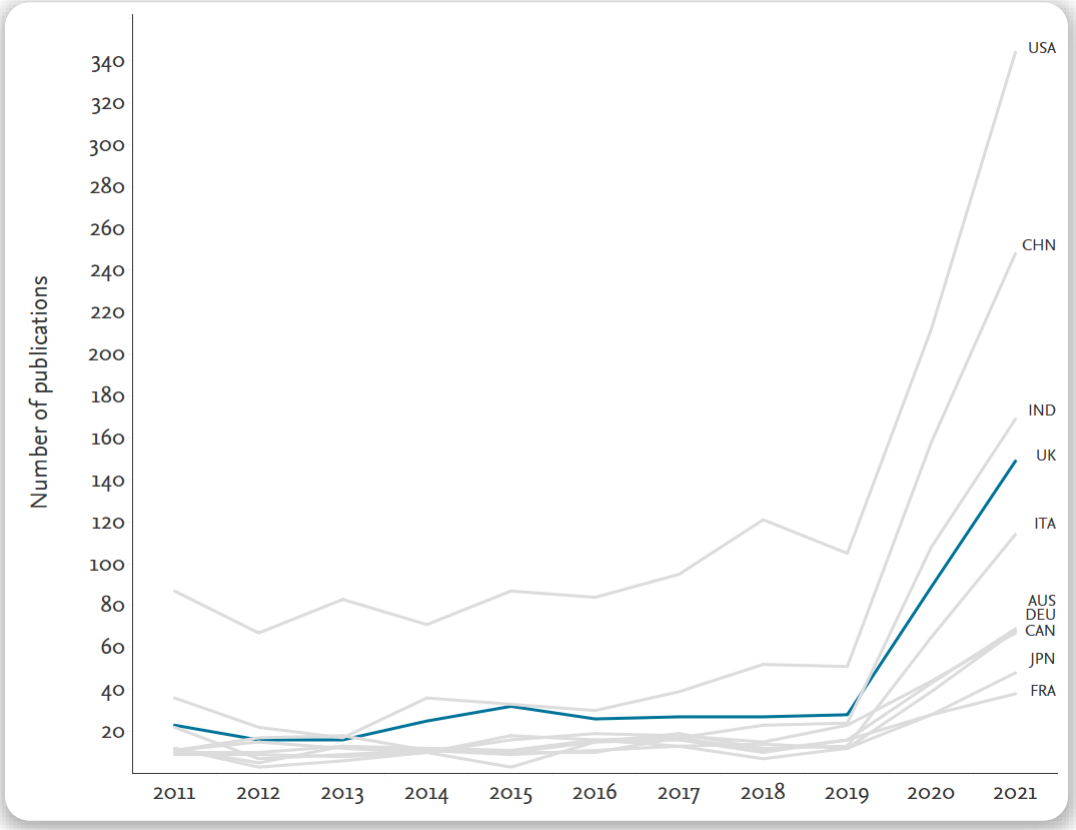
Share of publications in IRE by sector for selected comparator, 2011-2021.
Source: Scopus

Trend show steep increase starting with the COVID-19 pandemic

Top national contributors showed the steepest increase in output.

The United States was the leading contributor across the full period.

India overtook the United Kingdom in 2019.



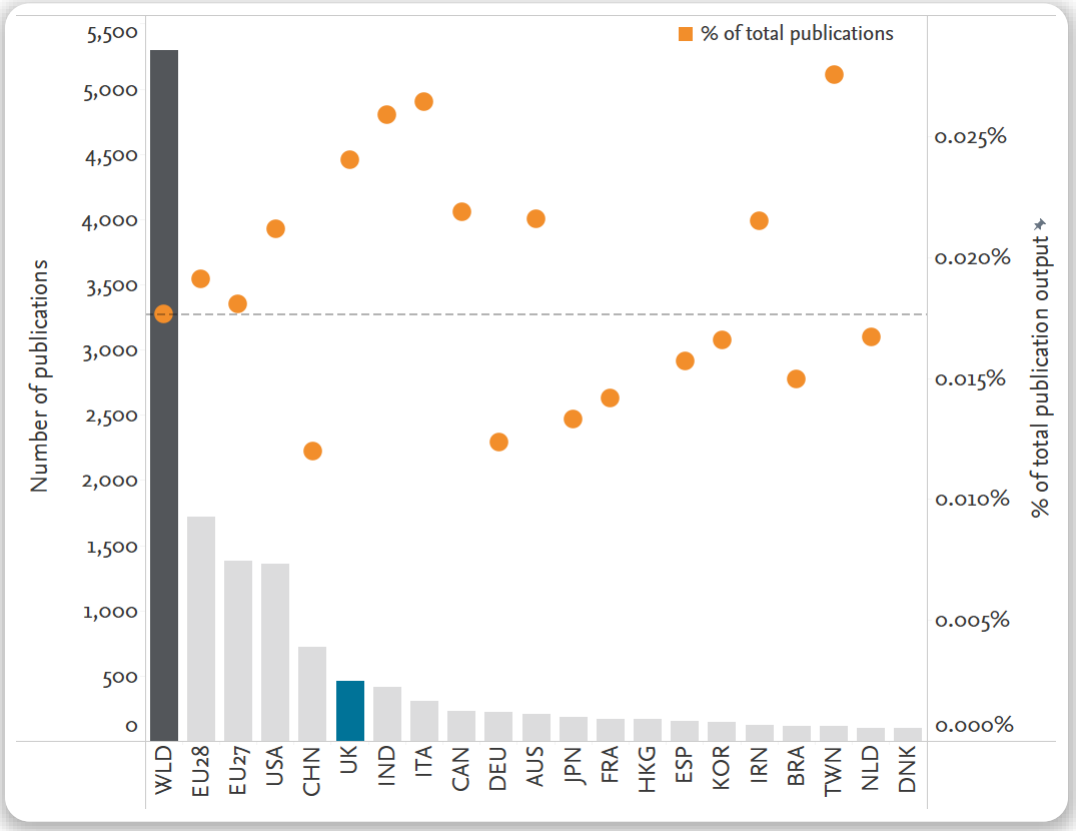
Annual output in IRE for top 10 single contributor by output, 2011-2021.
Source: Scopus

Italy, United Kingdom, India lead by share of total publications

Number of publications relates to the total research output, but the share of total output in this field might be an indication of focus.

Overall, this share is relatively small (as IRE is a narrow research field), but some countries are well above the global average.

China is well below the global average, so their increase in production seems to be more of a “side effect” of general trends.

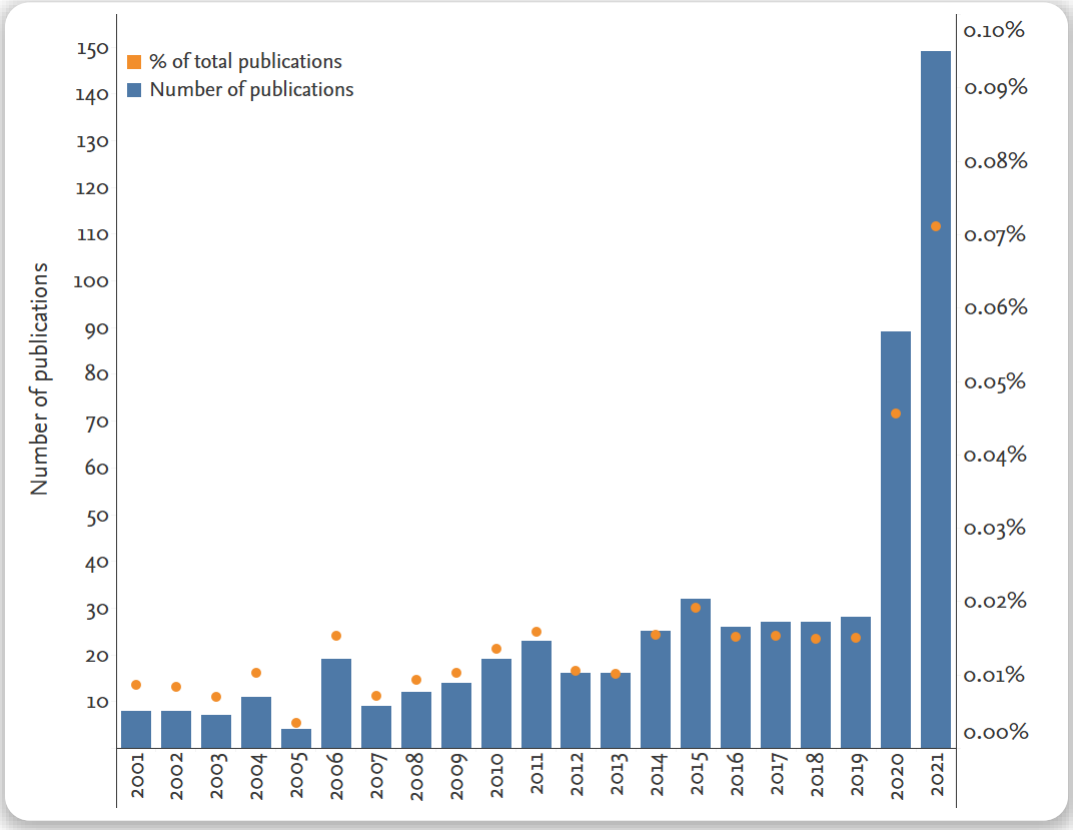


Total output IRE (bars) and share of total output (orange dots) for top 20 regions and countries by output, 2011-2021; dashed line indicate global average share of IRE output.
Source: Scopus

Annual IRE output and share of total output, UK, 2001-2021

Similar to the output trend, the UK's share of output in IRE research shows a steep increase after the start of the COVID-19 pandemic.

While the total output jumped from 30 to 90 publications, the share increased by 0.03 percentage points, tripling the share as well.



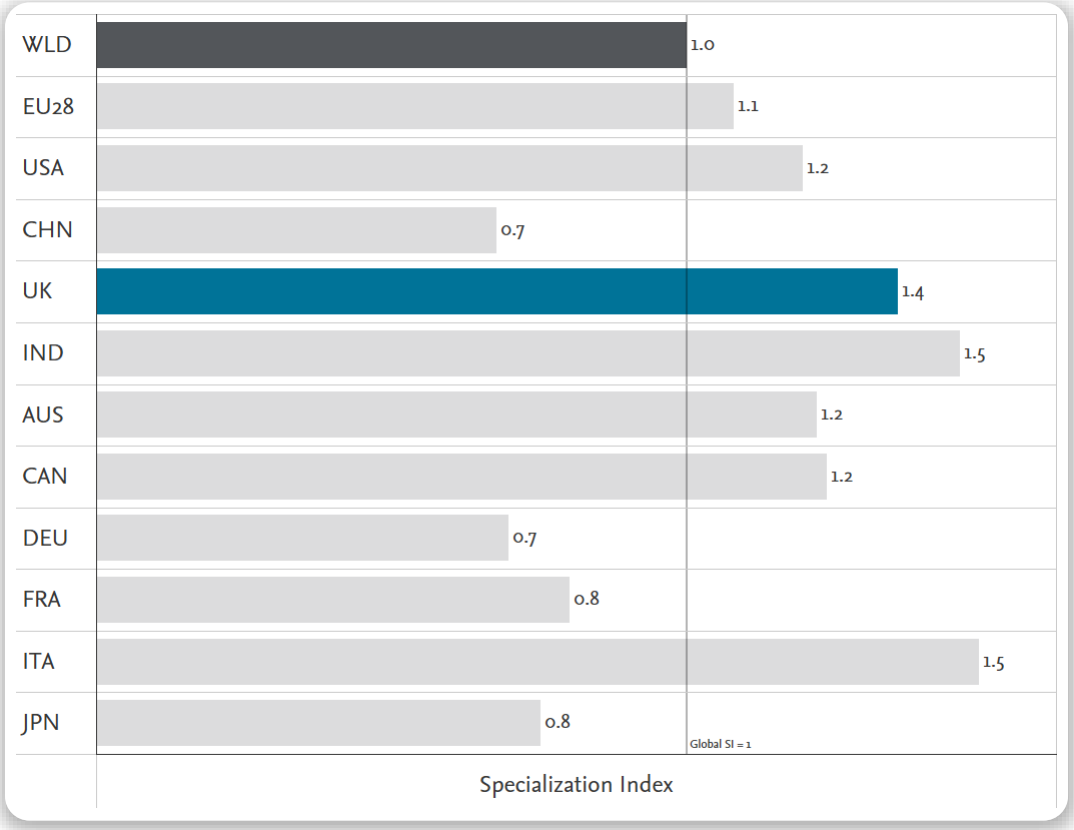
Total annual output IRE (bars) and share of total output (orange dots) for UK, 2001-2021.
Source: Scopus

A few countries have specializations in the field (2011–2021)

The Specialization Index is an indicator of focus. The share of publications in the field per entity is divided by the share of the field globally – above 1 indicates more focus, below 1 less focus.

India, Italy and the UK are the most specialized of the top 10 countries.

China, Germany, France and Japan are the least focused in the same list.



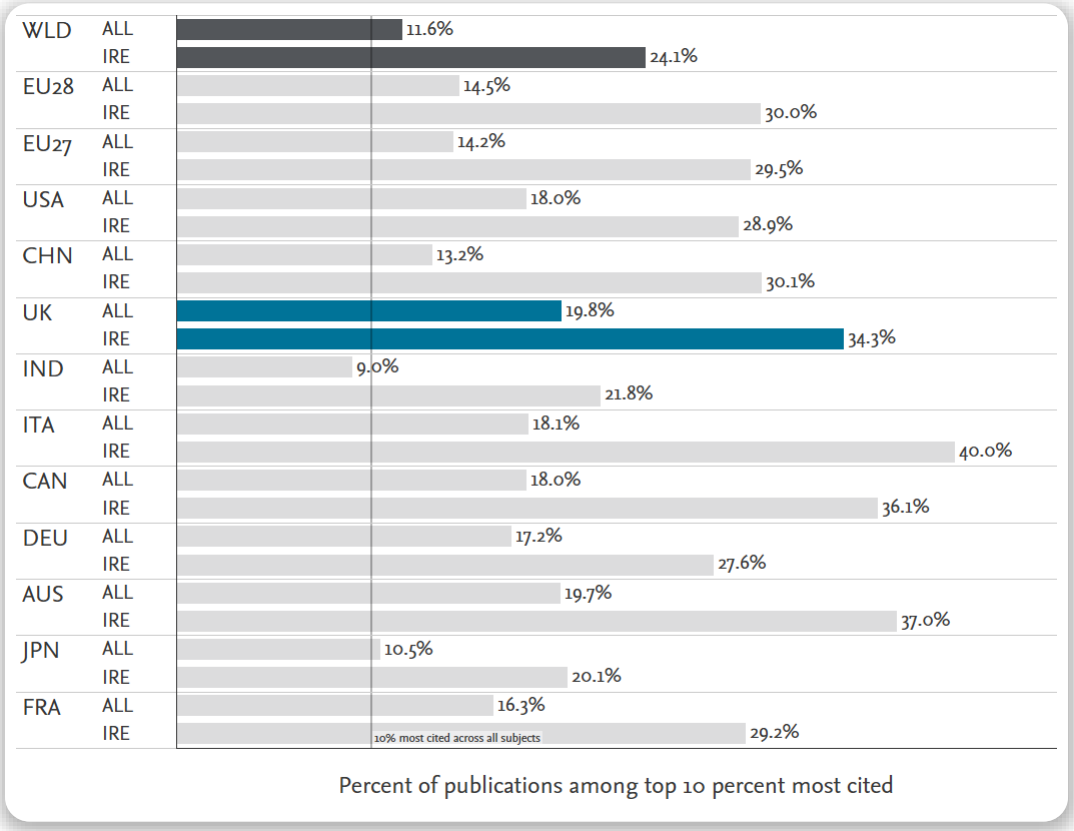
Specialization index for selected comparators, 2011-2021.
Source: Scopus

Field has generated a lot of interest

Share of publications in the top 10% most cited surpassed overall research output share for all countries.

For the UK, more than a third of the publications in IRE are among the top 10% most cited.

Data are for 2011-2021. Given the last year does not have complete coverage in Scopus yet and the time it takes for articles to receive citations, the results may be biased.

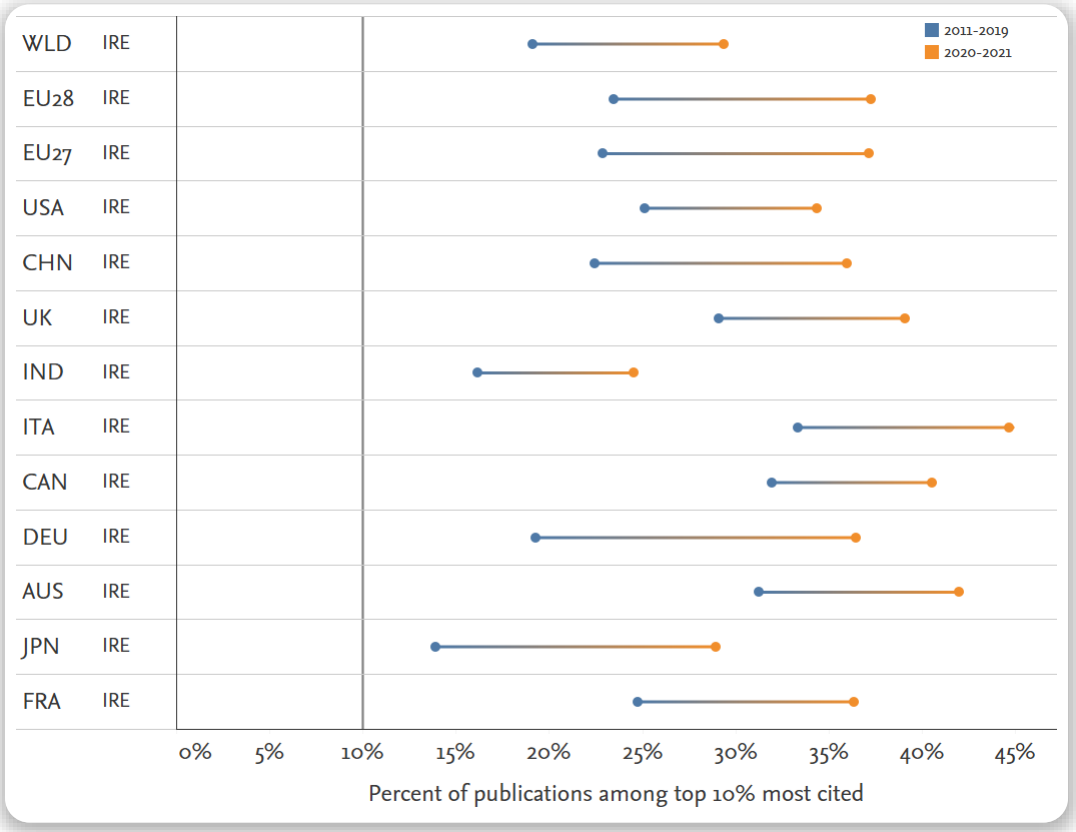


Share of total publications and of IRE publications in the top 10% most highly cited publications for selected comparators, 2011-2021.
Source: Scopus

Field has generated a lot of interest, especially in second period

Differentiated view indicates that the interest in the most current period has grown for all comparators – UK's share of most highly cited publications grew from 29% to 39%.

Data are for 2011-2021. Given the last year does not have complete coverage in Scopus yet and the time it takes for articles to receive citations, the results may be biased.



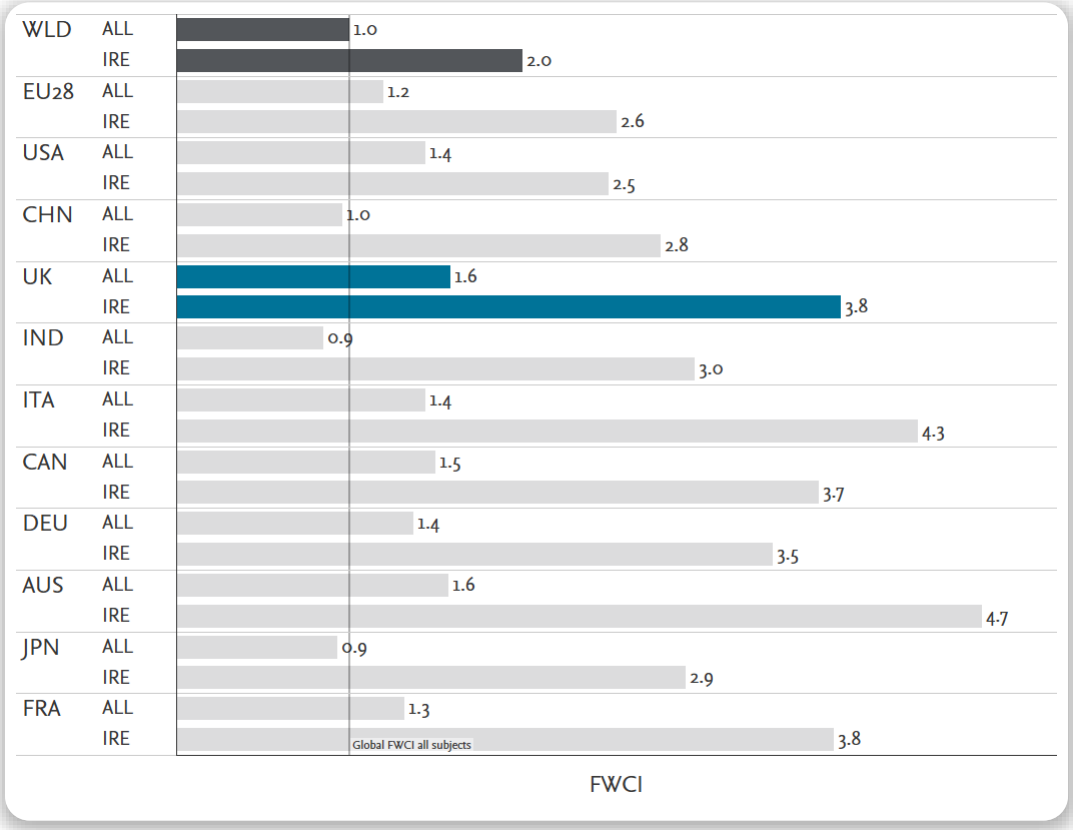
Change of share of IRE publications in the top 10% most highly cited publications for selected comparators, 2011-2019 (blue dot) and 2020-2021 (orange dot).
Source: Scopus

UK one of the leading countries in the field by citation impact

The United Kingdom's research is amongst the most impactful at the national level.

The IRE field is generally highly cited (as seen already with the top 10% most cited percentile).

Data are for 2011-2021. Given the last year does not have complete coverage in Scopus yet and the time it takes for articles to receive citations, the results may be biased.



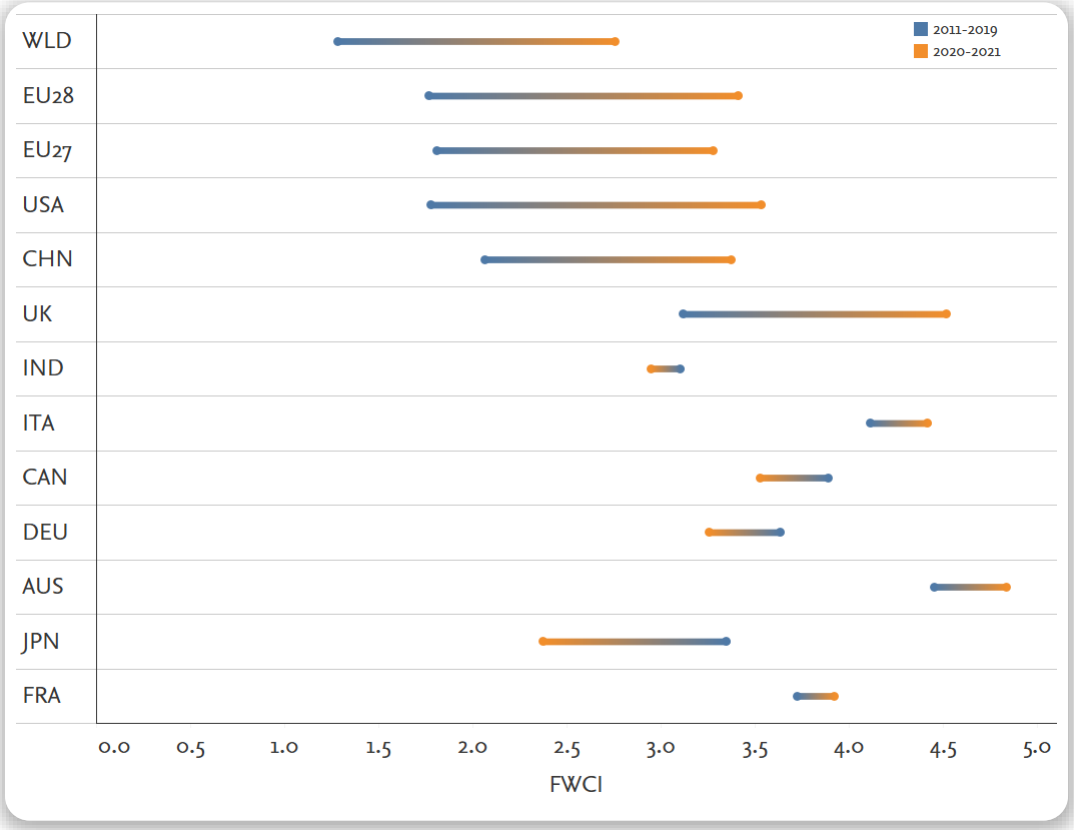
FWCI of total publications and of IRE publications for selected comparators, 2011-2021.
Source: Scopus

UK one of the leading countries in the field by citation impact in both periods

Many countries grew their citation impact in the second period, except India, Canada, Germany and Japan.

In the period 2020-2021, Australia and the UK have the highest citation impact of all comparators.

Data are for 2011-2021. Given the last year does not have complete coverage in Scopus yet and the time it takes for articles to receive citations, the results may be biased.

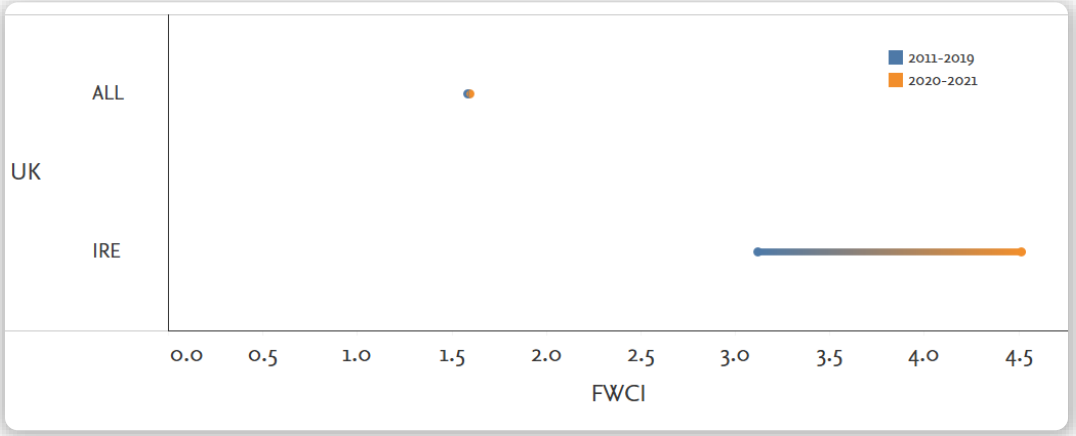


Change of FWCI for IRE publications for selected comparators, 2011-2019 (blue dots) and 2020-2021 (orange dots).
Source: Scopus

UK one of the leading countries in the field by impact -context

The growth in FWCI is seen explicitly in the field of IRE, across all subjects the FWCI grew only marginally for the UK.

Similar observations hold for most other national comparators.



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Source: Scopus

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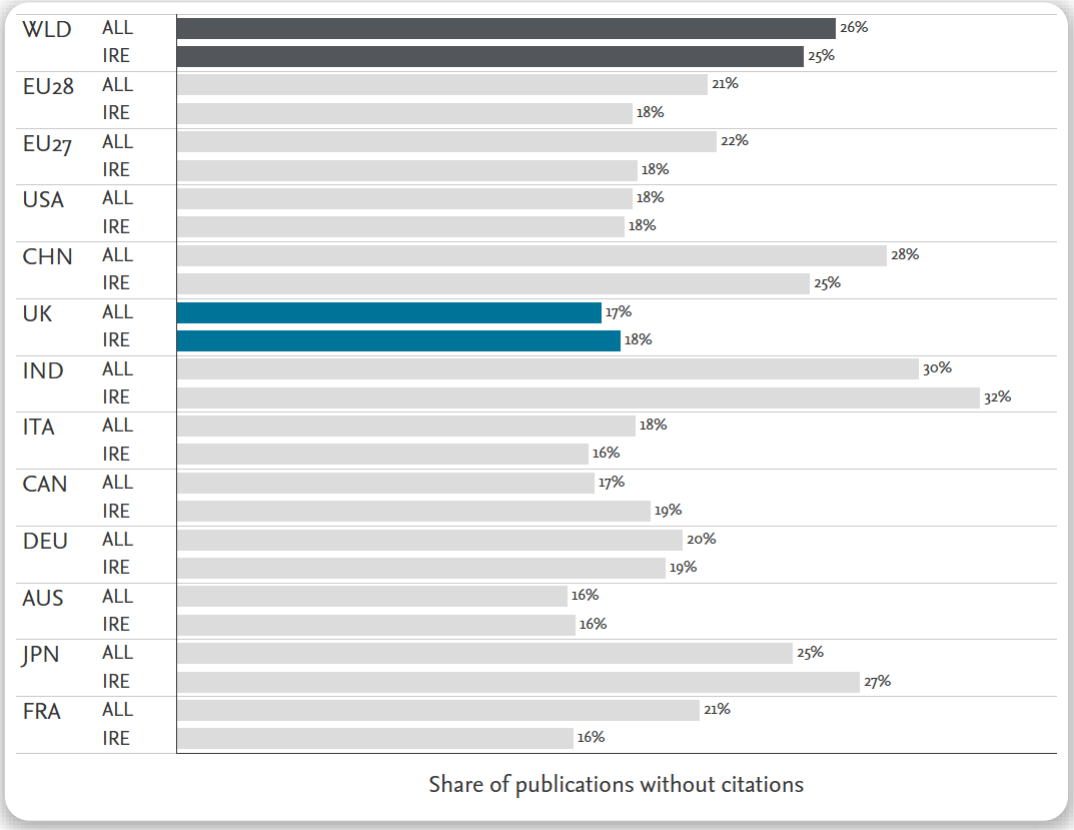
Large portion of research yet still uncited

Not surprisingly, a large portion of the papers are not yet cited. With the sharp rise of output in the two most recent years, this is to be expected.

The UK is among countries with a lower share of non-cited output.

European countries have in general slightly less non-cited output, which may be a consequence of collaboration.

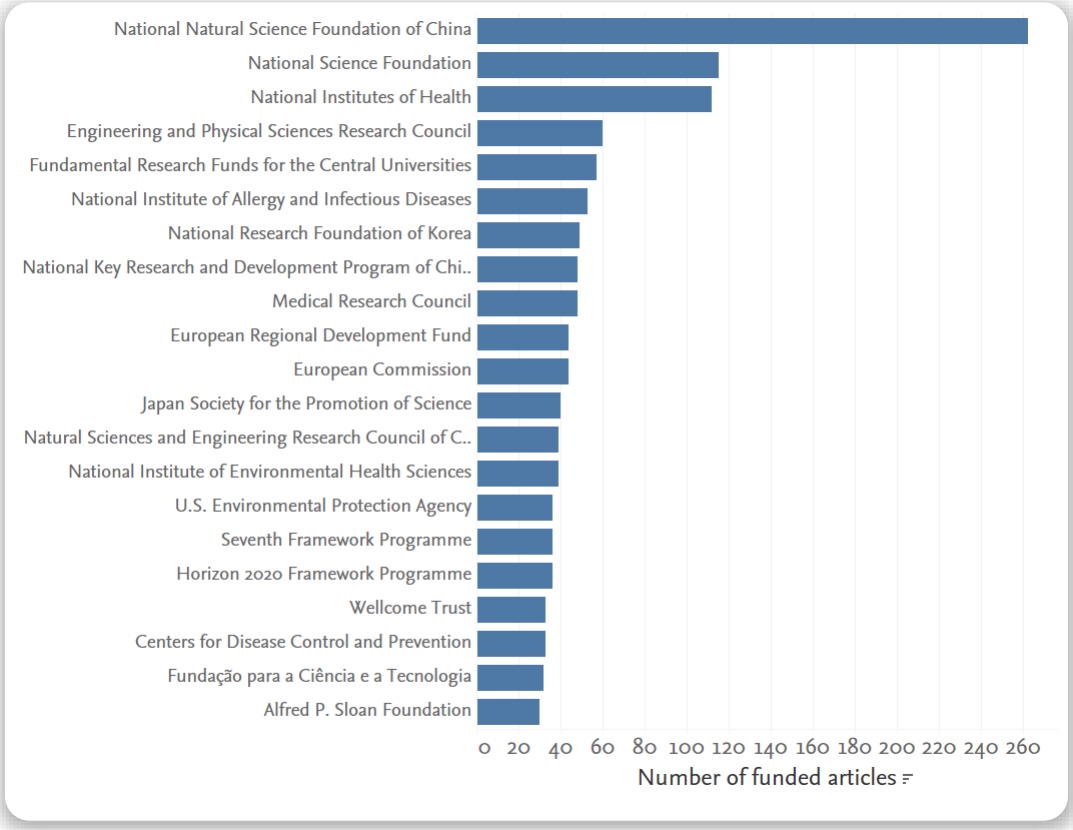


Share of publications without citations for IRE and all subjects for selected comparators, 2011-2021.
Source: Scopus

According to the number of funded articles worldwide, top funders are from China and the U.S.

The most-often credited funders in the world in IRE research are the National Natural Science Foundation of China and the National Science Foundation (U.S.) and the National Institutes of Health (U.S.).

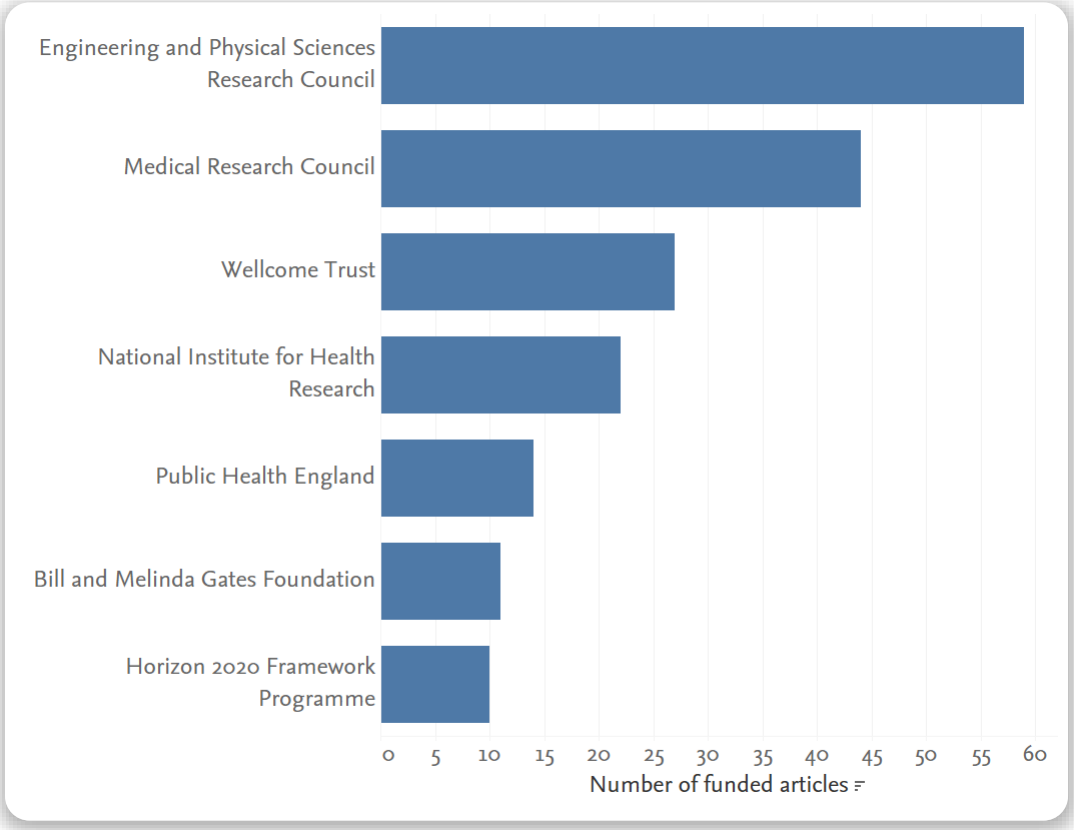
The first U.K. funder is EPSRC (4th).



Number of funded publications in IRE by funding body in the acknowledgement, ranked by output , 2011-2021.
Source: Scopus

Funding (UK)

7 funders were listed on more than 10 publications with at least one UK affiliation from 2011 to 2021.



Number of funded publications in IRE by UK funding body in the acknowledgement, ranked by output , 2011-2021.
Source: Scopus

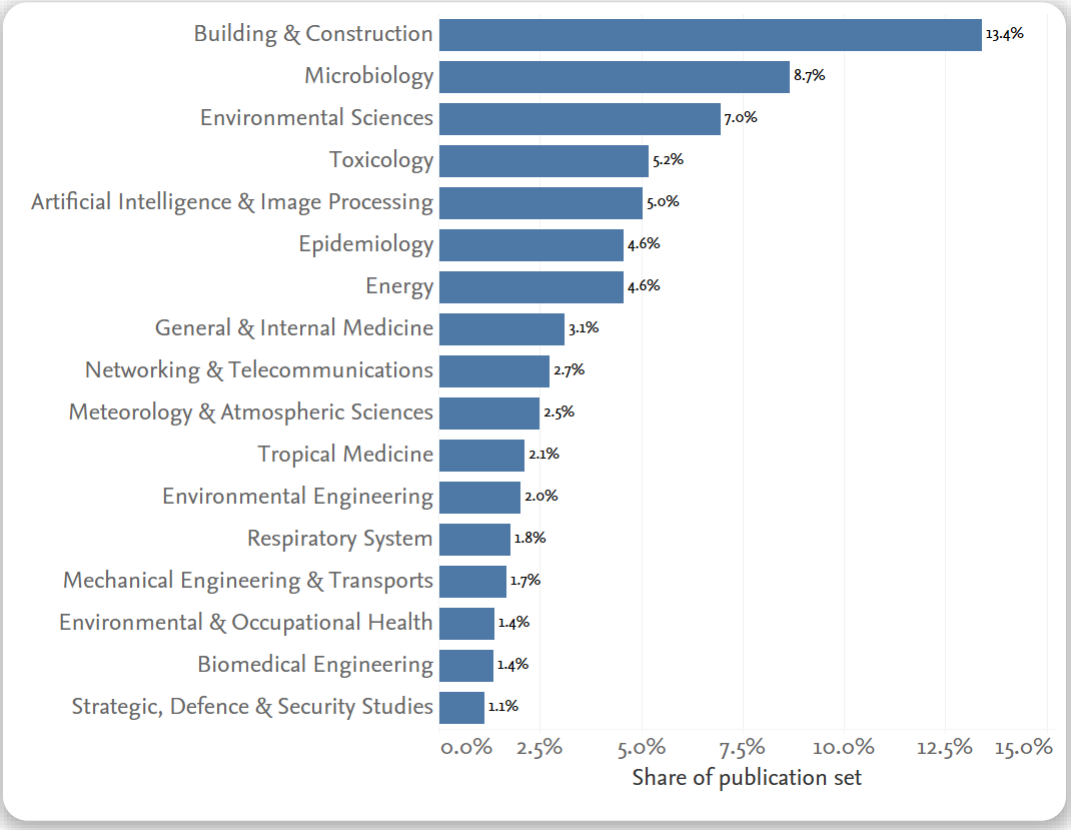
Interdisciplinarity and multidisciplinarity

Many scientific subfields play a role in the field

Many areas of science are involved in infection resilient environment research.

This graph shows the subfields of science (journal level) that have contributed 1% or more of the articles to the publication set.

Based on the Science-Metrix classification of science to align with subfields used for interdisciplinarity and multidisciplinarity computation.



Share of publications in IRE by Science-Metrix subfield, 2011-2021.
Source: Scopus

Research covers many SciVal topic clusters, but is mainly concentrated in two

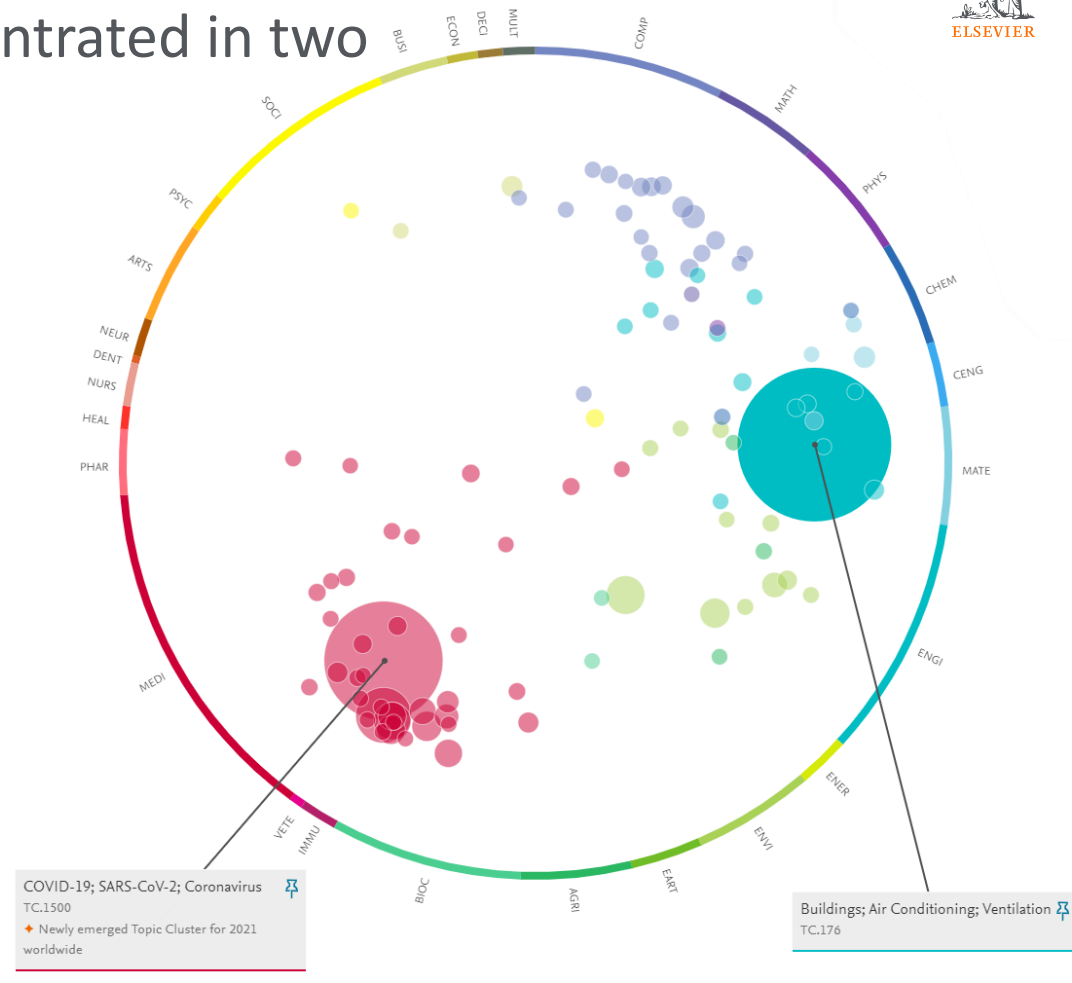
The two topic clusters containing the most publications are defined by the following keywords:

- Buildings; Air Conditioning; Ventilation
- COVID-19; SARS-CoV-2; Coronavirus

Other topics are mostly concentrated in the health sciences, engineering and the applied sciences.

Only small parts (< 2%) of each topic cluster are included in the publication set, highlighting the highly specific nature of the field.

Only top-100 topic clusters by output are shown.



Topic cluster circle diagram showing the top-100 topic clusters by IRE output, 2018-2021. Bubble size is proportional to IRE output volume in this topic cluster, color is assigned based on the dominant ASJC class of the topic, and bubble position is set based on the ASJC classification of all articles in the topic cluster, relative to the circle. The circle shows all 27 ASJC-27 classes, with sizes proportional to their total output volume.
Source: Scopus

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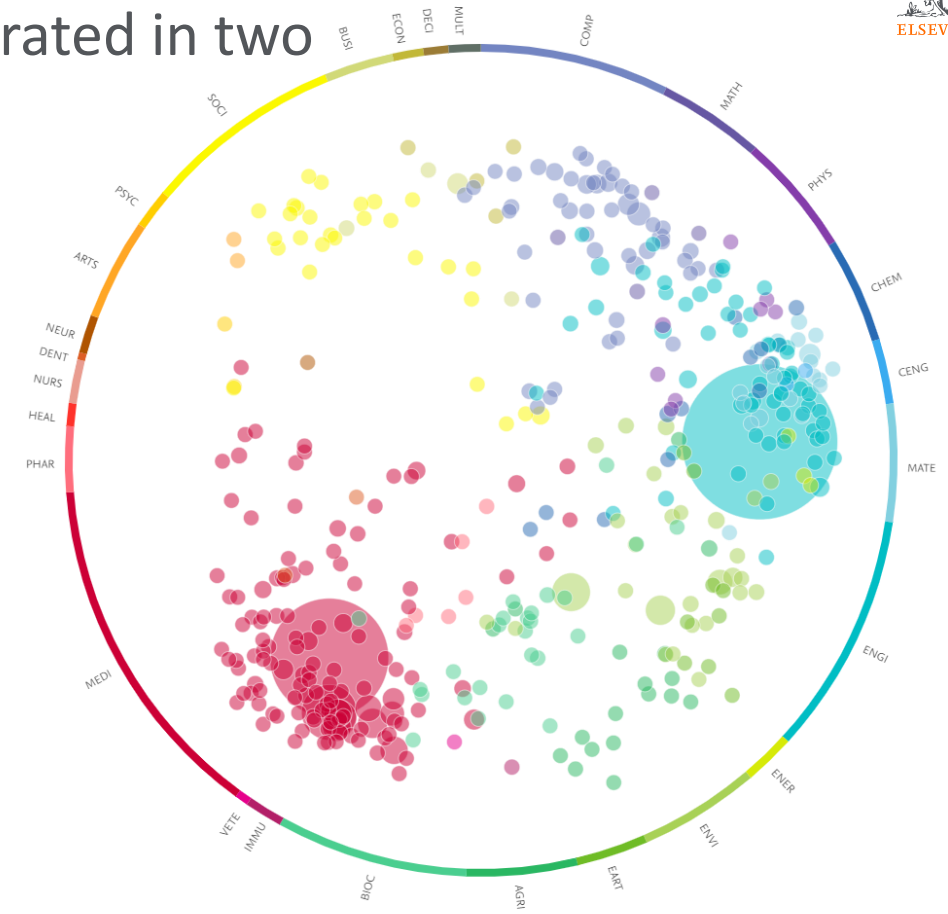

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Source: Scopus

Topic Cluster 176: Buildings; Air Conditioning; Ventilation

801 publications from IRE are within TC.176, calculates to a share of 1.69% of the total Cluster.

IRE publications are mainly driven by China and Hong Kong (187), followed by the United States (178). The UK has 69 publications in this cluster.

IRE output in this cluster is highly impactful (FWCI = 2.61 vs. 1.12 for the total cluster).

TC.176 is composed of 112 distinct Topics, one of which is specific to articles studying the ventilation of rooms in healthcare settings (e.g., operating rooms).

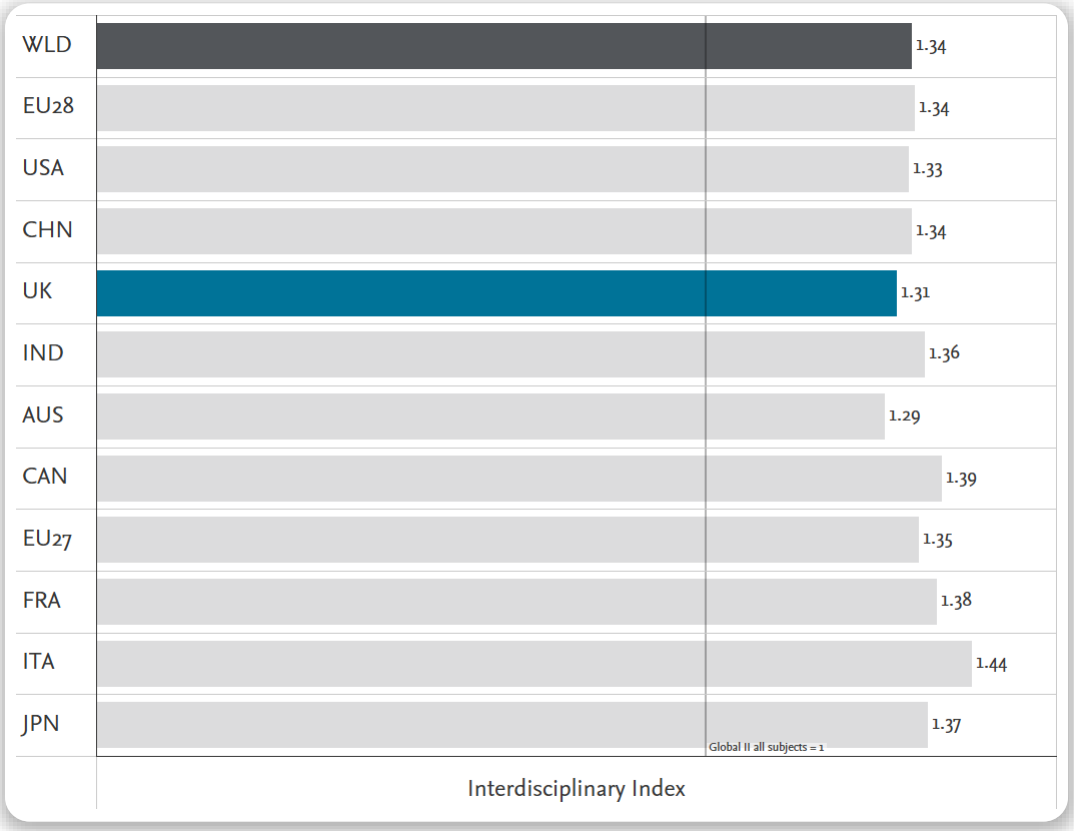
	Institution	Output
1	Tsinghua University	32
2	Southeast University, Nanjing	28
3	The University of Hong Kong	25
4	Ministry of Education, China	24
5	Hong Kong Polytechnic University	18
6	City University of Hong Kong	15
7	Queensland University of Technology	14
8	Technical University of Denmark	14
9	University of California at Berkeley	14
10	Aalborg University	13
	…	
15	University of Cambridge	11

The field is highly interdisciplinary

The Interdisciplinarity Index is an indicator of the diversity of knowledge being integrated by a set of publications. The index is normalized by scientific subfield and publication year.

All countries in the top 10 greatly exceed the Scopus average, with Italy and Canada leading the group.

The UK and Australia are the least interdisciplinary of the group, but still perform very close to the world average.

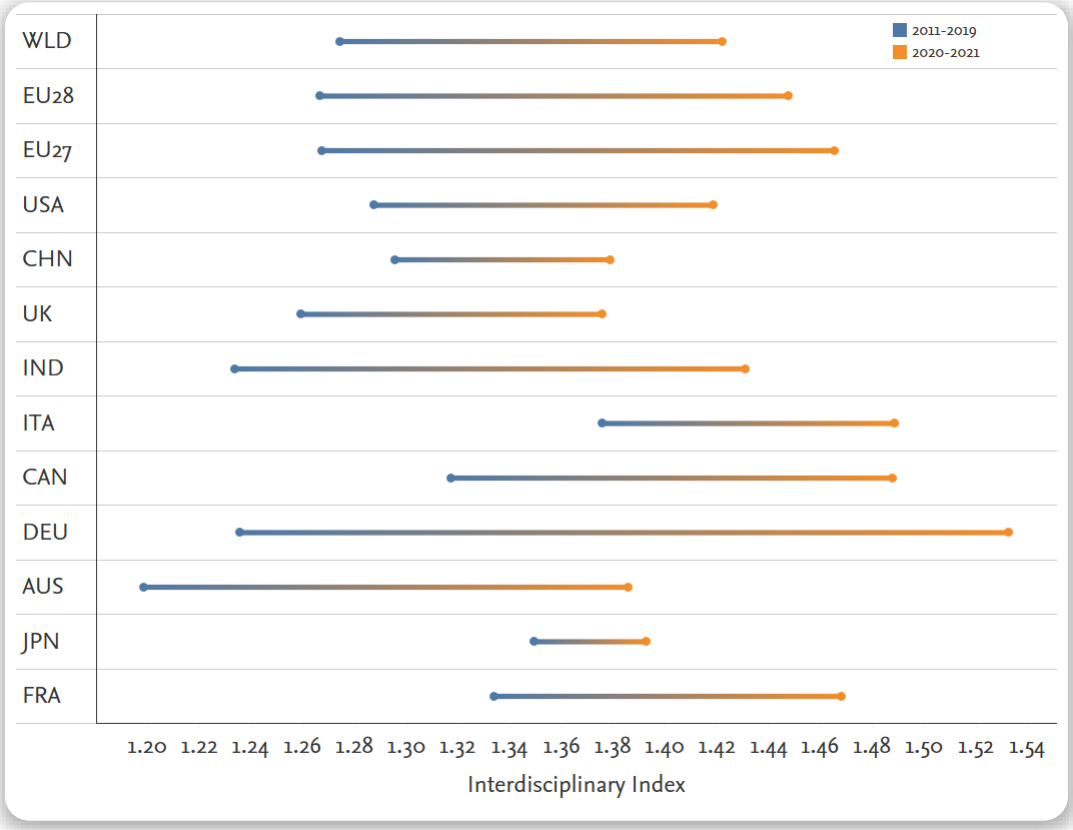


Interdisciplinary index for selected comparators, 2011-2021.
Source: Scopus

The field is highly interdisciplinary

The Interdisciplinarity Index has changed for all comparators towards a higher degree of interdisciplinarity. The effect is highest for Germany, changing from below to above world level.

The UK increased its interdisciplinary, but not to the extend of some other comparators.



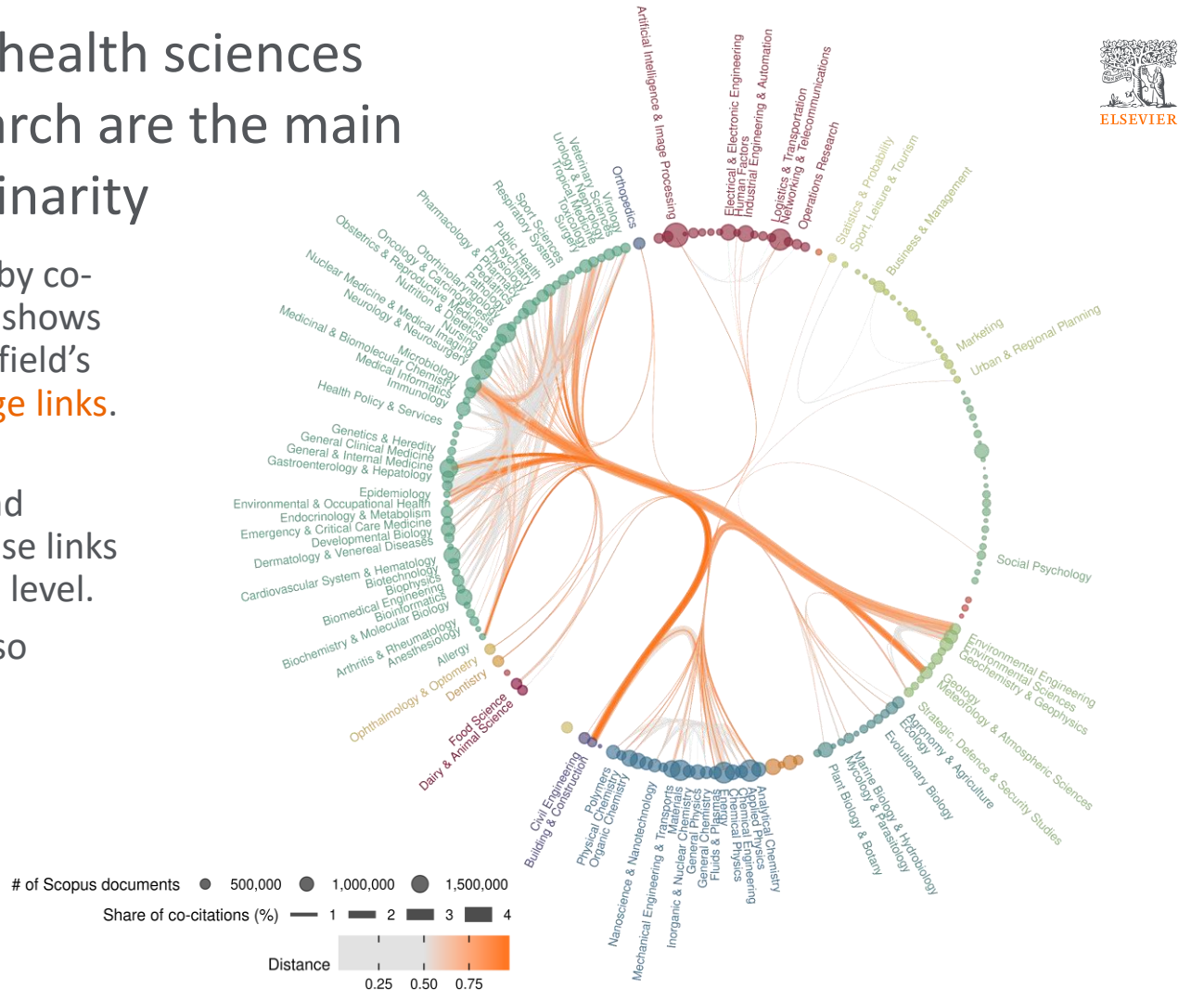
Change of interdisciplinary index for selected comparators, 2011-2019 (blue dots) and 2020-2021 (orange dots).
Source: Scopus

Links between the health sciences and buildings research are the main path to interdisciplinarity

Interdisciplinarity is defined by co-citation patterns. This figure shows the links contributing to the field's elevated index as wide orange links.

High number of connections between Health Research and Building & Construction. These links are otherwise rare at Scopus level.

High-importance links are also made to the environmental sciences.

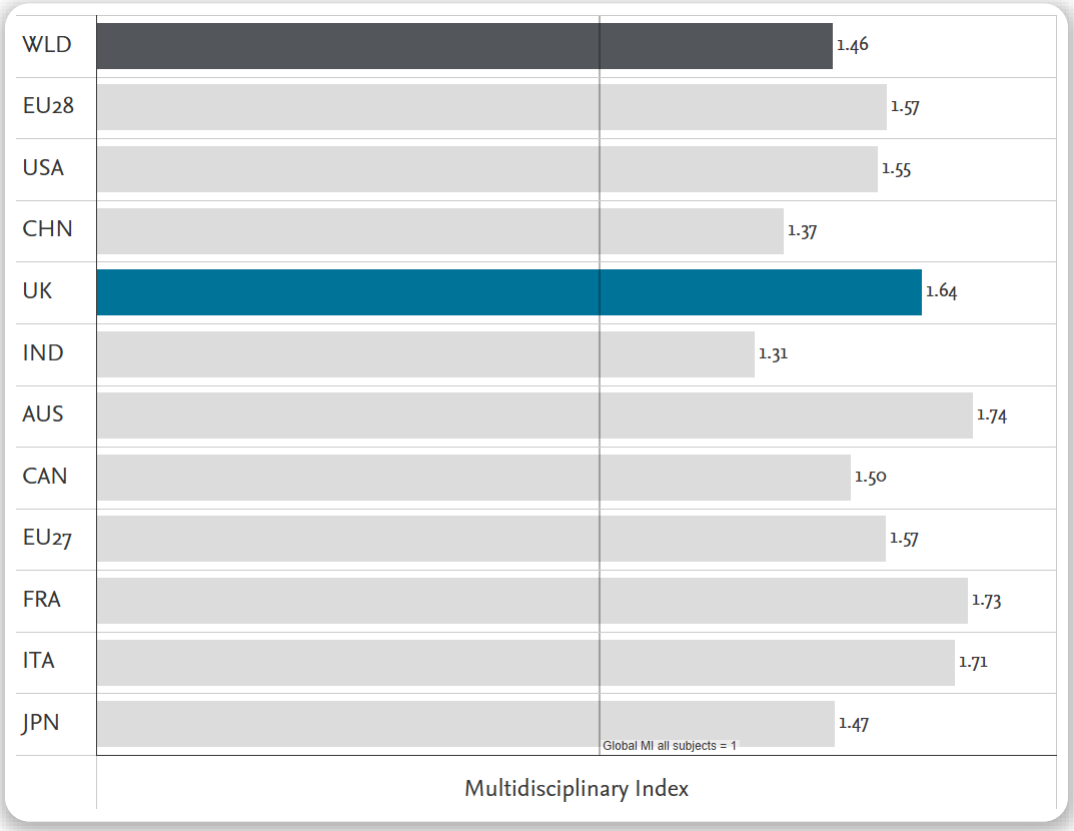


The field is highly multidisciplinary

The Multidisciplinarity Index of a publication is an indicator of the diversity of the authors' disciplinary backgrounds. The index is normalized by scientific subfield and publication year.

All countries in the top 10 exceed the average across all subjects, with Australia, France, Italy and the UK leading the group.

India and China are the least multidisciplinary of the group, falling slightly below the world average in the field.

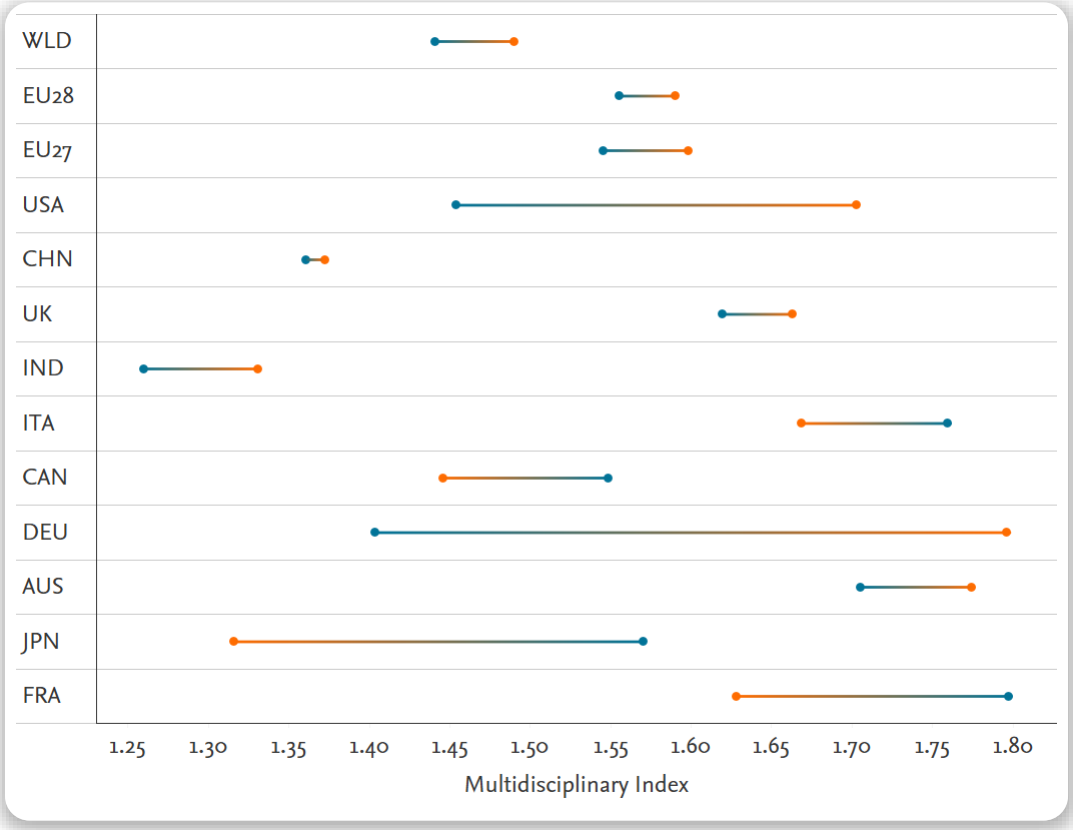


Multidisciplinary index for selected comparators, 2011-2021.
Source: Scopus

Multidisciplinary varied for most of comparators between periods

The Multidisciplinarity Index shows wide variations across the comparators from the first to the second period. While China and UK had more or less small changes, Germany, the US and Japan displayed high variations.

Italy, Japan, Canada and France had a higher multidisciplinary index in the first period.



Change of multidisciplinary index for selected comparators, 2011-2019 (blue dots) and 2020-2021 (orange dots).
Source: Scopus

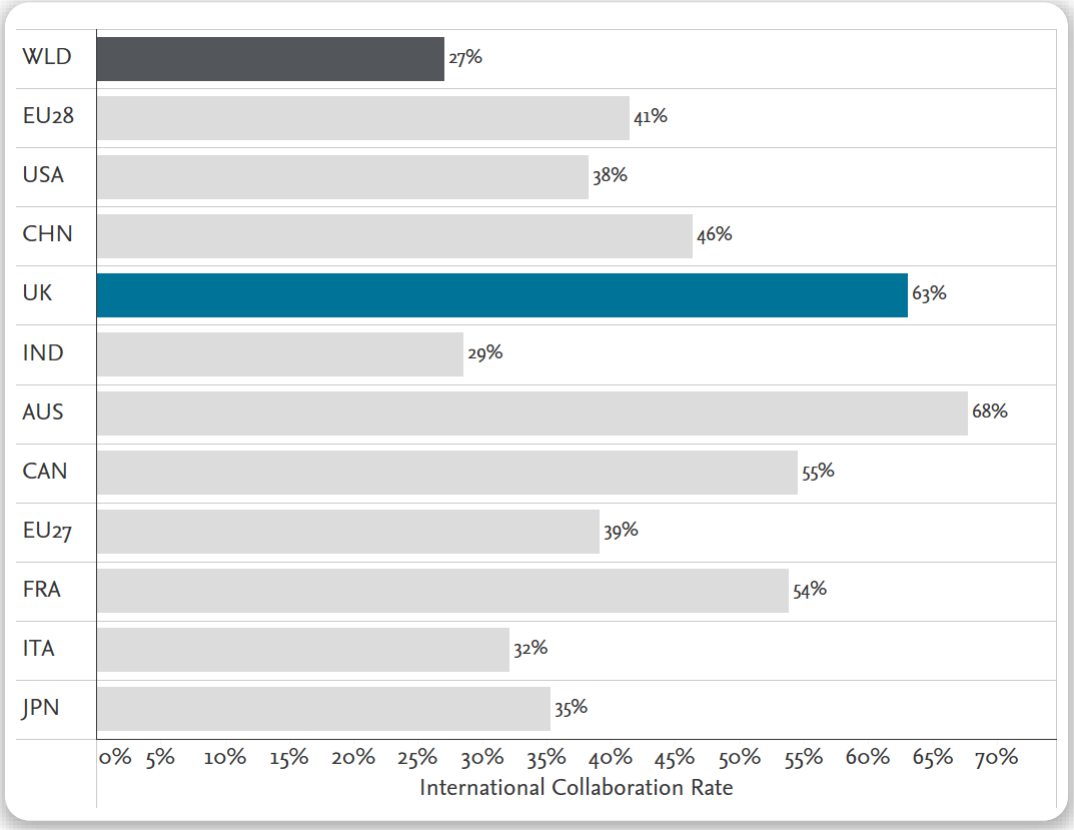
International and intersectoral collaboration

International collaboration

27% of publications were internationally co-written, above the Scopus average (19%).

Relative to their total outputs, the most collaborative countries among the top-10 are Australia and the United Kingdom.

The least collaborative are Japan, Italy and India.



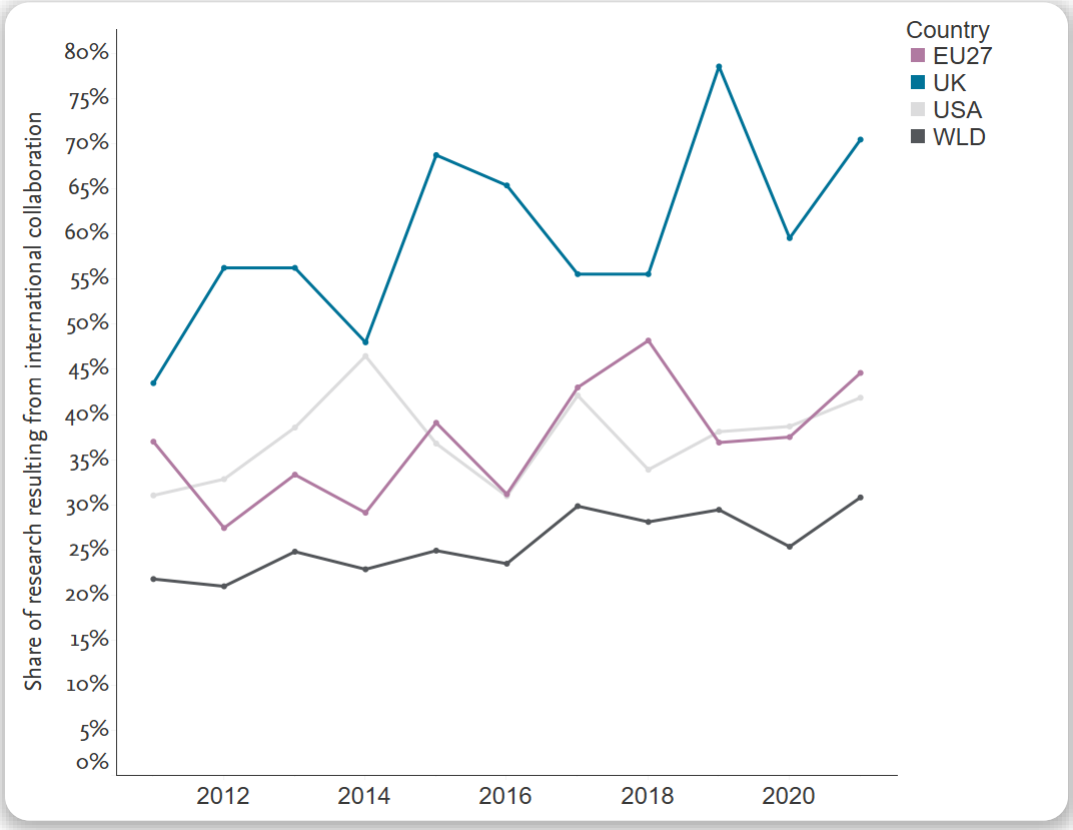
Share of IRE publications in international collaboration for selected comparators, 2011-2021.
Source: Scopus

International collaboration through time

International collaboration has become increasingly frequent worldwide from 2011 to 2021.

Although slightly unstable, the UK has seen its international collaboration rate rise much more than other comparable countries and regions, going from 43% in 2011 to 70% in 2021.

As a comparison, the EU-27's ICR in 2021 was 45%.

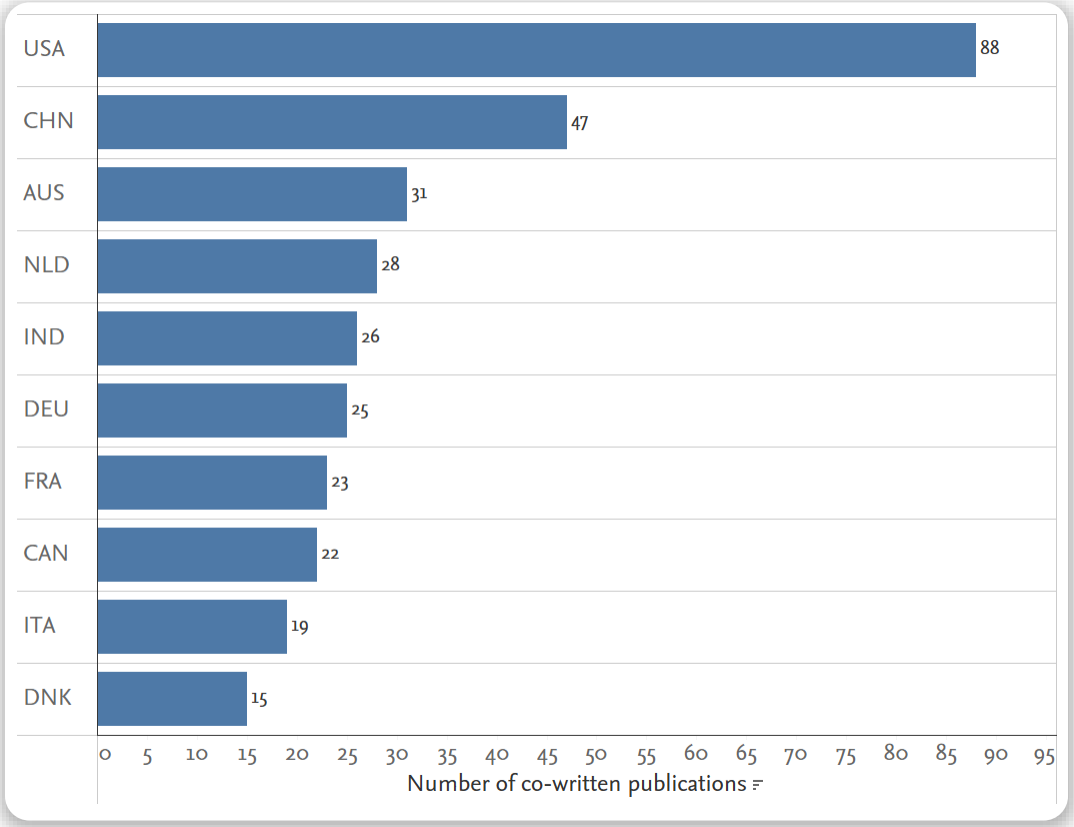


Annual share of IRE publications in international collaboration for selected comparators, 2011-2021.
Source: Scopus

The UK's main international collaborators in the field are the United States, China and Australia

In this field, the UK collaborates the most with the United States, with 88 publications co-written during the period 2011-2021.

China (47 publications), Australia (31 publications) and the Netherlands (28 publications) are next in-line.



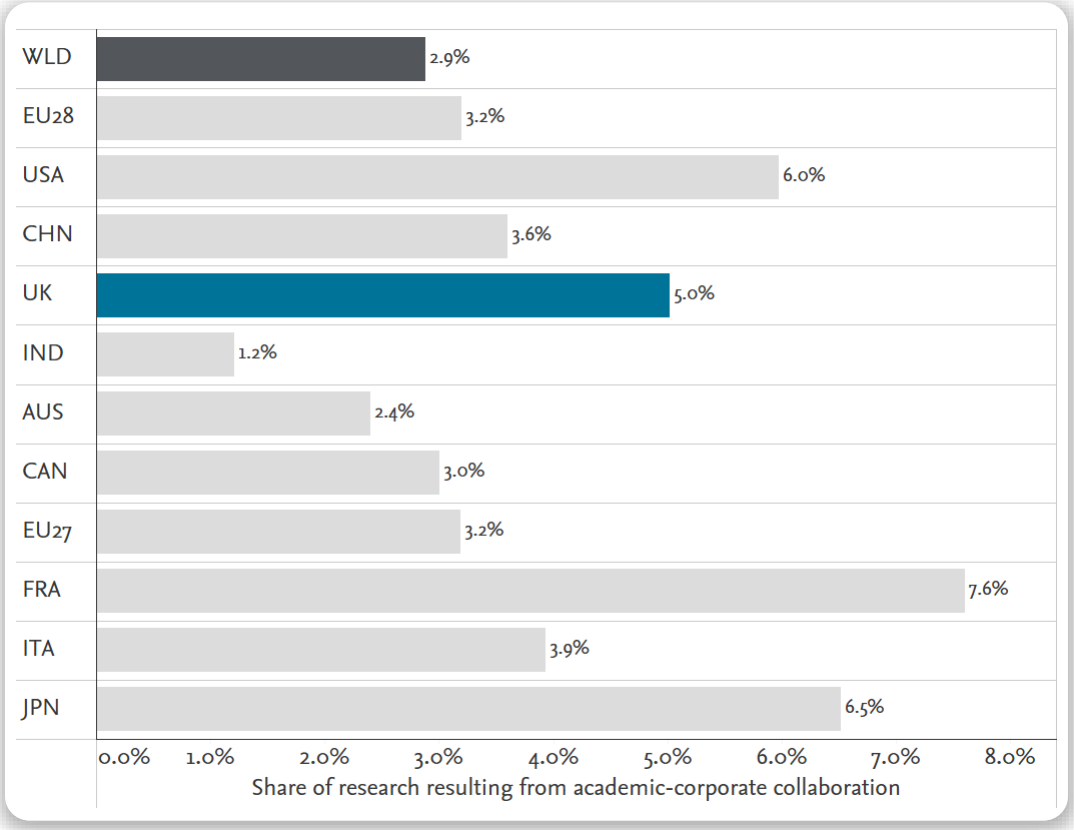
Number of international collaborated publications in IRE by collaborating country, ranked by output , 2011-2021.
Source: Scopus

Academic-corporate collaboration

Collaboration between the corporate and academic sectors is approximately as frequent worldwide as for all of Scopus (2.7% of publications).

Among the top-10 countries, those where this is the most frequent are France (7.6%), Japan (6.5%), the United States (6.0%) and the UK (5.0%).

Most of these rates are within a +1% margin of the national averages overall.

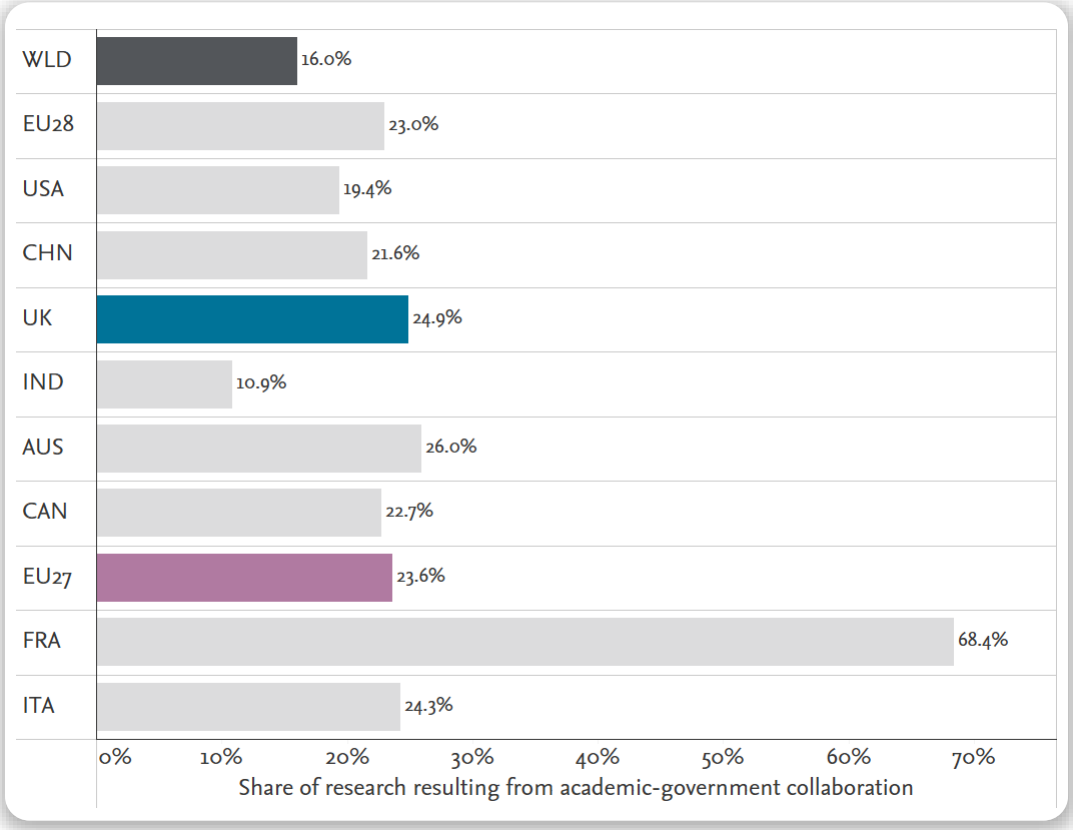


Share of IRE publications in academic-corporate collaboration for selected comparators, 2011-2021.
Source: Scopus

Academic-government collaboration

16% of all IRE publications worldwide were co-written by institutions from the government and academic sectors.

Among the top-10 countries, those where this is the most frequent are France (68.4%), Australia (26.0%) and the United Kingdom (24.9%).



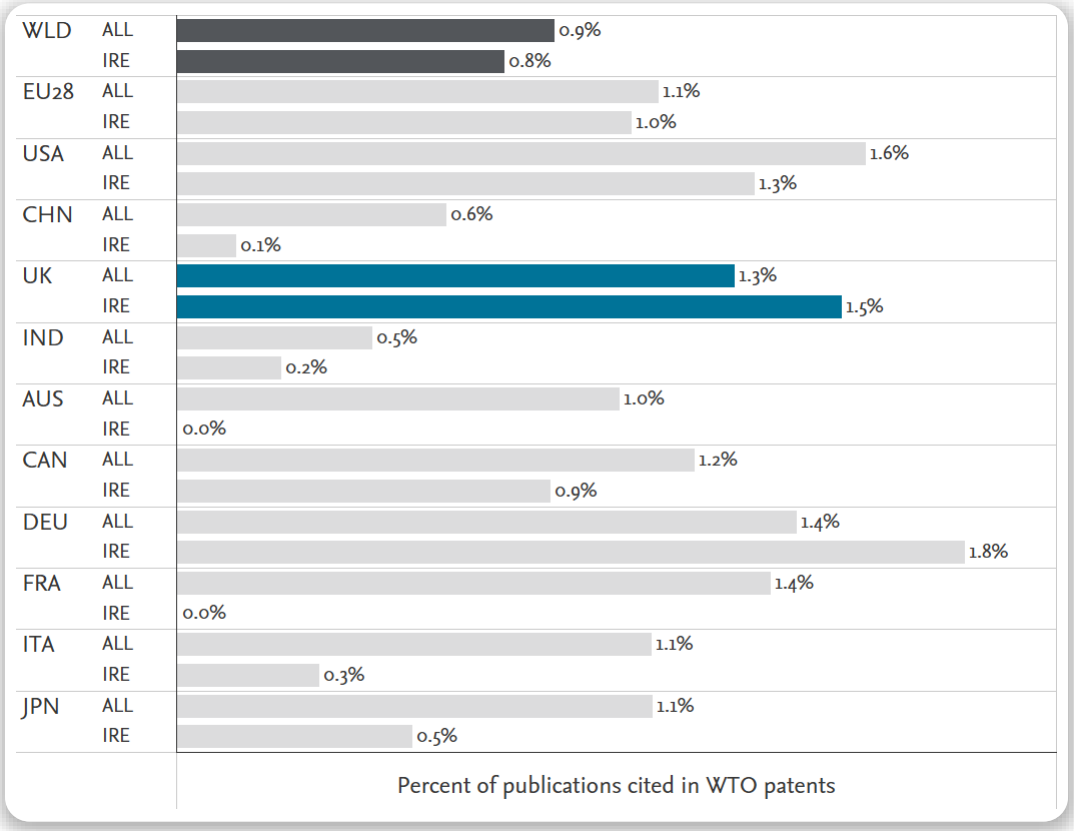
Share of IRE publications in academic-government collaboration for selected comparators, 2011-2021.
Source: Scopus

Knowledge Transfer

Patent citations are rare for IRE research

Not much uptake of IRE research in patents – this may be related to more recent research (patents take a long time to be published/granted).

And it might be that research is more geared towards existing – not developing new – technologies.

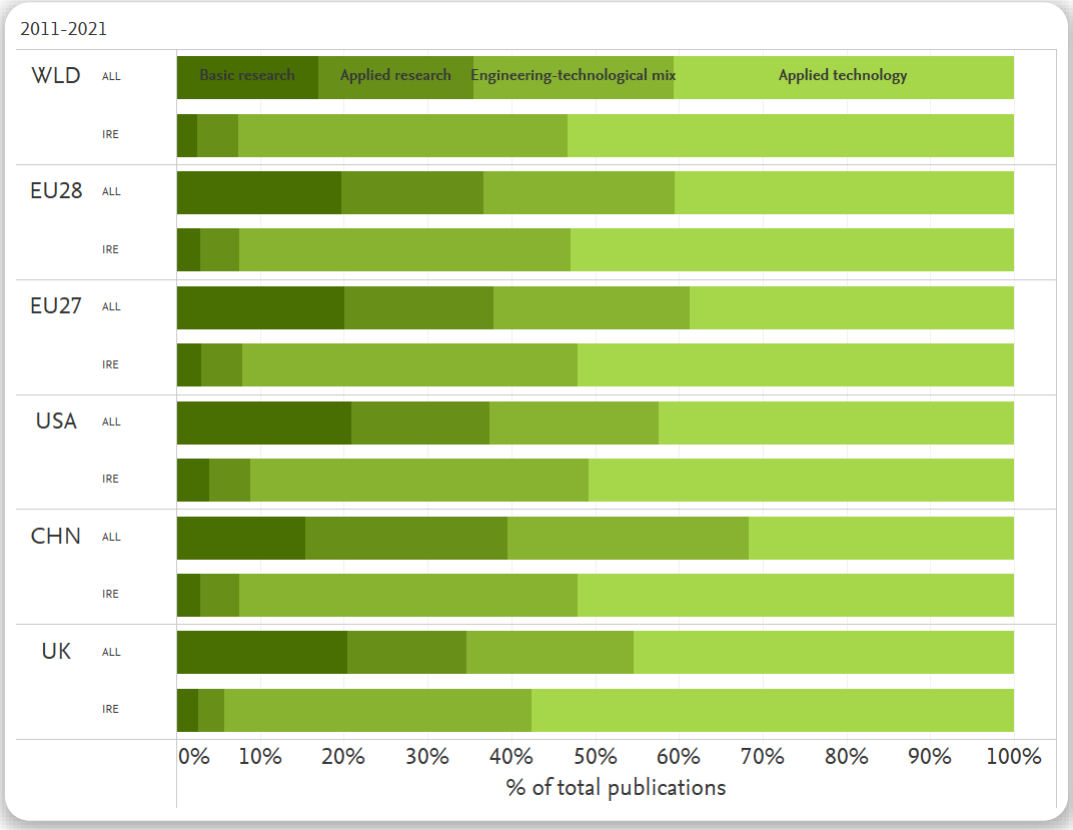


Share of total and IRE publications cited in patents filed at the WTO for selected comparators, 2011-2021.
Source: Scopus

Research levels shows a focus on applied technologies

Given small numbers, the results are to be taken with caution – but it may indicate there is a focus on the use of existing technologies and not basic research.

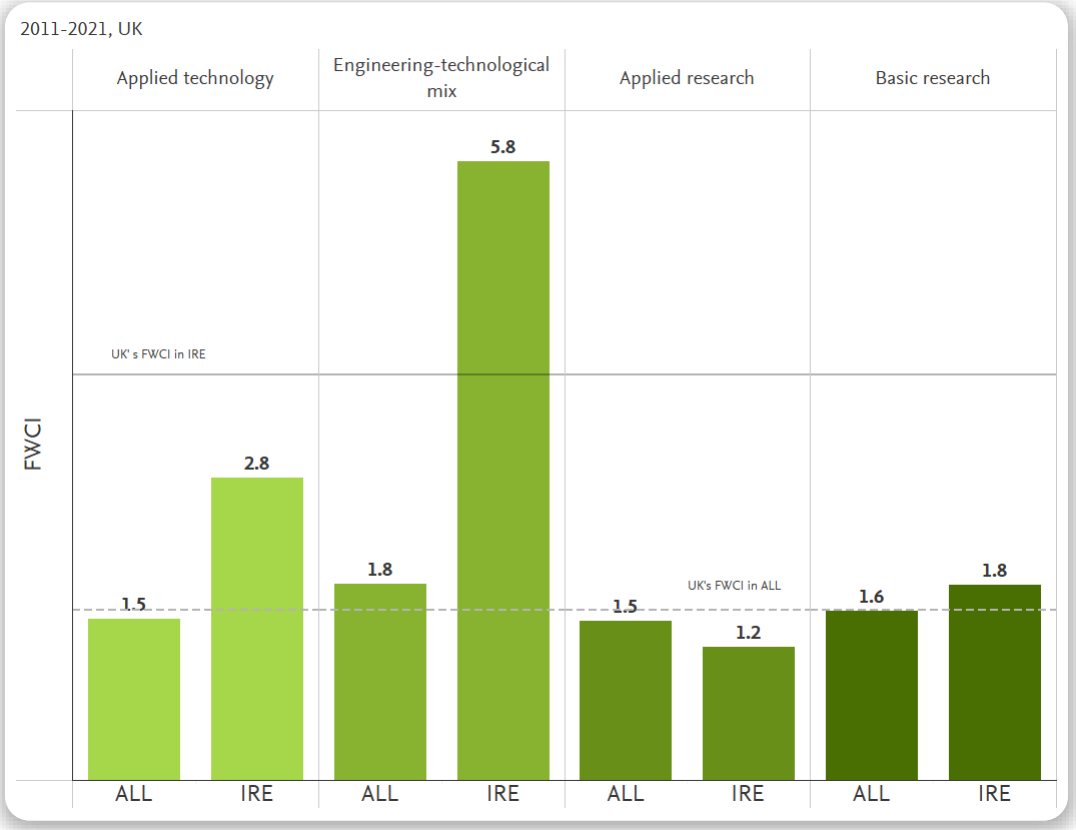
More than half of UK publications are in the level of applied technology.



Share of total and IRE publications based on research levels for selected comparators, 2011-2021.
Source: Scopus

The UK's most applied research in the field is more cited than on average

The citation impact of UK output is generally higher in IRE than overall, with the applied technology and engineering-technology mix application levels being the most impactful.



Citation impact (FWCI) of total and IRE publications by research level for UK, 2011-2021.
Source: Scopus

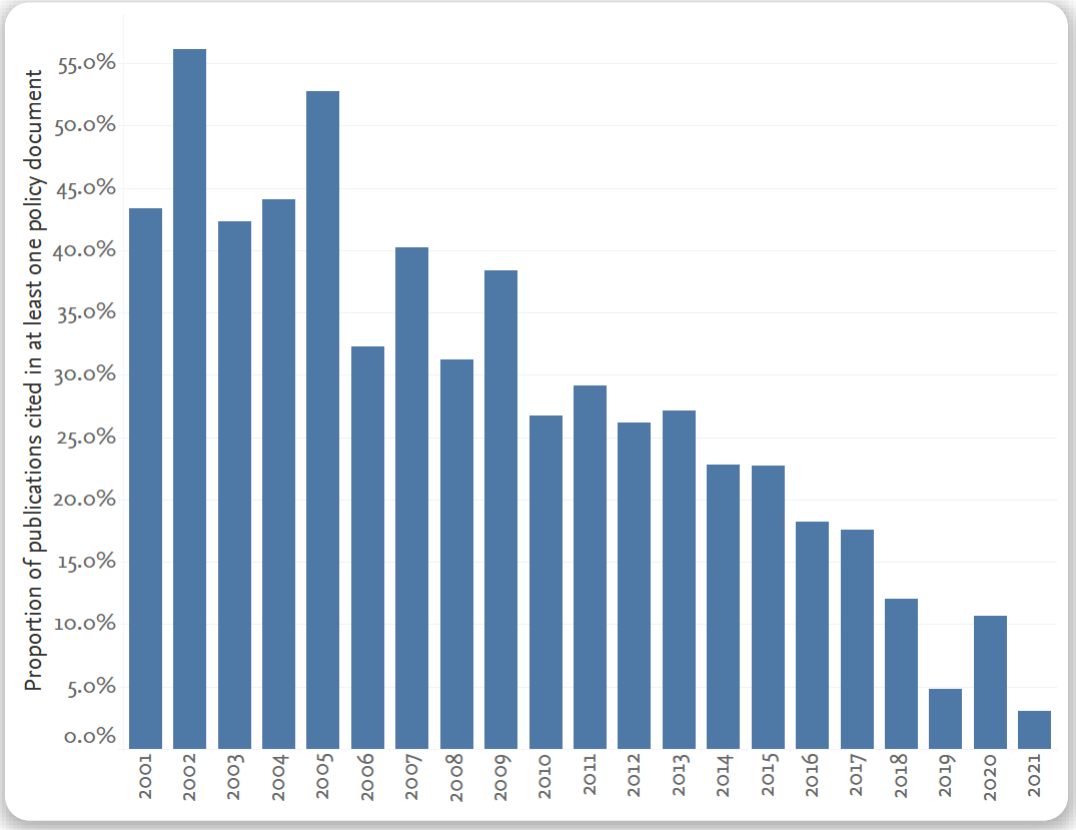
An elevated but decreasing proportion of publications are cited in policy documents worldwide

Between 2001 and 2010 around 40% (±10%) of all IRE publications have been cited in policy documents (Overton).

This is much higher than the Scopus average for the same period (~7%).

Recent decrease in the share might be related to two phenomena:

- Increase in IRE publication volume
- Normal delay between publication year and citation year

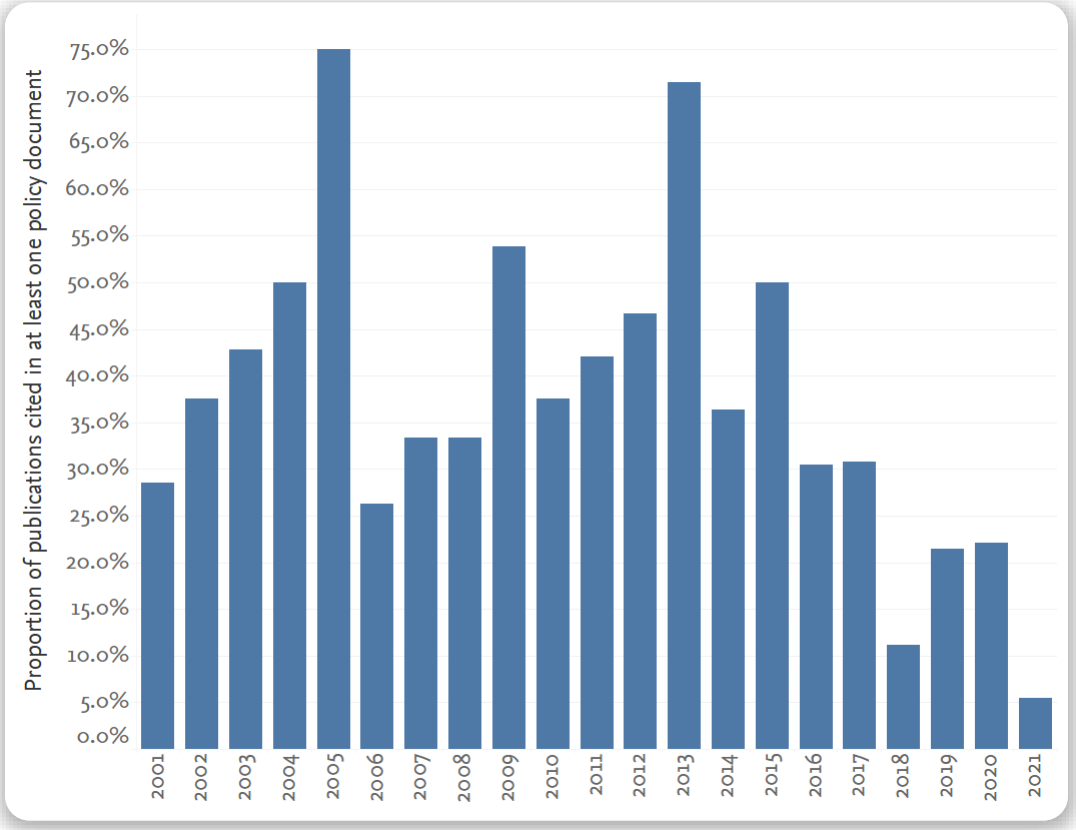


Share of global IRE publications cited in policy documents, 2001-2021.
Source: Scopus, Overton

The UK's share of cited documents seems to exhibit a seasonal pattern

UK IRE publications exhibit a different pattern than the world average.

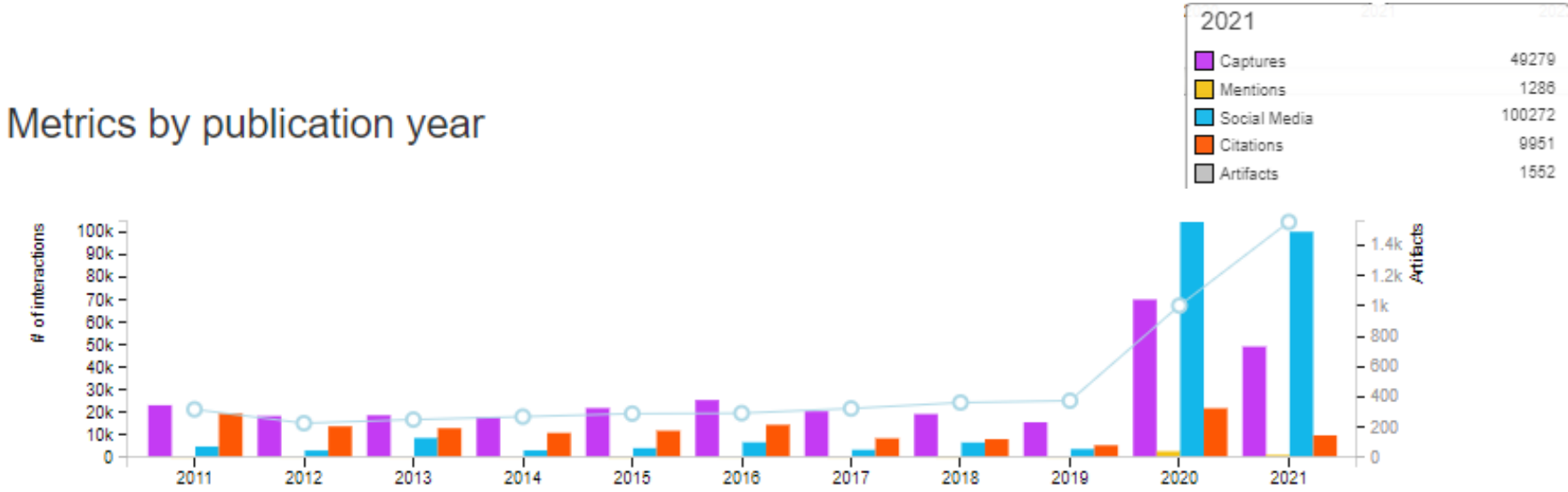
Seasonality could be the normal variations that are the consequence of small publication volumes but could be linked with another phenomenon (e.g., pandemics and their impact on policy)



Share of UK's IRE publications cited in policy documents, 2001-2021.
Source: Scopus, Overton

Use of IRE research in online media

IRE research was highly used in online media such as twitter or facebook – much more than regular citations.



Number of global IRE publications (light blue line) and use of it in different online sources, 2011-2021.
Source: PlumX

Top used publications in social media

Twitter is a major source for social media and individual publications are ‚pushed' heavily on that medium.

Year	Title	Type	All / Social Media		
			Shares +	Tweets +	Shares, Likes & Comments +
2020	COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China, 2020	Article		20016	31139
2021	Dismantling myths on the airborne transmission of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2)	Review		16463	1020
2021	Nosocomial outbreak of COVID-19 in a hematologic ward	Article		11416	24
2021	Probable airborne transmission of SARS-CoV-2 in a poorly ventilated restaurant	Article		8173	604
2021	Testing mobile air purifiers in a school classroom: Reducing the airborne transmission risk for SARS-CoV-2	Article		6540	395
2020	Community Outbreak Investigation of SARS-CoV-2 Transmission among Bus Riders in Eastern China	Article		5985	
2021	A paradigm shift to combat indoor respiratory infection	Review		5774	438
2020	Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing	Article		4385	5326
2021	Assessing the association between social gatherings and covid-19 risk using birthdays	Article		4219	
2020	Fluvoxamine vs Placebo and Clinical Deterioration in Outpatients with Symptomatic COVID-19: A Randomized Clinical Trial	Article		2964	

Scientific Advisory Group for Emergencies used by IRE output

Only four IRE publications cite SAGE, or SAGE groups

Query*:

REF ("Scientific Advisory Group for Emergencies" OR "nervtag" OR "SPI-M" OR "SPI-B" OR "COG-UK" OR "HDR-UK")

Authors	Title	Year	Source title
Capeyron O., …	A simple method for SARS-CoV-2 RNA detection in the air of an enclosed space	2022	Journal of Hospital Infection
Butera Y., …	Genomic sequencing of SARS-CoV-2 in Rwanda reveals the importance of incoming travelers on lineage diversity	2021	Nature Communications
Schijven J., ...	Quantitative microbial risk assessment for airborne transmission of sars-cov-2 via breathing, speaking, singing, coughing, and sneezing	2021	Environmental Health Perspectives
Tang J.W., …	Dismantling myths on the airborne transmission of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2)	2021	Journal of Hospital Infection

* Inclusion of SAGE led to too many false positives (e.g. SAGE publisher)

Institutional Statistics

Institutional production (UK)

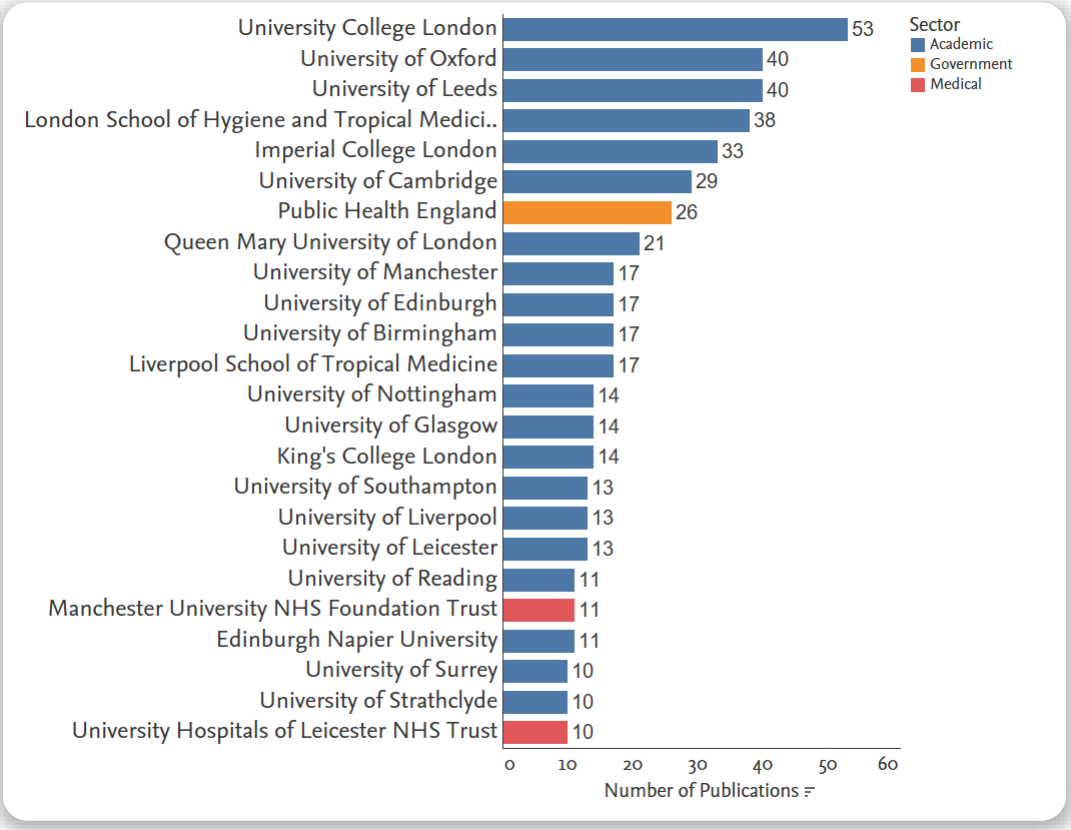
In the UK, the most active IRE research institutions are mostly from the academic sector.

Research is spread out across many institutions.

UCL was the most publishing institution in the field in the period 2011-2021, with 53 publications.

Public Health England is the UK governmental institution involved on the most papers.

The field has a small number of active researchers. Only around 20 researchers have published 5 papers or more with a UK address in the 2011–2021 period.



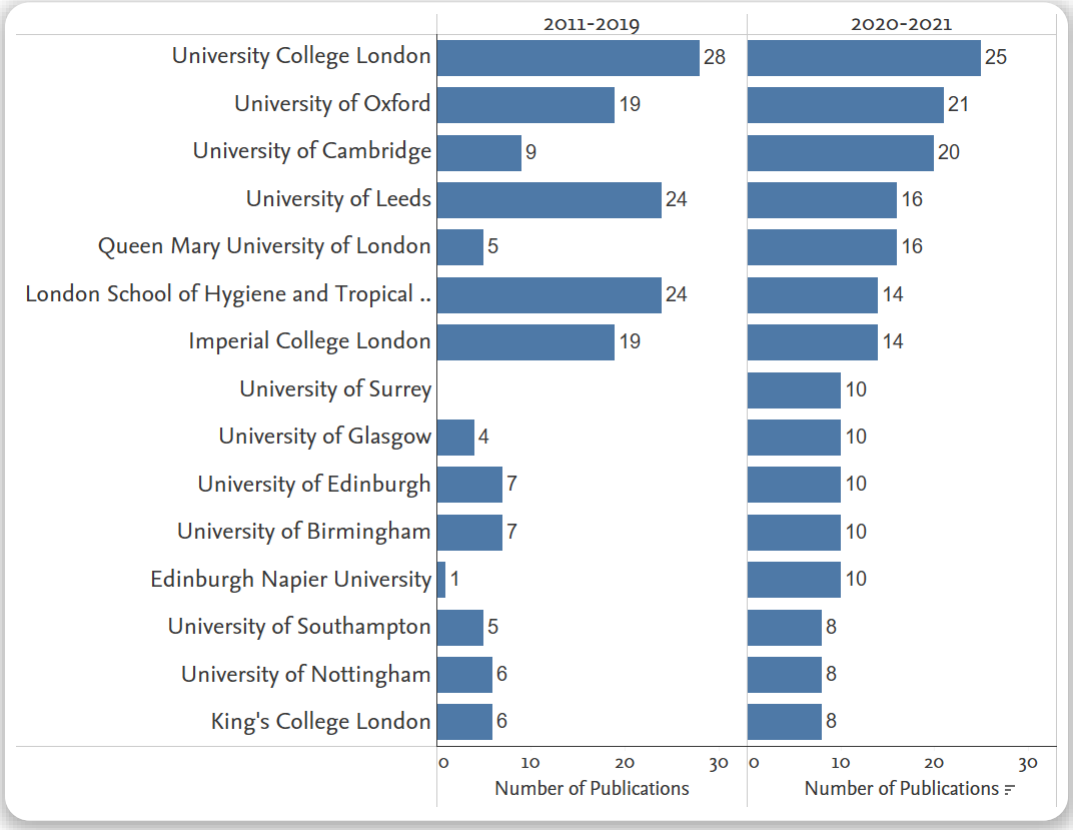
Total output in IRE, 2011-2021, for the top 24 most producing UK-located institutions
Source: Scopus

Institutional production (UK, split)

Comparing the 2011–2019 period and the 2020–2021 period, we see that all institutions have increased their yearly production.

Some institutions, like the University of Surrey, have progressed from not publishing in the field between 2011 and 2019 to publishing 8 or more articles in two years.

Institutions shown are the largest producers in 2020–2021.



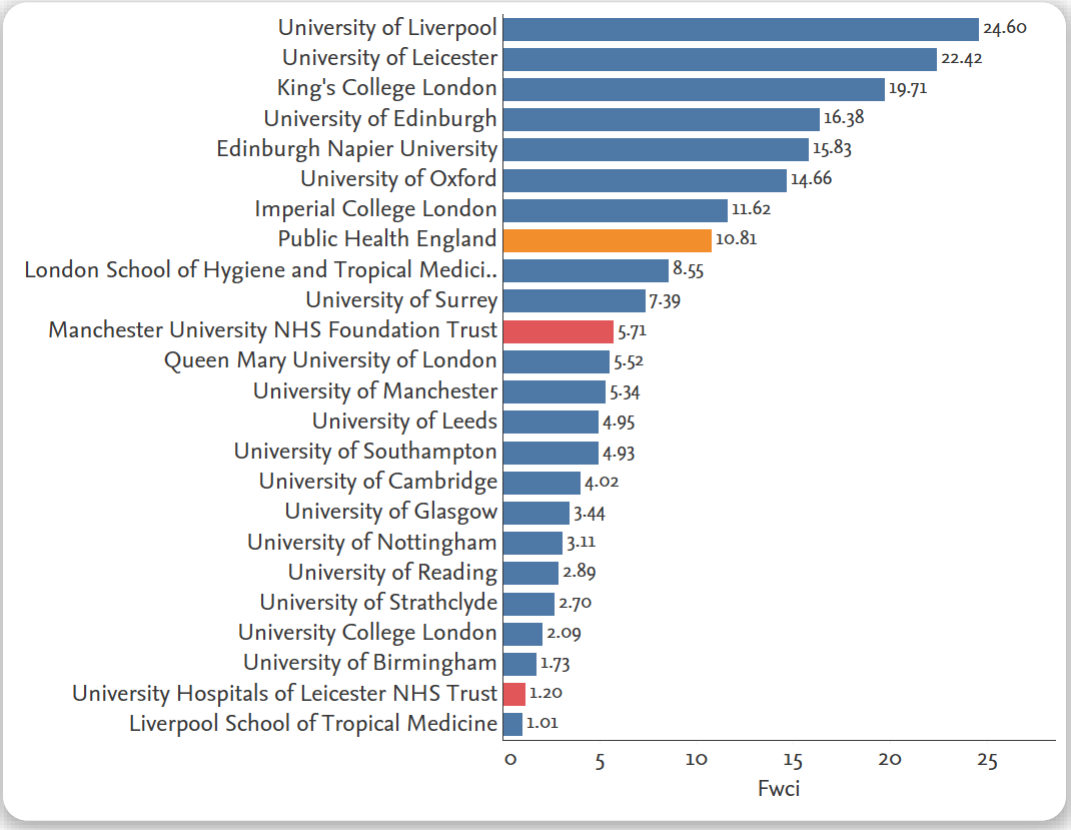
Total output in IRE, 2011-2019 and 2020-2021, for the top 15 most producing UK-located institutions based on the 2020-2021 period
Source: Scopus

Institutional impact (UK)

The top-20 institutional producers in the UK from the 2011–2021 period are all publishing articles that are on average more impactful than the world average.

The University of Liverpool's articles were cited over 24 times more than the average in the same fields and years.

The low publication volume and very recent uptick in the number of publications however means these numbers must be interpreted with caution.



Field-weighted citation impact in IRE, 2011-2021, for the top 24 most producing UK-located institutions
Source: Scopus

Institutional localization (UK)

This map shows where institutions conducting IRE research in the UK are located.

Most institutions are geographically located in England, with a few smaller clusters in Scotland and Wales.

Map showing the geographical localization of British institutions active in IRE research, 2011-2021. Bubble size is proportional to total output volume, and color is mapped to activity sectors.
Source: Scopus

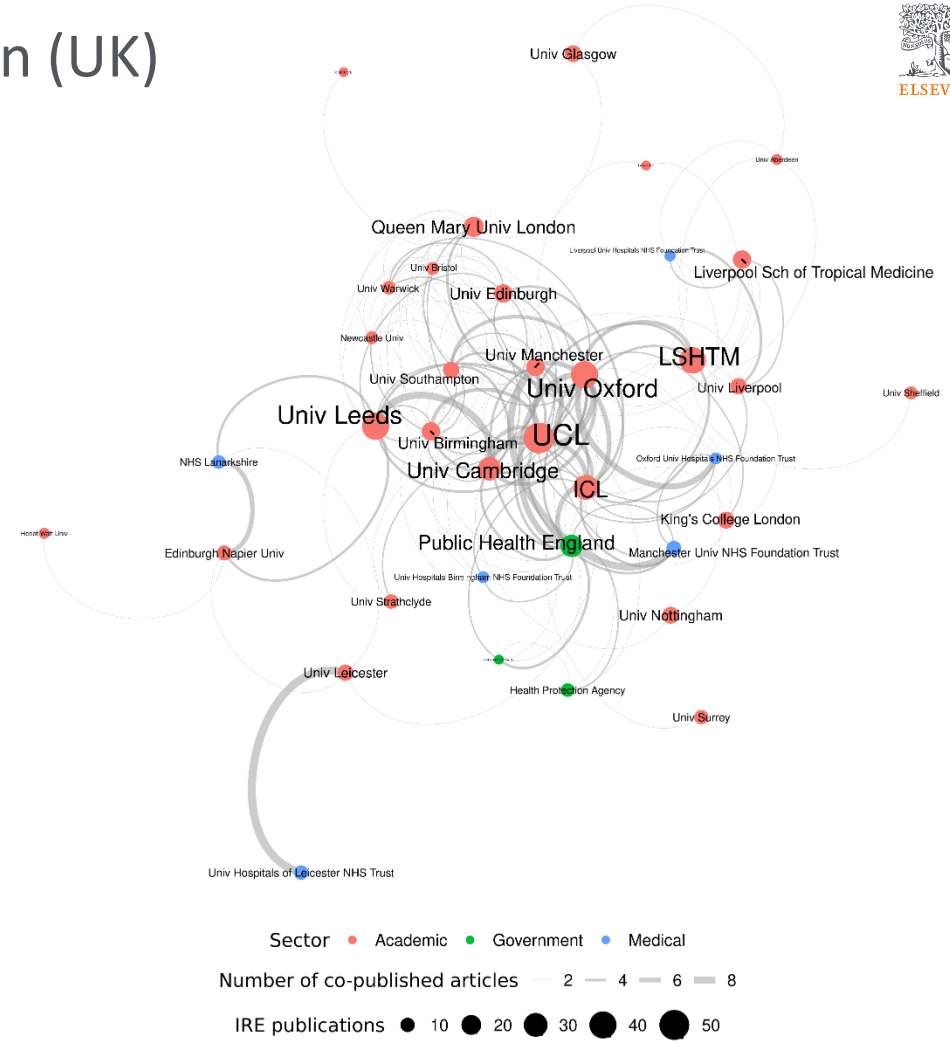
Inter-institutional collaboration (UK)

This network is limited to displaying collaborations between UK-located institutions.

Link width is proportional to the co-publication volume between two institutions. A minimum number of 2 collaborations is required for a link to be shown.

Node size is proportional to total output volume in the field. A minimum amount of 5 publications total is required for a node to be shown.

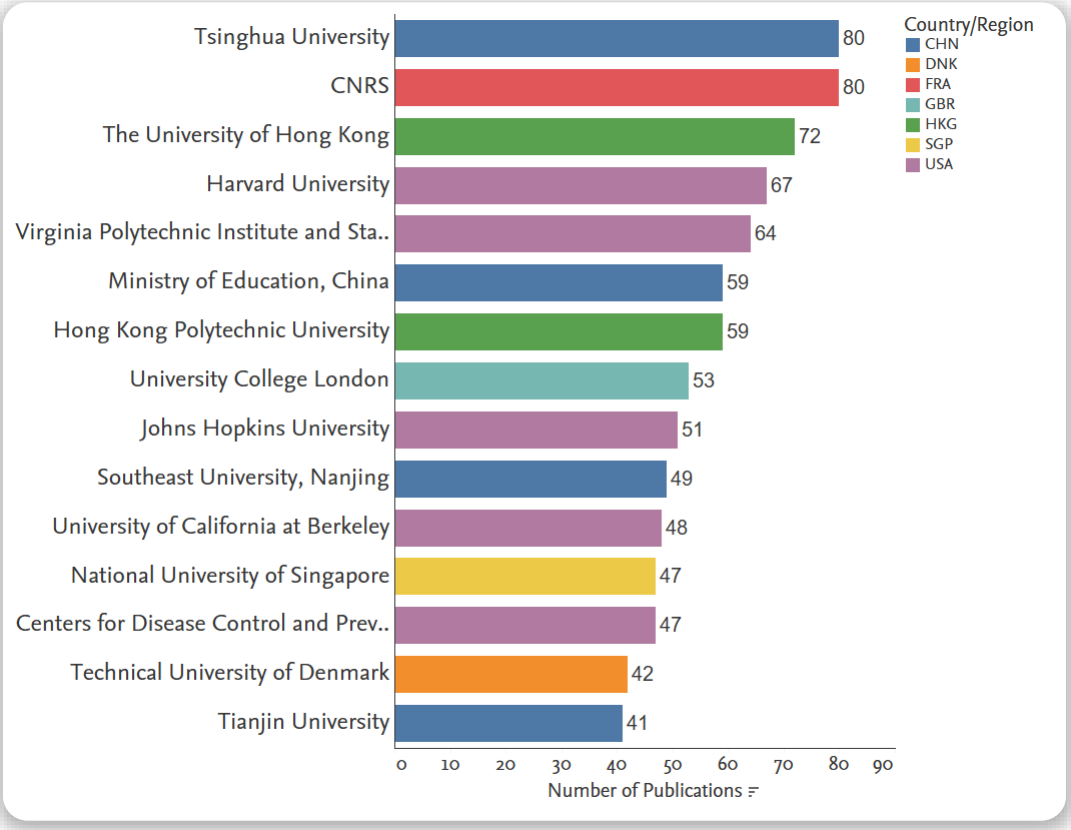
Color coding is used to represent the sector of activity attributed to every institution.



Institutional production (World)

The most productive institutions in the world are mostly located in the U.S. (5 out of top 15) and China (4 out of top 15).

The UK's University College London is the sole British institution to be included in the world's top 15.



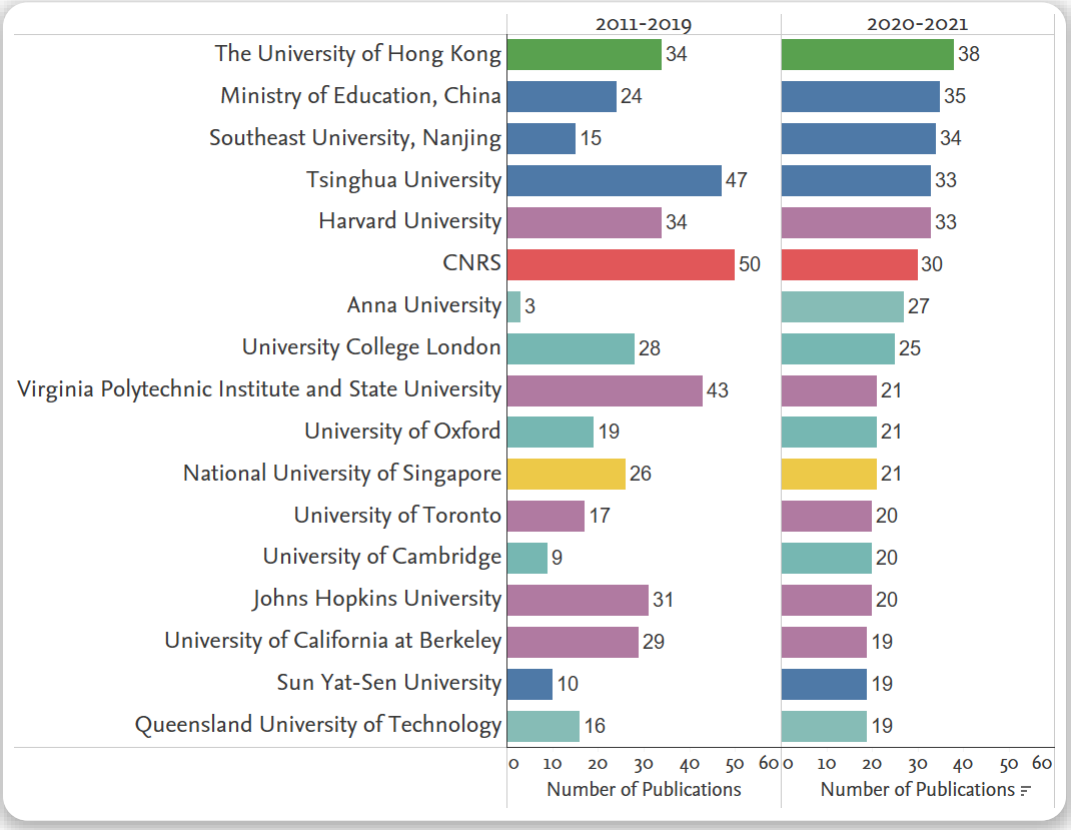
Total output in IRE, 2011-2021, for the top 15 most producing institutions worldwide
Source: Scopus

Institutional production (World, split)

Country/Region spread among top institutions in 2020-2021 is similar to the overall period.

Here again, we see all these institutions have ramped up their publication rate in the last two years.

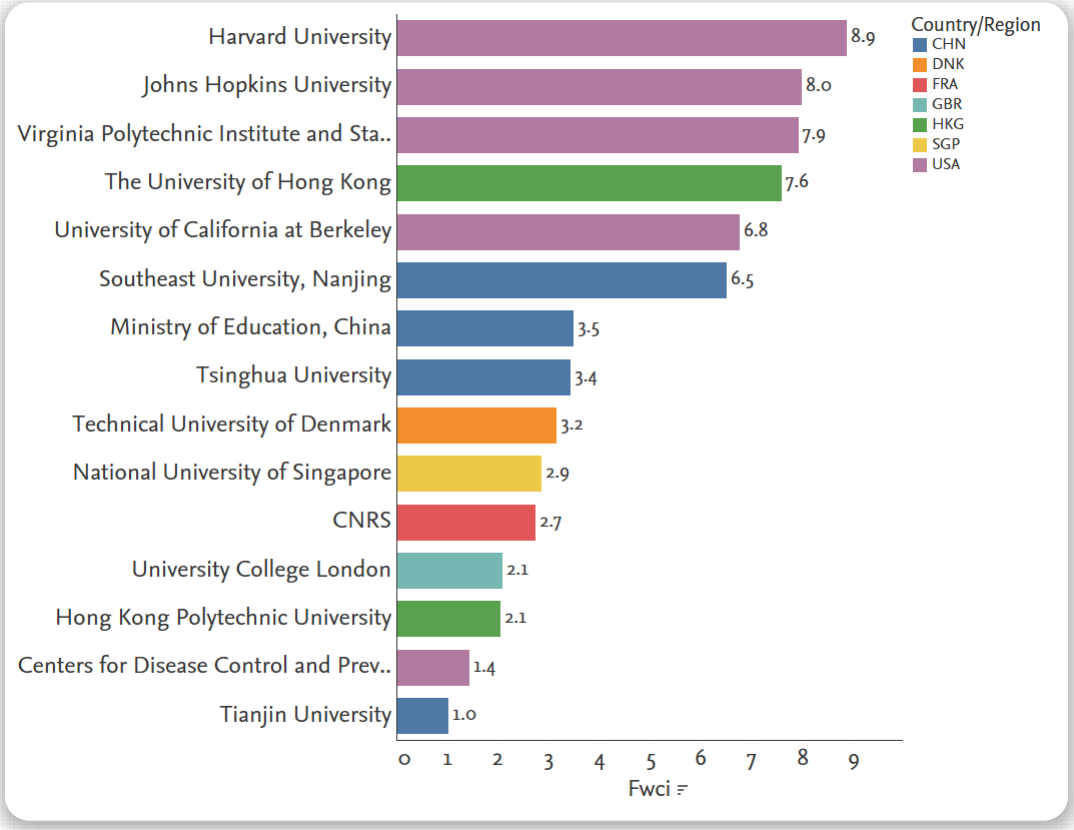
Anna University (India) went from publishing only 3 relevant articles in nine years to publishing 27 in two years.



Total output in IRE, 2011-2019 and 2020-2021, for the top 15 most producing institutions worldwide in 2020-2021 (17 institutions shown because of ties)
Source: Scopus

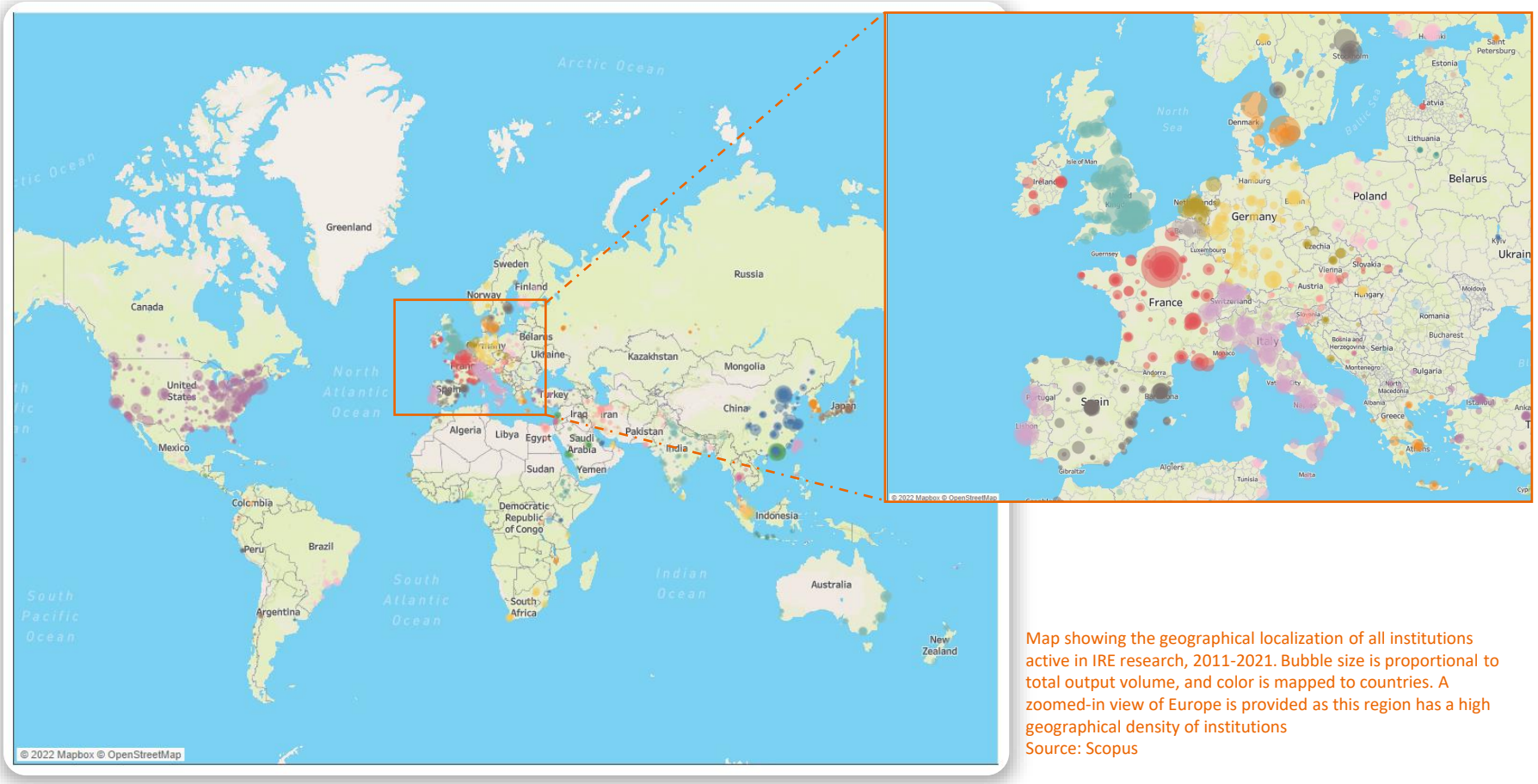
Institutional impact (World)

As it was the case for the UK, all the world's top-15 institutional producers are publishing articles that are more cited than the World average in the same fields and years.



Field-weighted citation impact in IRE, 2011-2021, for the top 15 most producing institutions worldwide
Source: Scopus

Institutional localization (World)



Map showing the geographical localization of all institutions active in IRE research, 2011-2021. Bubble size is proportional to total output volume, and color is mapped to countries. A zoomed-in view of Europe is provided as this region has a high geographical density of institutions
Source: Scopus

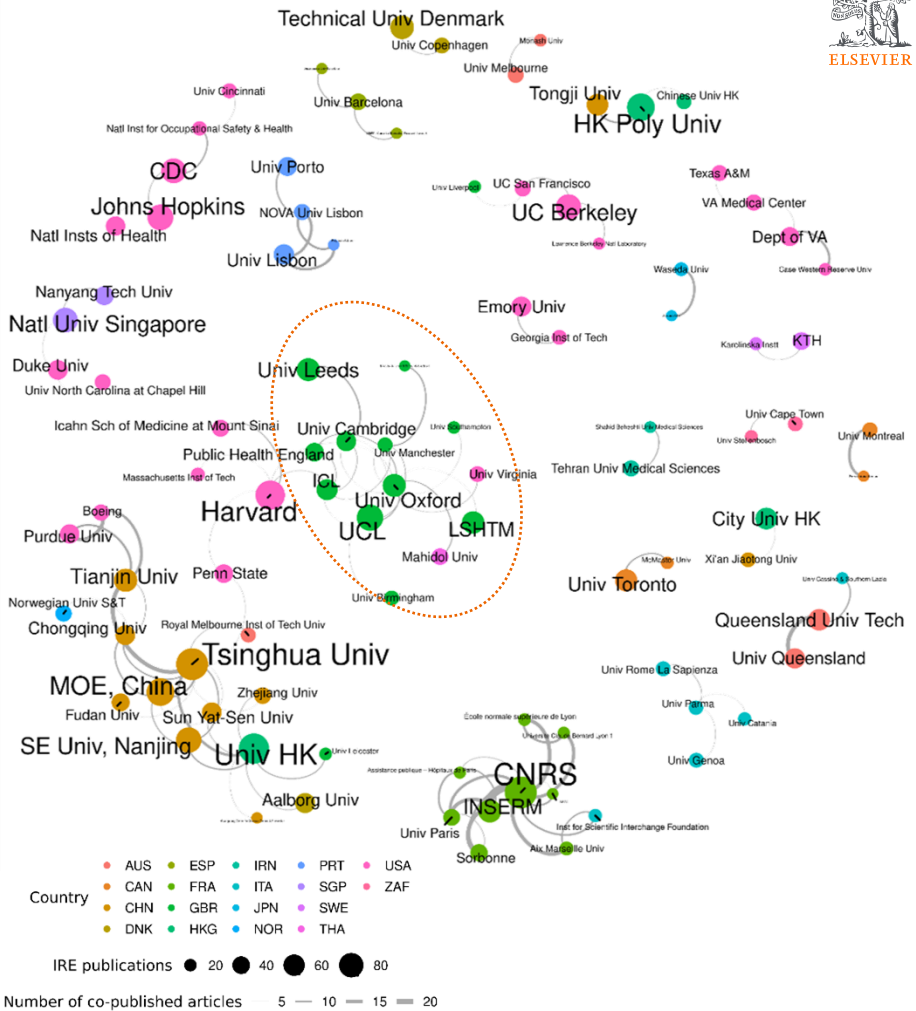
Inter-institutional collaboration

This network is not limited by country.

Link width is proportional to co-publication volume. A minimum number of 5 collaborations is required for a link to be shown.

Node size is proportional to total output volume in the field. A minimum amount of 10 publications total is required for a node to be shown. Unconnected nodes are not shown.

Color is mapped to country of the institutions.



Appendix

Indicators and Methods

Indicators – Research output and impact

- Publication counts
  - Publications (peer-reviewed articles, reviews and conference papers)
  - Publications were counted once for every entity (country, institution, author) participating in the research reported
- Growth Ratio (GR) & Growth Index (GI)
  - **GR**: The number of publications in the last year of a period divided by the number of publications in the first year of the period.
  - **GI**: The growth ratio of an entity divided by the growth ratio of the world. An entity with a GI higher than 1 is growing faster than the world average.
- Relative activity index (Specialization Index)
  - Share of an entity's total output in a specific field of science relative to the world's share of total output in the same research field
  - To measure an entity's research focus

Indicators – Research output and impact

- Field Weighted Citation Impact (FWCI)
  - Sum of the citation count of a publication normalized against the average number of citations across all publications at the world level in the same publication year, document type, and research field or research level.

FWCI > 1 → Impact above the world level

FWCI < 1 → Impact below the world level

- Citation percentile
  - Share of an entity's publications among the top 1%, 5% and 10% most cited publications
  - normalized relative to the world level by research field of research level.
- Author addresses were used to classify publications by sector of activity (Academic, corporate, government, medical, and other).
  - The classification is not mutually exclusive, i.e., publications can be part of more than one sector.
  - The classification is not perfect, particularly in the corporate sector where it is very difficult to identify SMEs.

Indicators – Research collaboration

- International collaboration
  - Absolute number
  - Share of the entity's output
- Top collaborating partners
  - Number of collaborated publications
- Interdisciplinarity index
  - A measure of the disciplinary diversity of knowledge integrated in a publication, as measured through a publication's references.
  - Normalized with respect to the document's scientific subfield and publication year.
- Multidisciplinarity index
  - A measure of the disciplinary diversity of knowledge integrated in a publication, as measured through a publication's authors.
  - Normalized with respect to the document's scientific subfield and publication year.

Indicators – Knowledge transfer

- Academic-corporate collaboration
  - Share of entity's total output
- Patent-cited publications
- Research can be categorized into different stages, ranging from the basic to more applied/clinical
  - Generally, research in physics, chemistry, biology and some aspects of medicine tends to be more basic, while engineering, computer science, social sciences and clinical medicine are more applied
  - In these areas, there is a positive correlation between citation count (impact) and research level: citation counts decrease during the transition from basic to applied research.

Topic clusters

- Topics refer to nearly 96,000 research topics created using citation patterns of Scopus-indexed publications. The methodology for using citation patterns to define research topics was developed through an Elsevier collaboration with research partners. The advantage of taking a citation-based approach to identify research topic is that one need not rely on identifying all the relevant keywords to define a research area. Indeed, the research area is delineated by citation patterns in the topic, whereby research that appears in the same citation network is clustered together in the same topic. This approach provides a more nuanced definition of the research topic.
- Topic clusters are a higher-level aggregation of these research topics based on the same direct citation algorithm that created the Topics. While topics are easy to understand for the subject experts, that is more difficult for subject generalists. To help aid discovery and understanding of the Topics, we have taken the Topics and aggregated them to around 1,500 Topic Clusters.
- The Topics and Topic Clusters are named by the three most relevant key phrases to provide a context.