A BIBLIOMETRIC LENS FOR SCIENCE DIPLOMACY

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OECD

"Mobility…serves to both strengthen the scientific capacity of the countries and benefit the scientific careers of individual researchers"

ROYAL SOCIETY

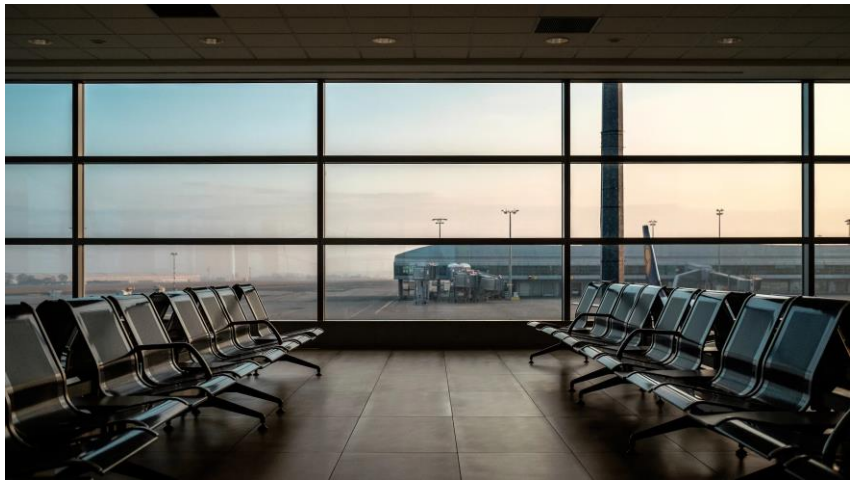
"International collaboration plays an important role in fostering high-quality knowledge production"

Rising nationalism

The executive order: temporarily suspend entry of individuals from *Iran, Iraq, Libya, Somalia, Sudan, Syria, and Yemen* and place restrictions on visa renewals for additional 38 countries. (Jan 2017)

Brexit hinders scientific mobility, collaboration, and has implications for funding

Visa scheme for graduates from top 50 non-UK universities is launched



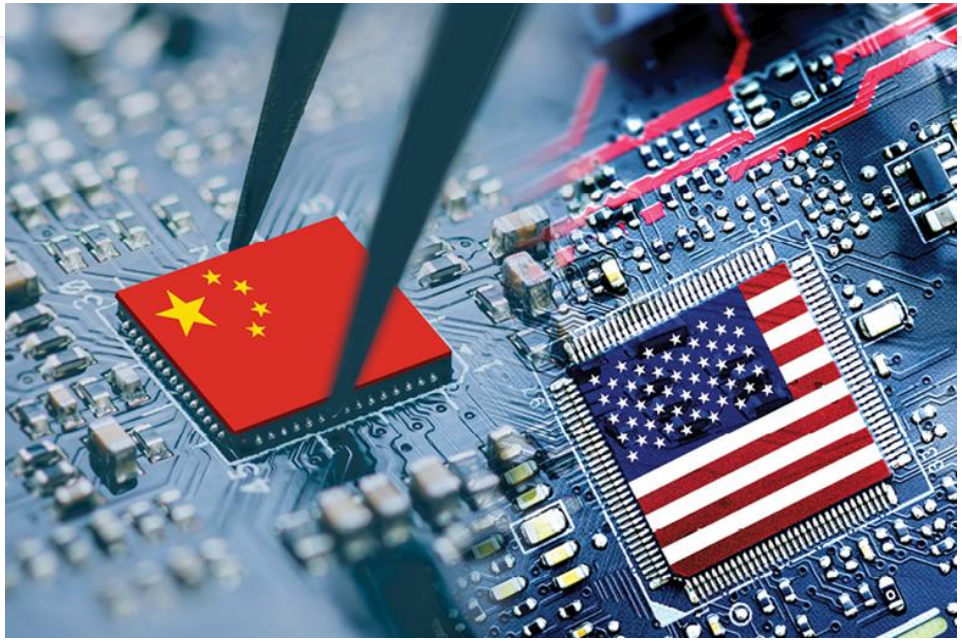
Air traffic reduced by 95% during the pandemic, with effects on student enrollment

Post-pandemic behavior towards conferencing changes

COOPERATION V. COMPETITION

The Washington Post

China increasingly challenges American dominance of science



“ It will invest in research and development, science and technology, and the workforce of the future to keep the United States the leader in the industries of tomorrow.” CHIPS and Science Act

SCIENCE DIPLOMACY

Diplomacy for science	The use of diplomatic action to facilitate international scientific collaboration, e.g., by negotiating R&D agreements and exchange programmes or enabling the establishment of international research infrastructures
Science for diplomacy	The use of science as a soft power to advance diplomatic objects, e.g., for building bridges between nations and creating good will on which diplomatic relations can be built
Science in diplomacy	The direct support of diplomatic processes through science, e.g., by providing scientific advice and evidence to inform and support decision-making in foreign and security policies

OPEN QUESTIONS

- Could scientometrics provide the empirical base for science diplomacy?
- How can scientometrics reveal global inequities?
- Where do scientometric datasets and indicators fail in providing accurate global information?
- How could we create more inclusive datasets and indicators for social good?

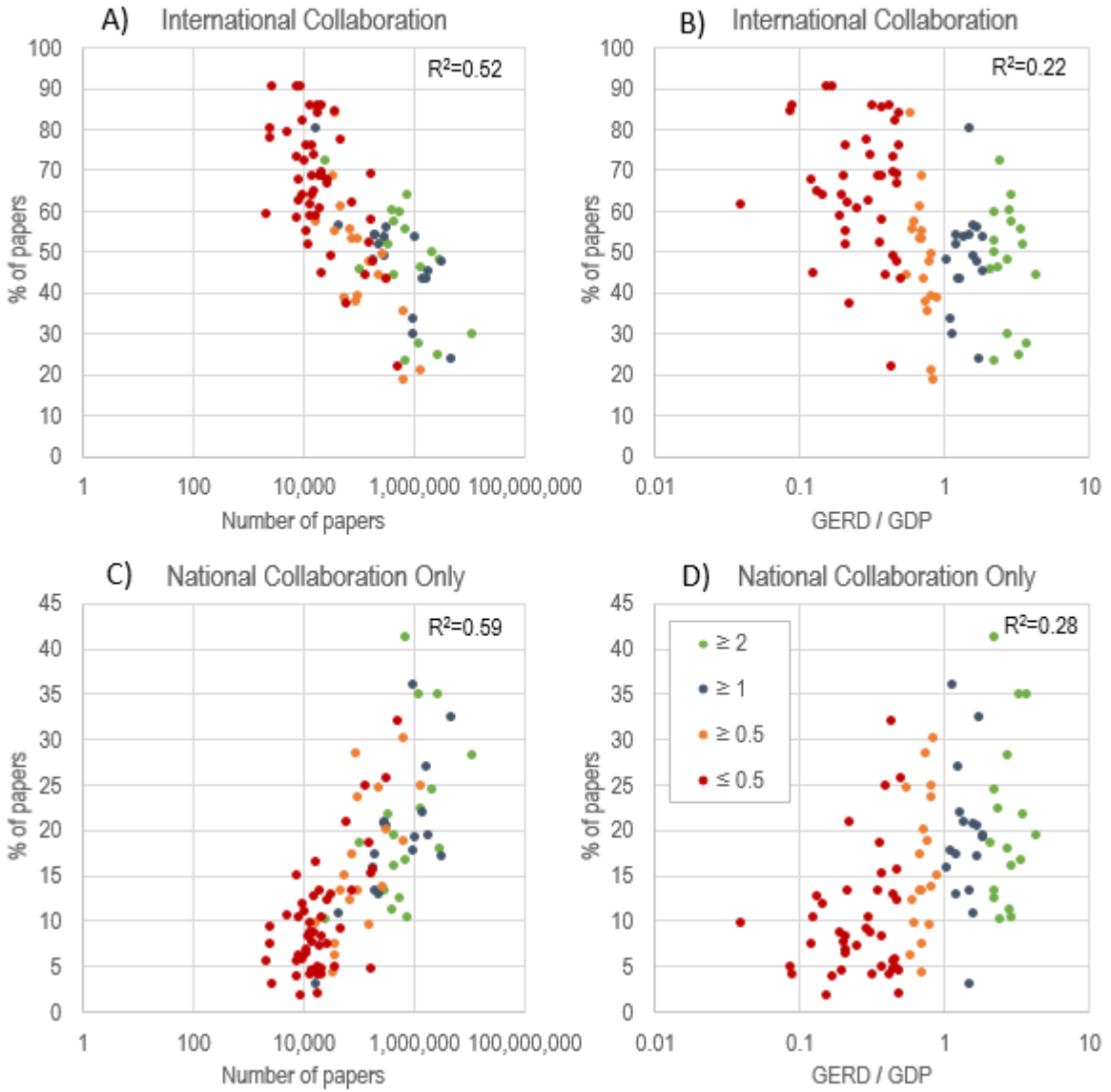
COLLABORATION

COLLABORATION & LEADERSHIP

Proportion of output in international collaboration, national collaboration, and not in collaboration; percentage of papers in international leadership

PRODUCTION & INVESTMENT

Percent of papers in international/national collaboration by number of papers and GERD/GDP; demonstrates relationship between scientific capacity and international portfolio



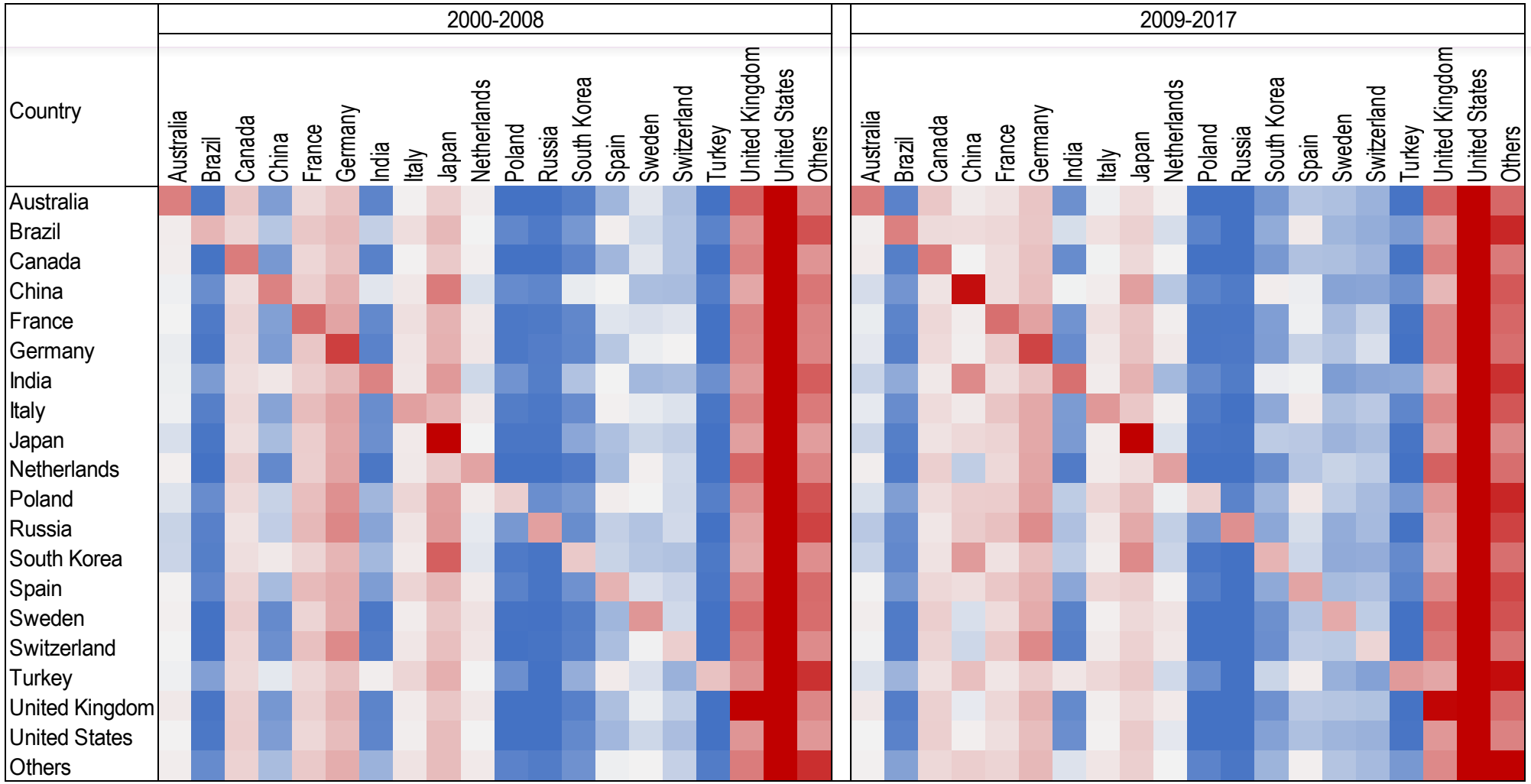
Self-citation at the continent level

Authors' continent	As a percentage of citations received						As a percentage of references made					
	Africa	Asia	Europe	North America	Oceania	South America	Africa	Asia	Europe	North America	Oceania	South America
Africa	25.2%	32.0%	23.4%	13.5%	2.3%	3.5%	23.5%	1.1%	0.8%	0.7%	0.8%	1.4%
Asia	1.2%	63.2%	19.0%	12.9%	1.7%	2.0%	26.2%	50.7%	15.3%	15.6%	14.9%	19.3%
Europe	0.9%	22.8%	51.1%	20.1%	2.8%	2.4%	29.2%	26.2%	58.7%	34.7%	34.5%	32.4%
North America	0.8%	25.0%	28.4%	40.8%	3.0%	2.2%	15.2%	17.8%	20.3%	43.8%	22.9%	18.5%
Oceania	1.0%	22.9%	30.0%	22.4%	21.3%	2.4%	3.0%	2.5%	3.3%	3.7%	25.3%	3.2%
South America	1.5%	24.9%	25.1%	15.1%	2.2%	31.2%	2.8%	1.7%	1.7%	1.5%	1.6%	25.2%

Self-references at the country level

Country	Australia	Brazil	Canada	China	France	Germany	India	Italy	Japan	Netherlands	Poland	Russia	South Korea	Spain	Sweden	Switzerland	Turkey	United Kingdom	United States	Others
Australia	9%	1%	5%	3%	3%	5%	1%	2%	4%	3%	0%	0%	1%	2%	2%	1%	0%	10%	38%	10%
Brazil	3%	9%	4%	4%	4%	5%	2%	3%	4%	2%	1%	0%	1%	3%	1%	1%	1%	7%	31%	13%
Canada	3%	1%	9%	3%	4%	5%	1%	2%	4%	3%	0%	0%	1%	2%	2%	1%	0%	8%	42%	9%
China	2%	1%	3%	15%	4%	5%	2%	3%	7%	2%	1%	0%	3%	2%	1%	1%	1%	6%	29%	11%
France	2%	1%	4%	3%	9%	7%	1%	3%	5%	3%	0%	0%	1%	2%	2%	2%	0%	8%	35%	10%
Germany	2%	1%	4%	3%	4%	12%	1%	3%	5%	3%	0%	0%	1%	2%	2%	2%	0%	8%	36%	9%
India	2%	1%	3%	8%	4%	5%	9%	3%	6%	1%	1%	1%	2%	2%	1%	1%	1%	6%	28%	13%
Italy	2%	1%	4%	3%	5%	6%	1%	7%	5%	3%	1%	0%	1%	3%	2%	2%	1%	8%	35%	11%
Japan	2%	1%	3%	4%	4%	6%	1%	3%	15%	2%	0%	0%	2%	2%	1%	2%	0%	7%	35%	8%
Netherlands	3%	0%	4%	2%	4%	7%	1%	3%	4%	7%	0%	0%	1%	2%	2%	2%	0%	10%	39%	10%
Poland	2%	1%	4%	4%	4%	7%	2%	4%	5%	2%	4%	1%	1%	3%	2%	2%	1%	7%	29%	13%
Russia	2%	1%	3%	5%	5%	8%	2%	3%	6%	2%	1%	8%	1%	2%	1%	2%	0%	6%	30%	12%
South Korea	2%	1%	3%	7%	3%	5%	2%	3%	8%	2%	0%	0%	6%	2%	1%	1%	1%	6%	35%	9%
Spain	2%	1%	4%	4%	5%	6%	1%	4%	4%	3%	1%	0%	1%	7%	2%	2%	1%	8%	33%	12%
Sweden	3%	0%	4%	2%	4%	6%	1%	3%	4%	3%	0%	0%	1%	2%	6%	2%	0%	10%	37%	11%
Switzerland	2%	1%	4%	2%	5%	8%	1%	3%	4%	3%	0%	0%	1%	2%	2%	4%	0%	9%	40%	9%
Turkey	2%	1%	3%	5%	3%	4%	3%	4%	5%	2%	1%	0%	2%	3%	1%	1%	7%	6%	28%	15%
United Kingdom	3%	1%	4%	2%	4%	6%	1%	3%	4%	3%	0%	0%	1%	2%	2%	2%	0%	15%	38%	10%
United States	2%	1%	4%	3%	4%	5%	1%	3%	5%	2%	0%	0%	1%	2%	1%	1%	0%	7%	48%	8%
Others	3%	1%	4%	4%	4%	6%	2%	3%	4%	2%	1%	0%	1%	3%	2%	2%	1%	8%	33%	15%

CHINA: FROM 9% - 15%



Helicopter science

- Scientists from wealthy nations visiting lower-income countries, collecting samples, publishing the results with little or no involvement from local scientists, and providing no benefit for the local community.
- Local researchers cannot decide the priority of international collaboration
- Less recognized conditioned on the scientific performance

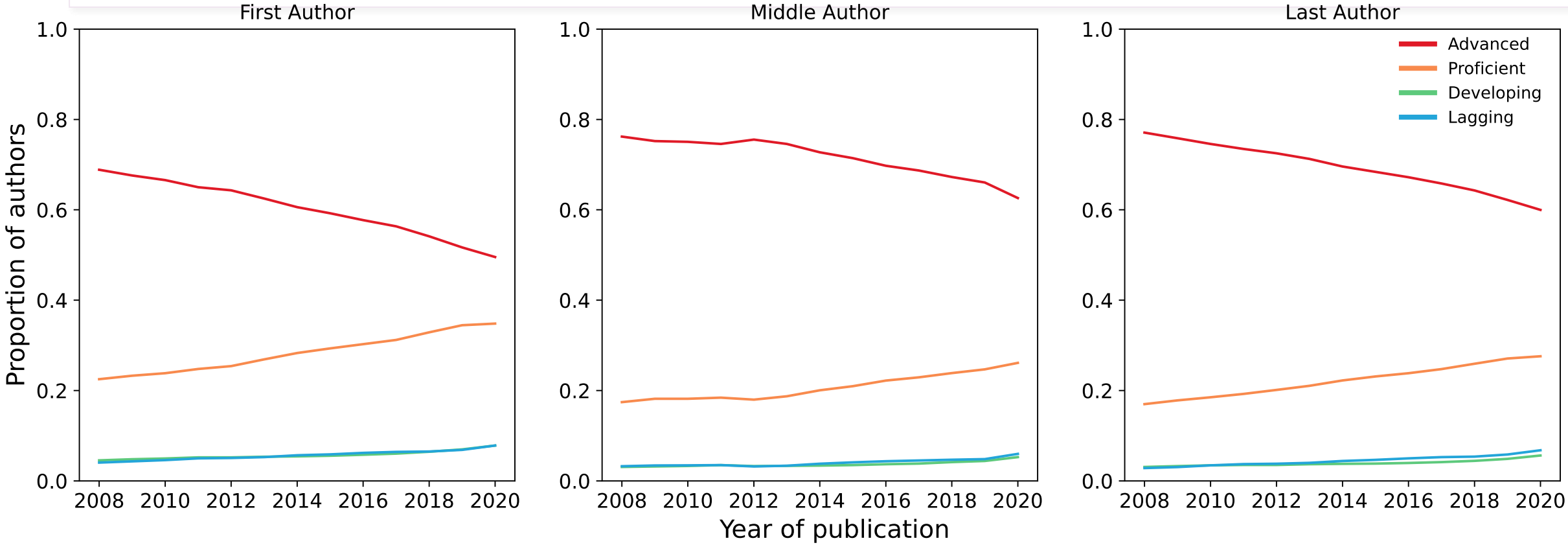
Correspondence | Published: 15 April 2021

Open letter to international funders of science and development in Africa

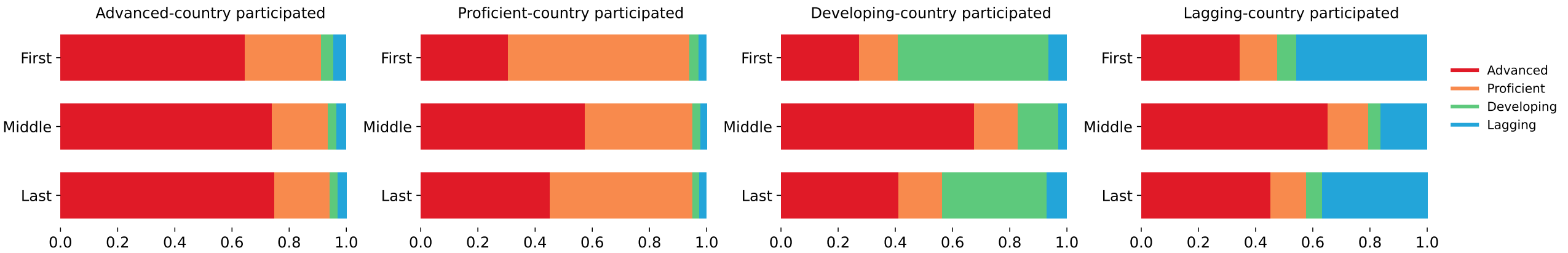
Ngozi A. Erondu ✉, Ifeyinwa Aniebo, Catherine Kyobutungi, Janet Midega, Emelda Okiro & Fredros Okumu

Nature Medicine **27**, 742–744 (2021) | Cite this article

Authorship distribution

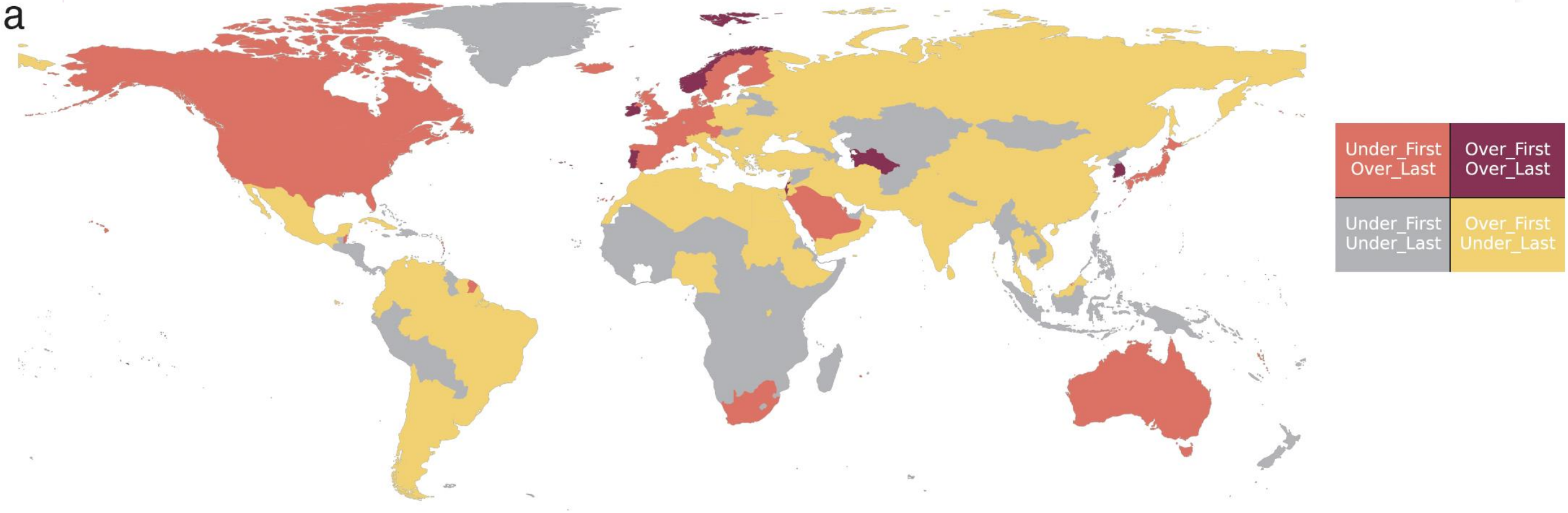


Conditional authorship distribution

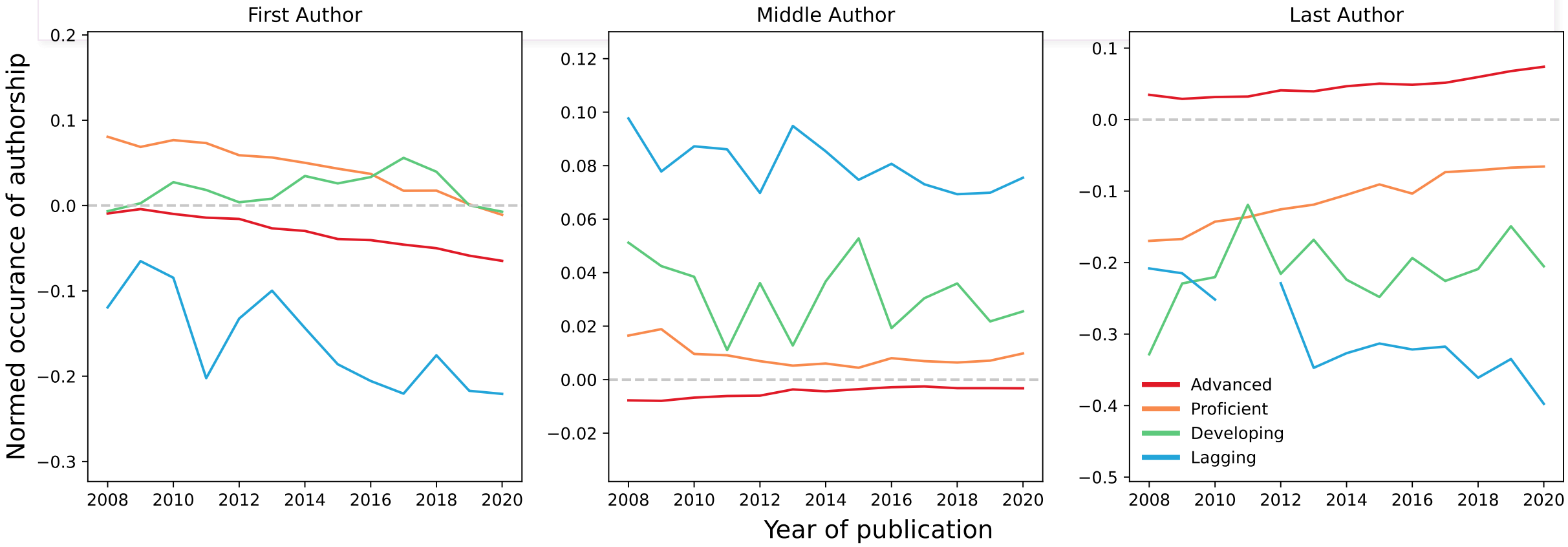


Hierarchical structure in authorship

a



Hierarchical structure in authorship



Researchers from non-advanced countries are disadvantaged in being the last author

Variables	(1) First Author		(2) Last Author	
Model	Conditional logit	Linear fixed	Conditional logit	Linear fixed
Male	-0.23***	-0.02***	0.22***	0.02***
	(0.02)	（0.002）	(0.03)	(0.001)
Log(Num_pub)	-0.21***	-0.02***	0.50***	0.04***
	(0.008)	（0.0008）	(0.01)	(0.0003)
Lagging	0.41***	0.05***	-0.21***	-0.03***
	(0.02)	(0.001)	(0.02)	0.001
R^2		0.017		0.05
Observations	407707	407707	40770	40770

Researchers from non-advanced countries are disadvantaged in being the last author even if they are funded

Variables	(1) First Author		(2) Last Author	
Male	-0.20***	-0.20***	0.25***	0.25***
	(0.01)	(0.01)	(0.01)	(0.01)
Log(Num_pub)	-0.18***	-0.18***	0.47***	0.48***
	(0.003)	(0.003)	(0.004)	(0.004)
Lagging	0.61***	0.43***	-0.45***	-0.38***
	(0.01)	(0.03)	(0.01)	0.02
Funded	1.10***	0.93***	0.37***	0.42***
	(0.01)	(0.02)	(0.01)	(0.02)
Lagging*Funded		0.34***		-0.13***
		(0.05)		(0.05)
Observations	414000	414000	414000	414000

MOBILITY

The motivation

"Mobility—and in particular international mobility—of skilled human resources plays an important role in innovation. It contributes to the creation and diffusion of knowledge, particularly tacit knowledge, which is more effectively shared within a common social and geographical context." --OECD (2010)

EXTANT DATA
(EUROSTAT, OECD, NSF, ETC.)

THE PROBLEM (OECD, 2008)

The construction of internationally comparable mobility indicators for the scientific workforce is a persistent policy need.

Quantitative evidence on the impact of mobility patterns is not readily available.
(OECD, 2008)

- *Stock*, rather than *flow*
- Aggregate, rather than individual
- Does not account for short-term stays
- Delays in reporting
- Idiosyncratic practices
- Response bias
- Conceptualization of “highly skilled”

BIBLIOMETRIC APPROACHES TO MOBILITY (2008-PRESENT)

WEB OF SCIENCE™

Scientists have most impact when they're free to move

By: Sugimoto, CR (Sugimoto, Cassidy R.)[1,2]; Robinson-Garcia, N (Robinson-Garcia, Nicolas); Murray, DS (Murray, Dakota S.); Yegros-Yegros, A (Yegros-Yegros, Alfredo); Costas, R (Costas, Rodrigo); Lariviere, V (Lariviere, Vincent)

View ResearcherID and ORCID

NATURE
Volume: 550 **Issue:** 7674 **Pages:** 29-31
DOI: 10.1038/550029a
Published: OCT 5 2017
Document Type: Editorial Material
View Journal Impact

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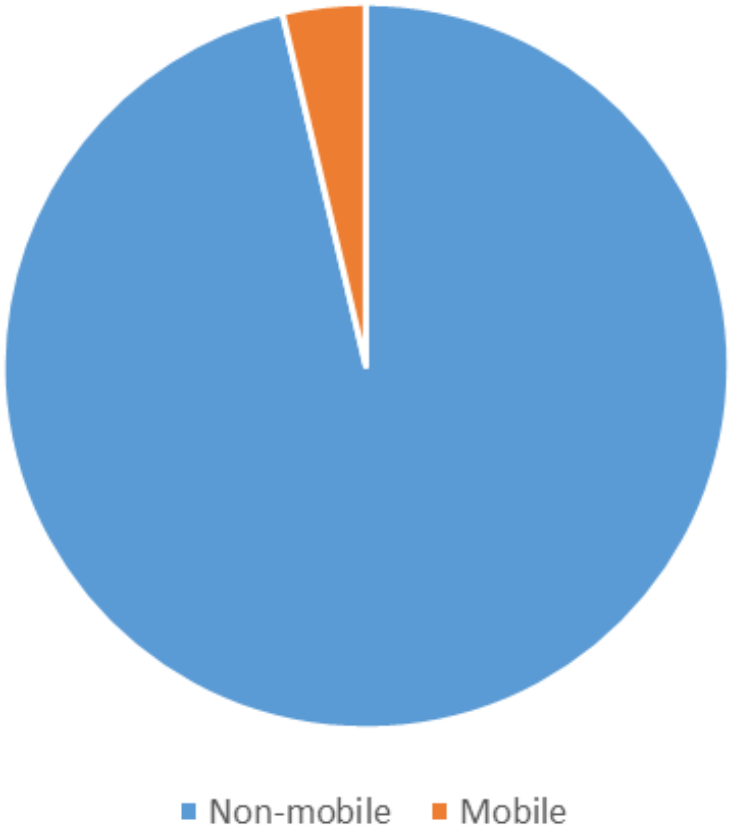
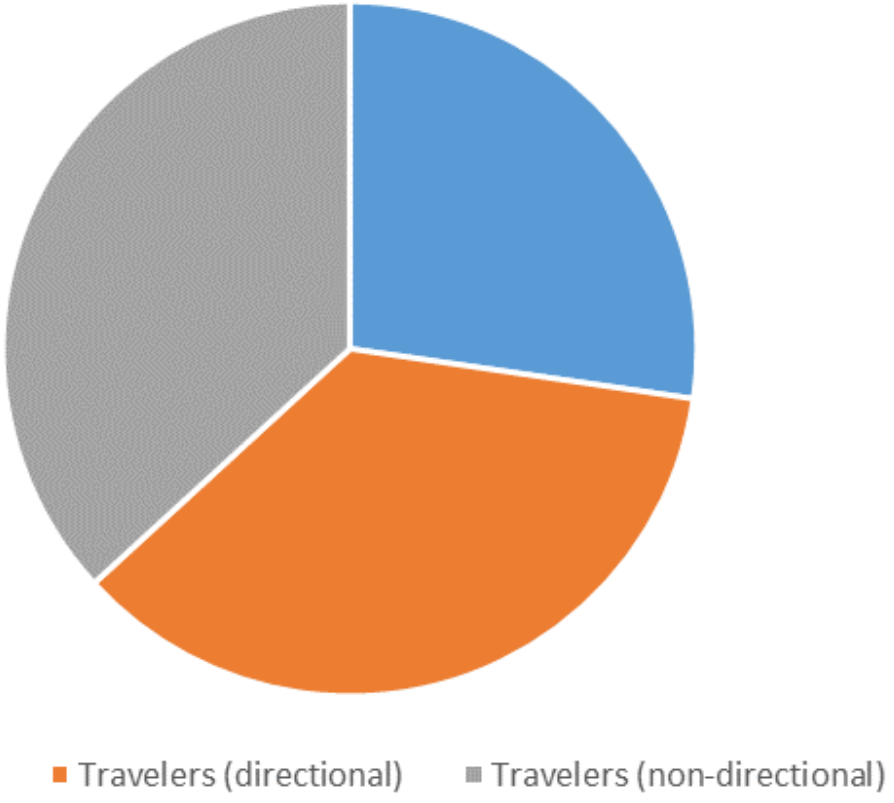
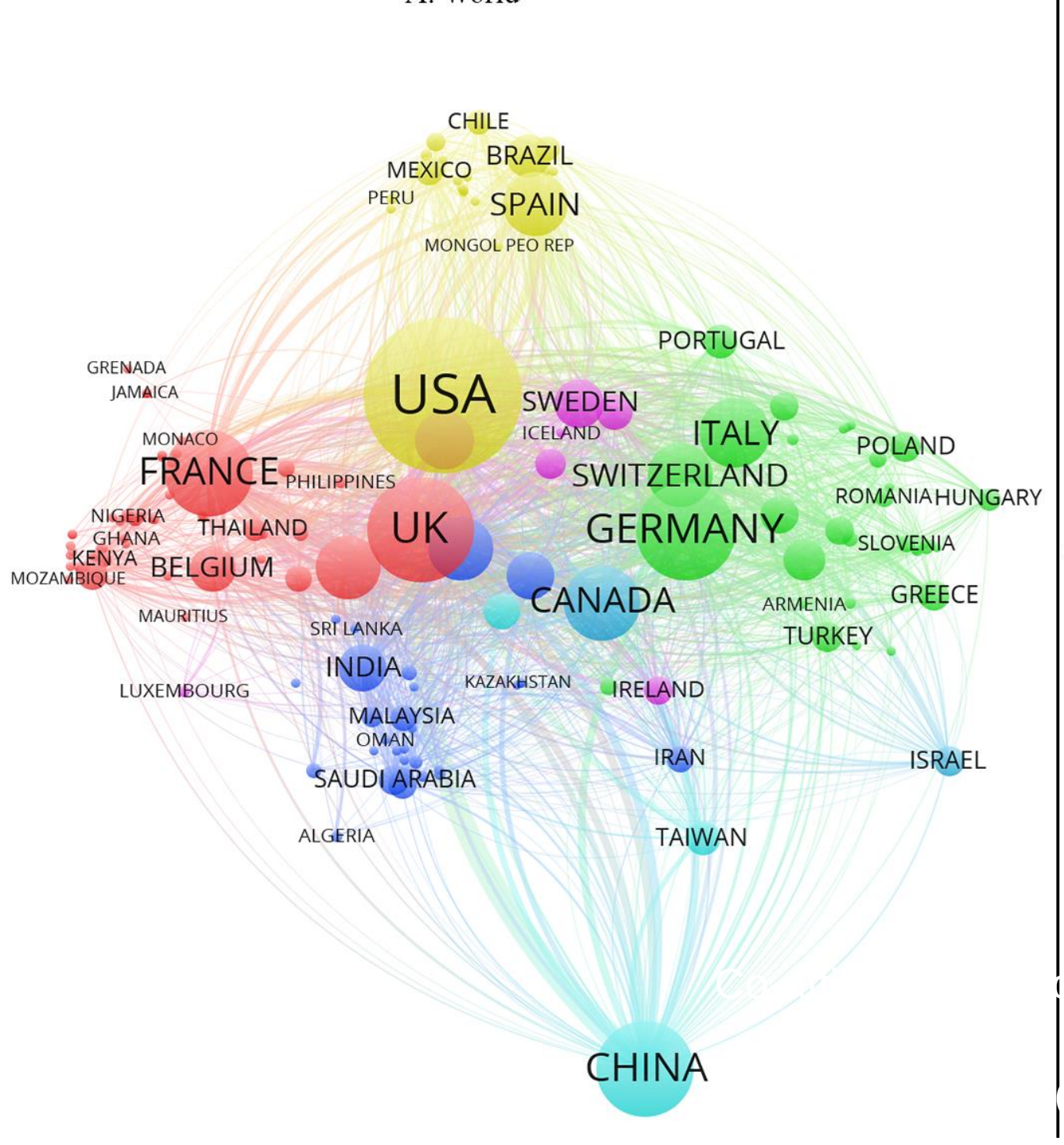
CWTS
Meaningful metrics

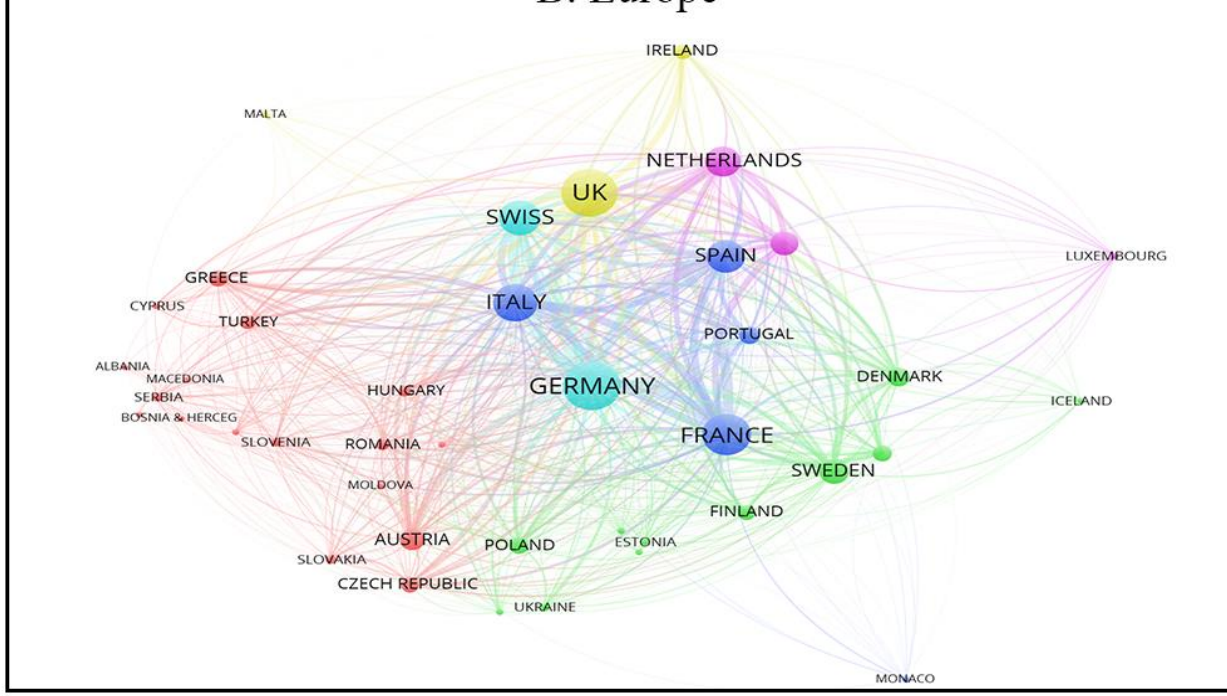
Mobility types (2008-2015)



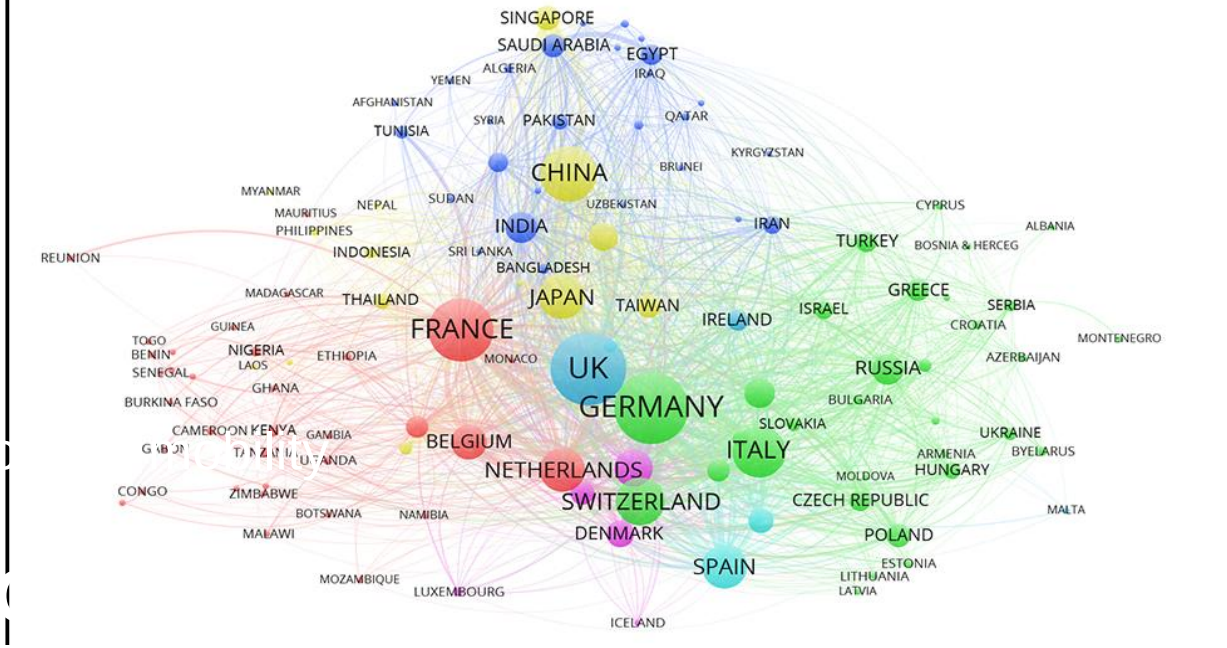




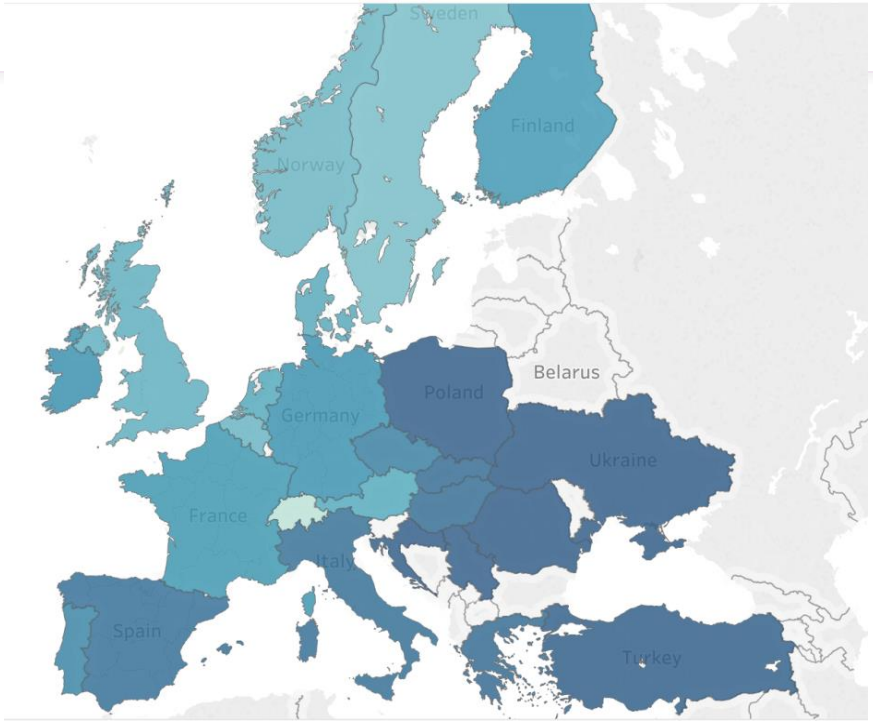
B. Europe



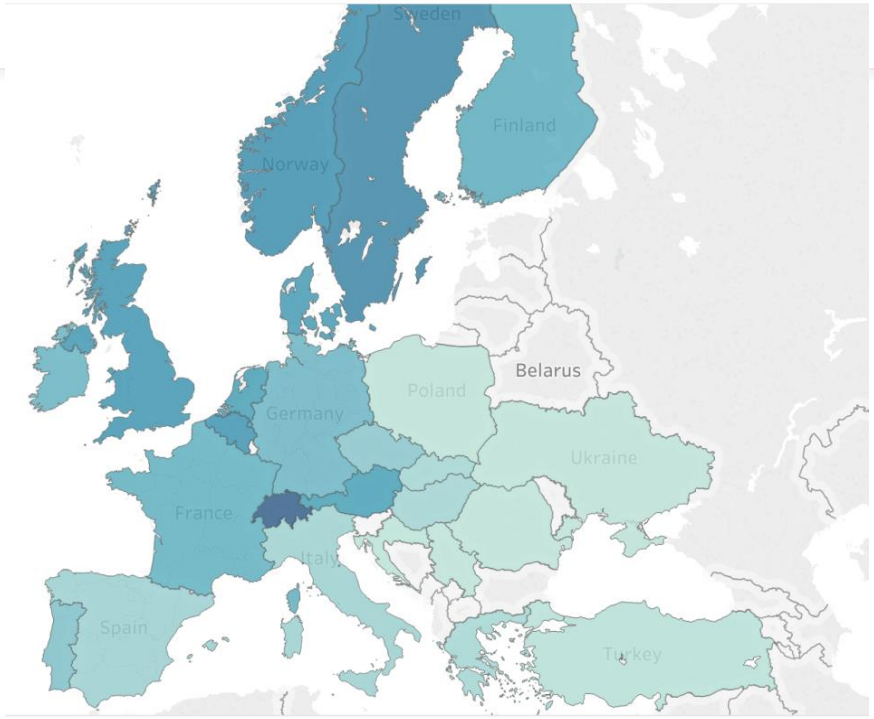
C.Africa, Asia, Europe, and Middle East



Normalized share of migration

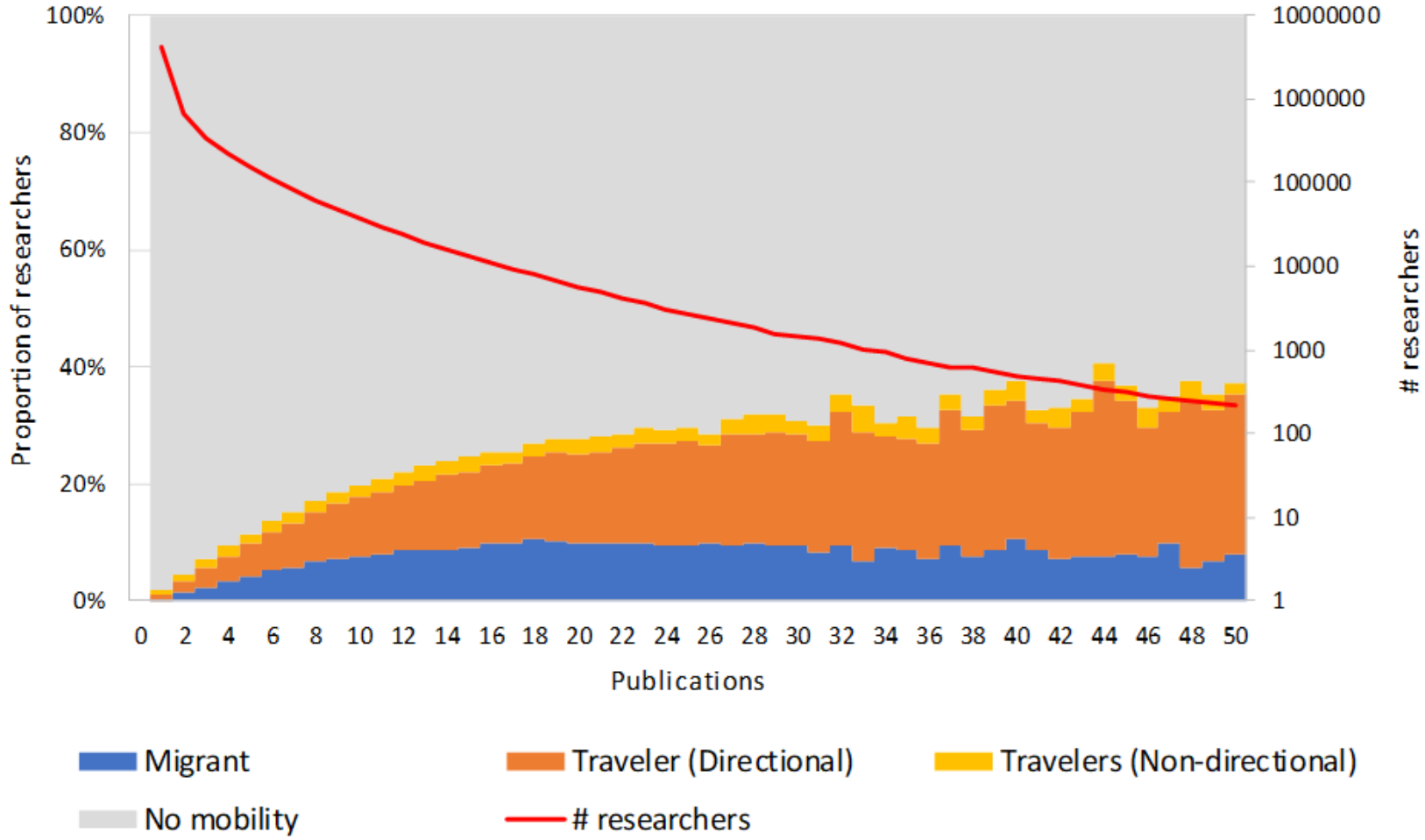


Sending Countries



Receiving Countries

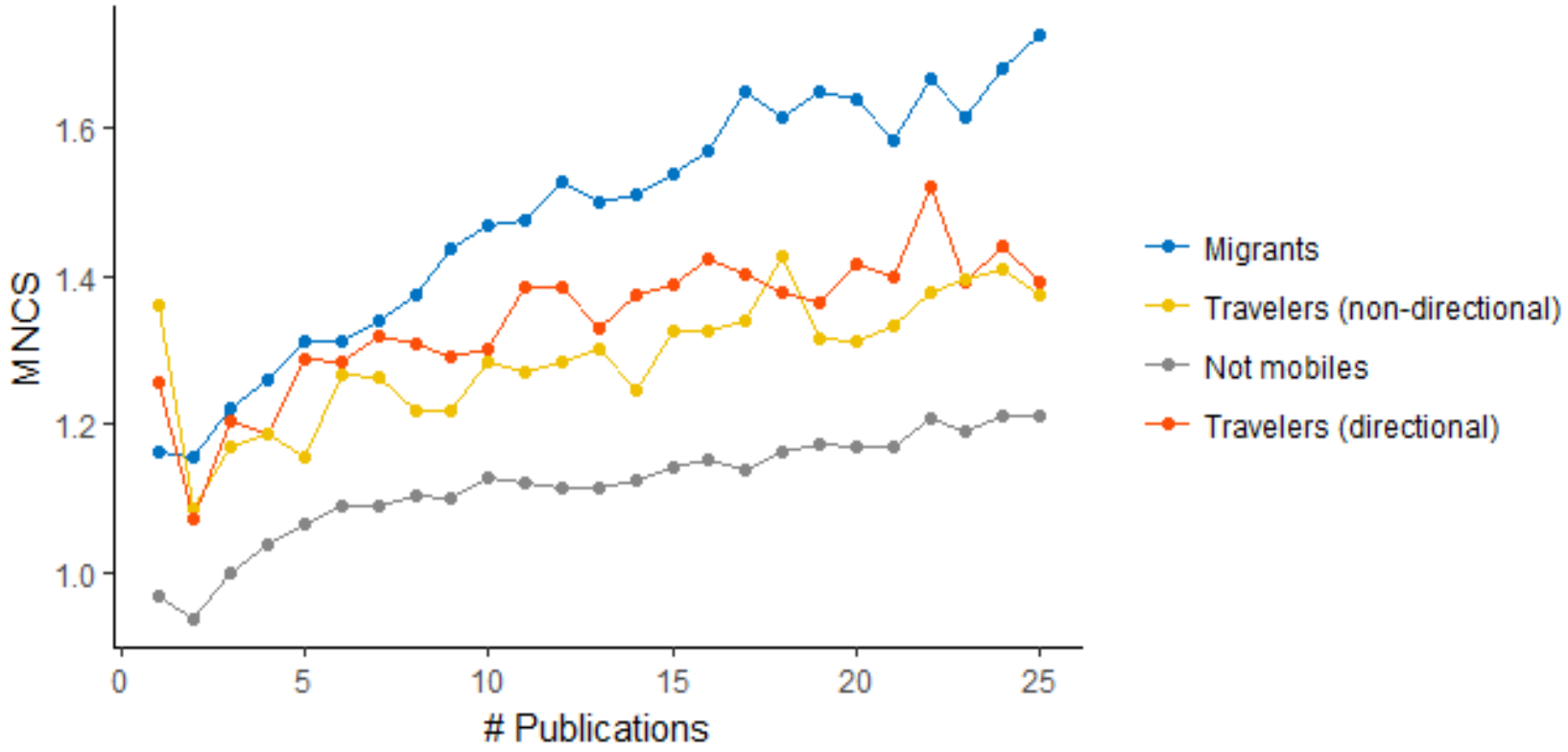
Production advance in mobility



Proportion of researchers by number of publications (left axis) and number of researchers in logarithmic scale by number of publications (right axis)

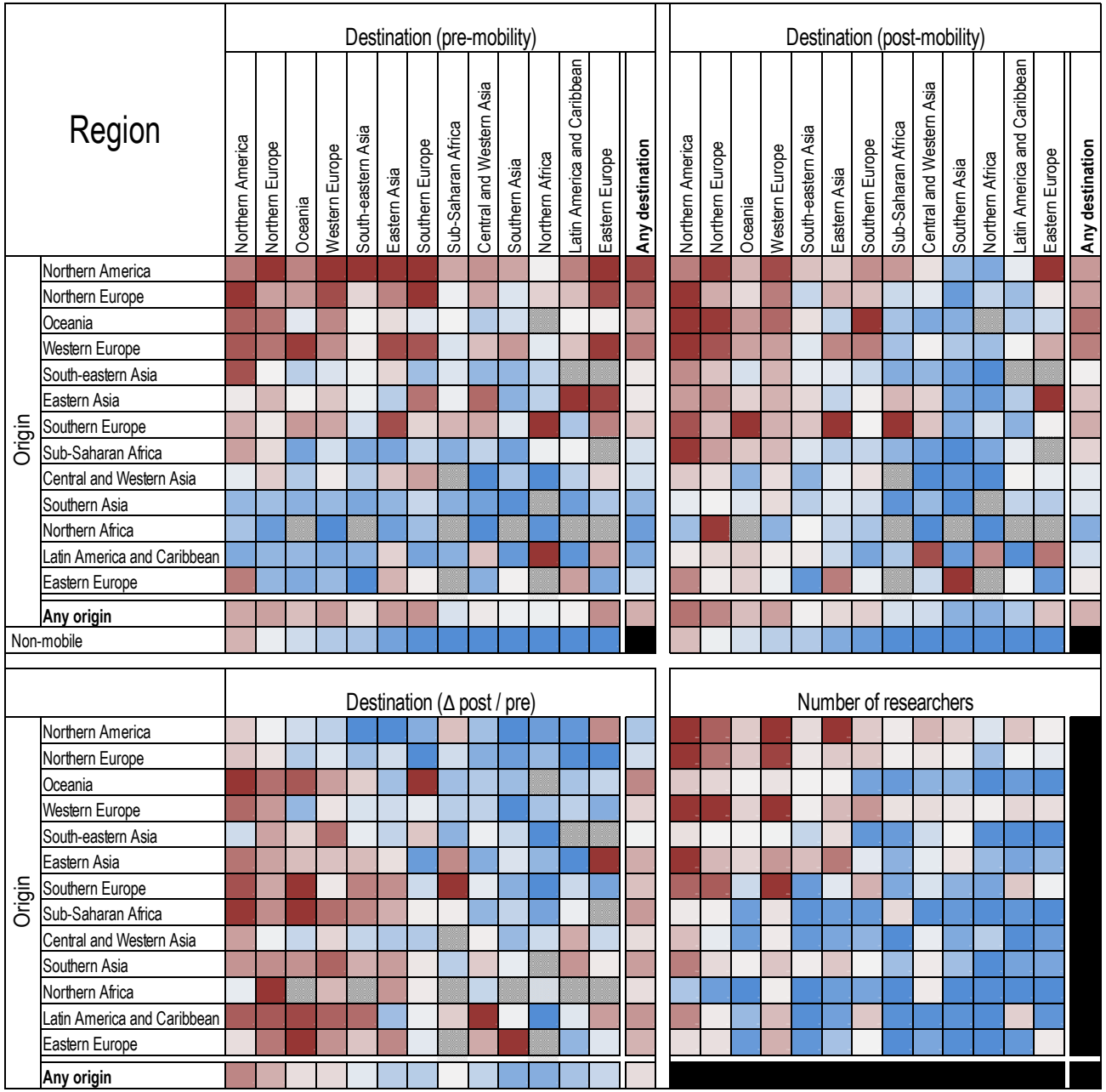
Citation advantages of mobility

MNCS values at the researcher level by mobility type controlling by number of publications



Exchange matrix

Average MNCS for individuals by region of origin and region of destination, and for non-migrants

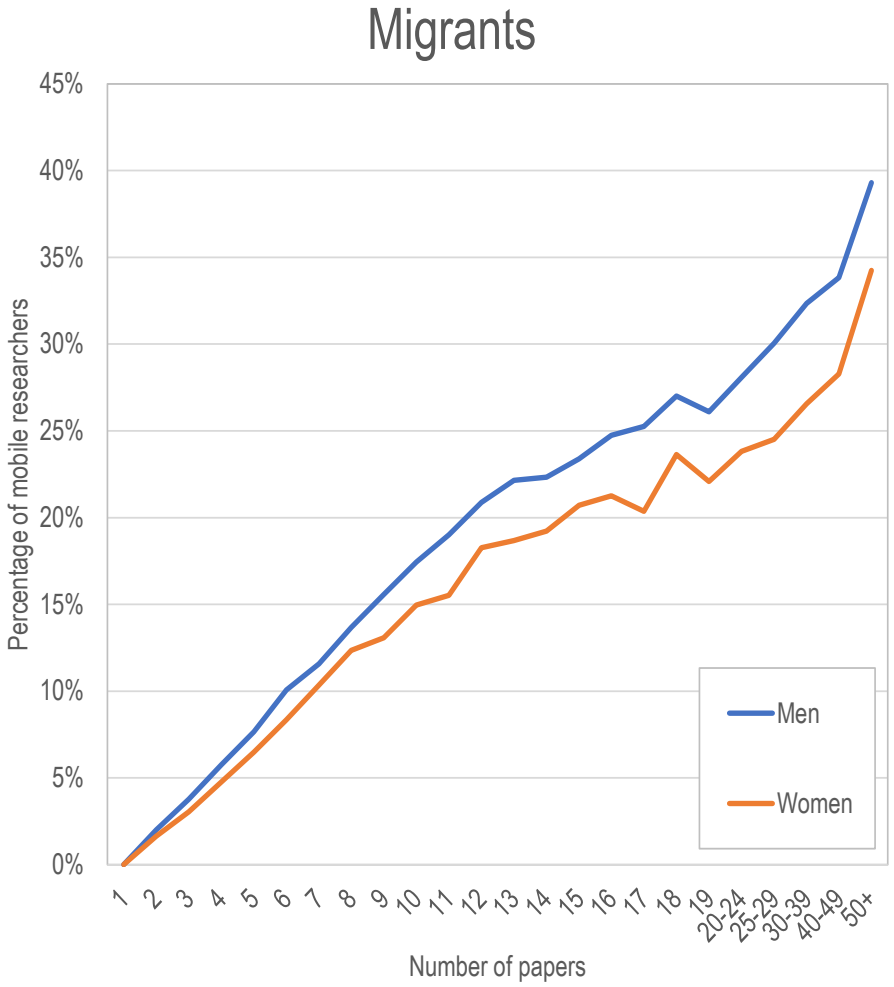


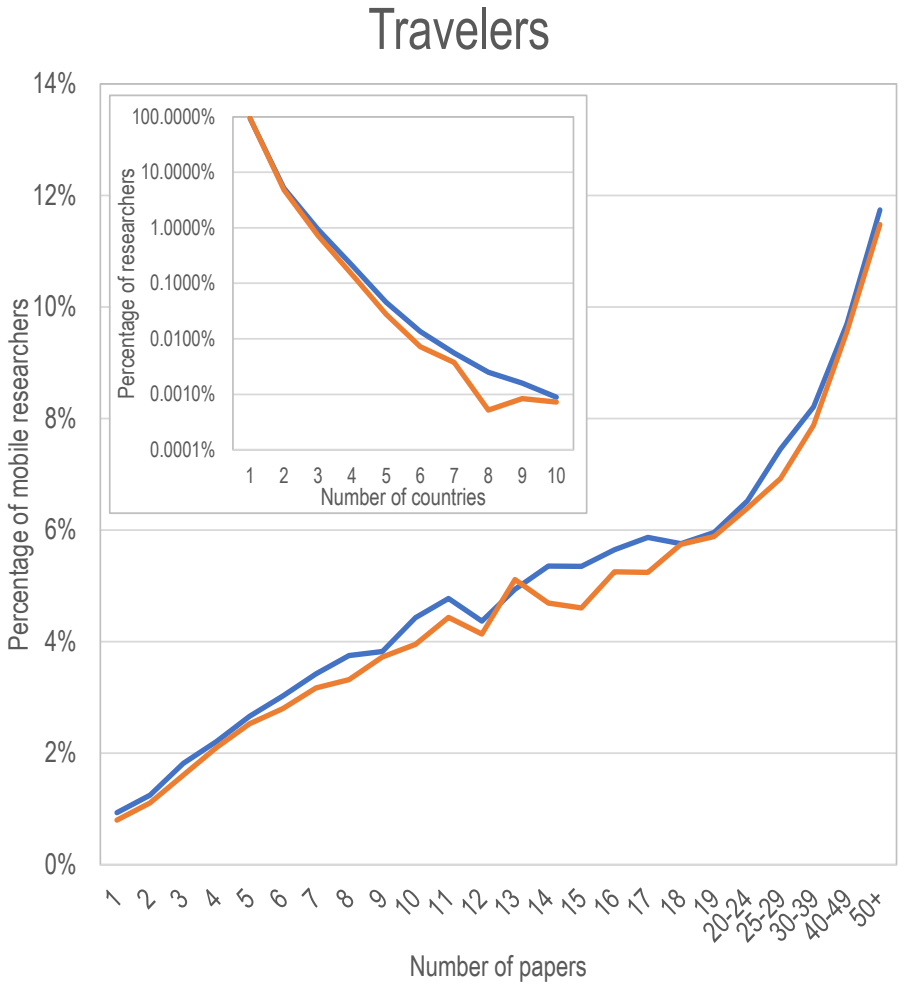
Gendered mobility in the late 1800s

“We were told that the only reason women wanted a university education was to make trouble for the government. If foreign governments did not object, that was all right, but Germany had more sense.”

–Alice Hamilton

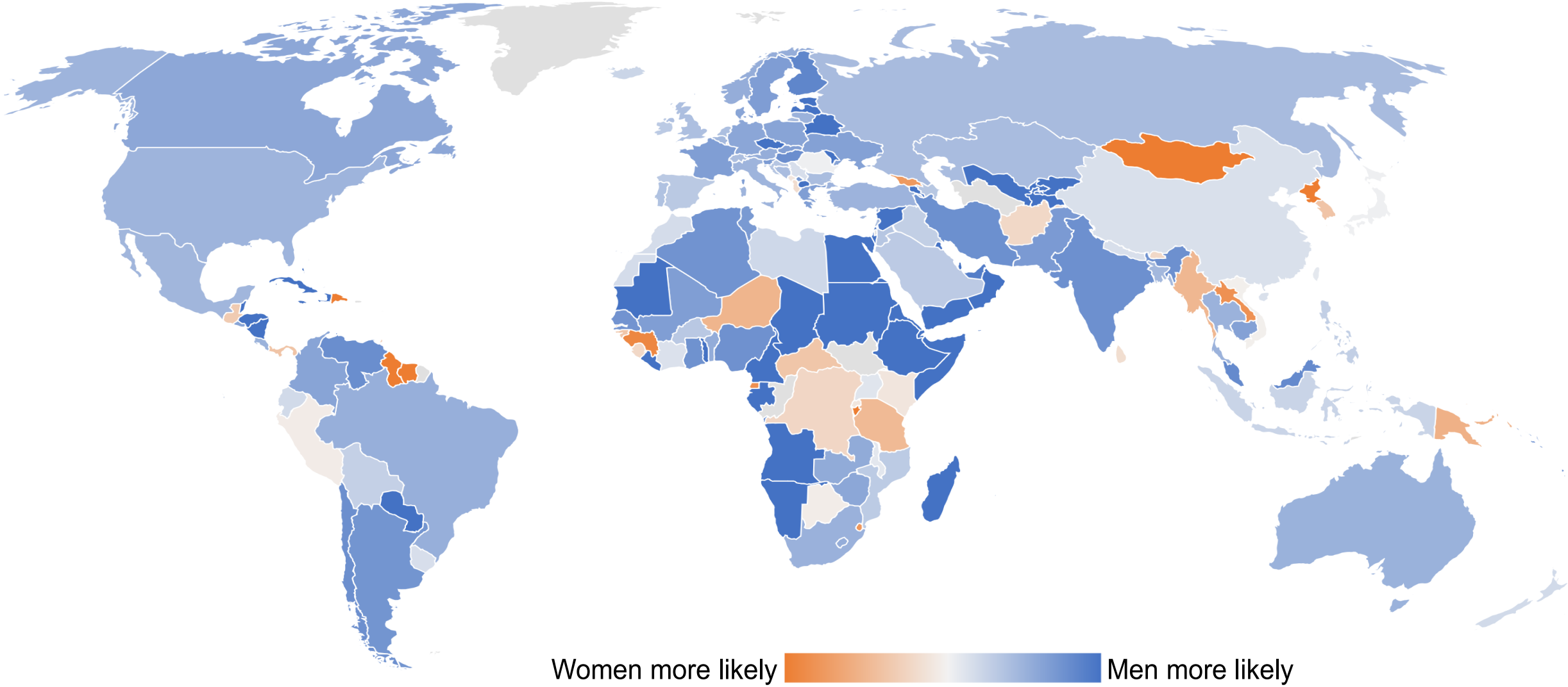
Gender differences in mobilitv





- First paper between 2008-2010
- 6.1% international mobility
- 61.3% of researchers had a single paper; 82.1% have ≤ 5
- Travelers: 1.7% of women; 1.9% of men
- Migrants: 4.0% for women; 4.5% for men

Country differences in mobility



Region of destination

Region of origin \ Region of Destination	Northern Europe	Western Europe	Southern Europe	Australia and New Zealand	Northern America	South-eastern Asia	Eastern Europe	Sub-Saharan Africa	Latin America and the Caribbean	Eastern Asia	Western Asia	Northern Africa	Southern Asia
Northern Europe	82%	95%	90%	83%	96%	95%	91%	94%	108%	187%	154%	200%	198%
Western Europe	87%	101%	84%	83%	101%	100%	71%	94%	94%	164%	166%	93%	199%
Southern Europe	91%	99%	87%	109%	97%	146%	104%	184%	111%	158%	161%	125%	312%
Australia and New Zealand	81%	96%	106%	92%	89%	88%	149%	86%	86%	160%	185%	88%	167%
Northern America	86%	89%	66%	76%	88%	86%	84%	70%	78%	131%	140%	151%	158%
South-eastern Asia	72%	68%	98%	80%	89%	88%	139%	143%	97%	105%	310%	285%	194%
Eastern Europe	101%	104%	76%	64%	102%	57%	90%	129%	135%	109%	174%	270%	418%
Sub-Saharan Africa	86%	89%	113%	93%	78%	108%	183%	145%	128%	119%	127%	107%	146%
Latin America and the Caribbean	101%	98%	100%	86%	94%	151%	127%	86%	109%	198%	121%	522%	308%
Eastern Asia	104%	106%	107%	111%	96%	87%	85%	102%	96%	95%	201%	139%	179%
Western Asia	72%	83%	97%	124%	88%	233%	70%	131%	134%	215%	169%	127%	200%
Northern Africa	106%	57%	78%	126%	151%	135%	225%	130%	361%	302%	130%	113%	84%
Southern Asia	96%	93%	80%	83%	86%	116%	90%	123%	95%	142%	150%	335%	156%

FUNDING

The Problem with Studying Funding

Danmarks Grundforskningsfond
Danish National Research Foundation

NSERC CRSNG

EPSRC
Engineering and Physical S
Research Council

SSHRC CRSH
Social Sciences and Humanities Research Council of Canada
Conseil de recherches en sciences humaines du Canada

wellcome

BILL & MELINDA GATES foundation

erc European Research Council

NIH

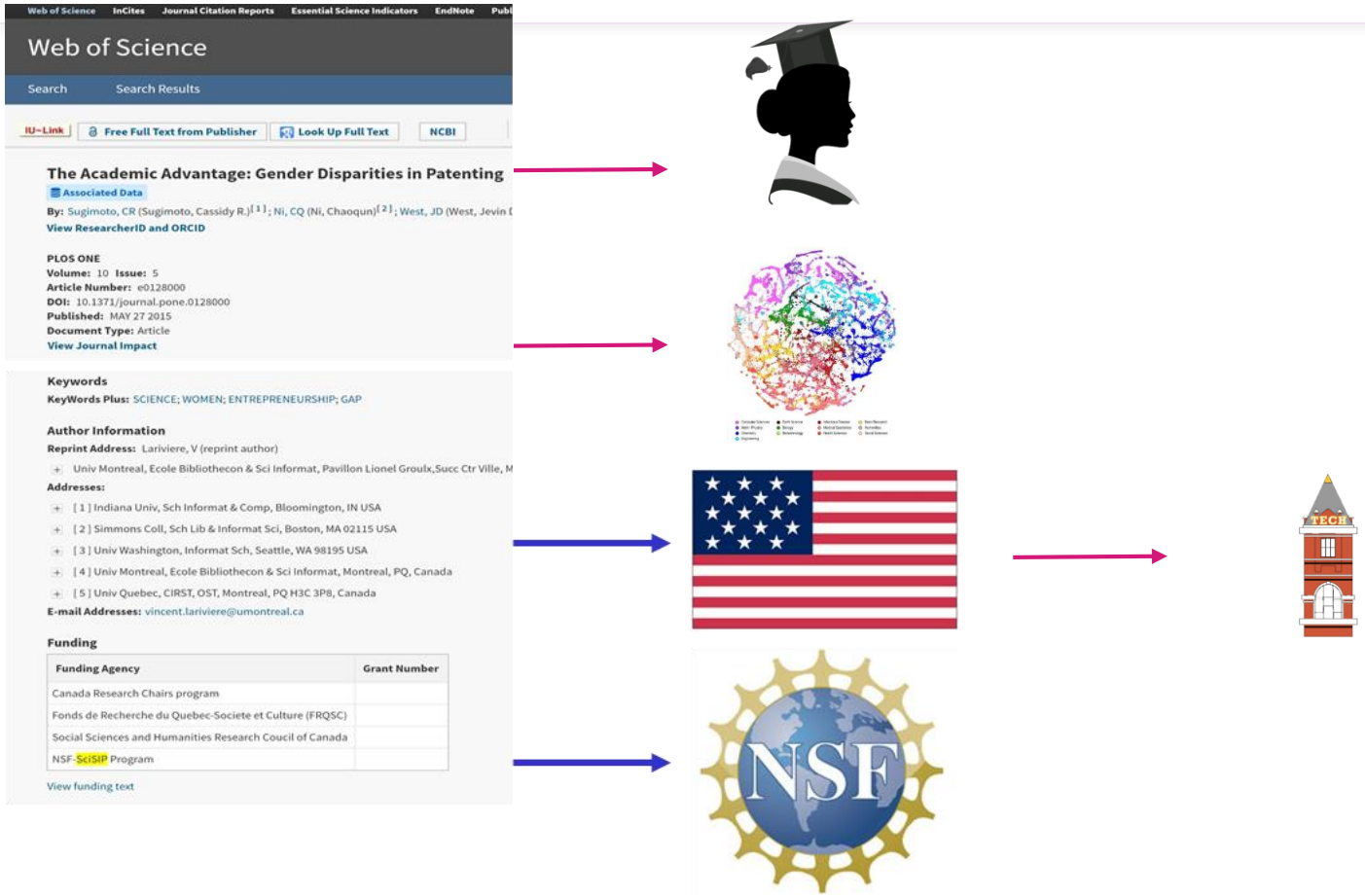
CIHR IRSC

NSF

MRC Medical Research Council

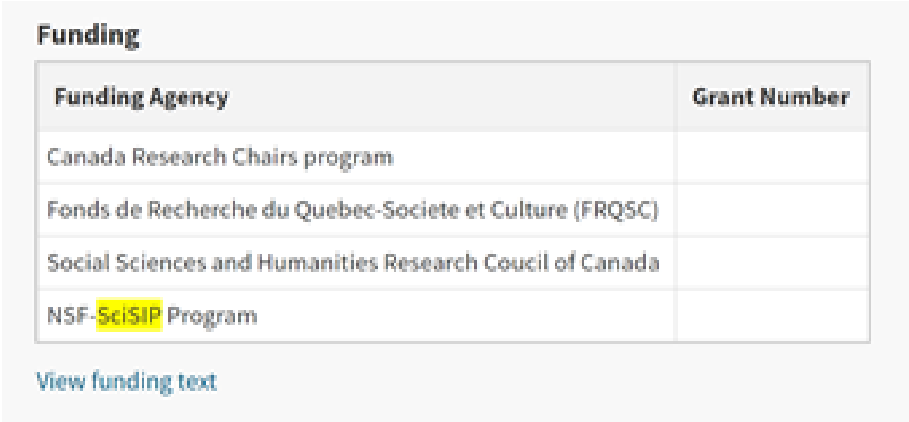
E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

Deriving funding from bibliometric sources



The Method: Extracting funders

754,539 distinct strings



Funding

Funding Agency	Grant Number
Canada Research Chairs program	
Fonds de Recherche du Quebec-Societe et Culture (FRQSC)	
Social Sciences and Humanities Research Coucil of Canada	
NSF-SciSIP Program	

View funding text

- NIH
- National Institutes of Health (NIH)
- National Cancer Institute of the NIH
- National Institute of Neurological Disorders and Stroke of the NIH
- NIH/NCATS Clinical and Translational Science Award
- NIH (Pediatric Heart Network)
- NIH from the NIDDK

2009

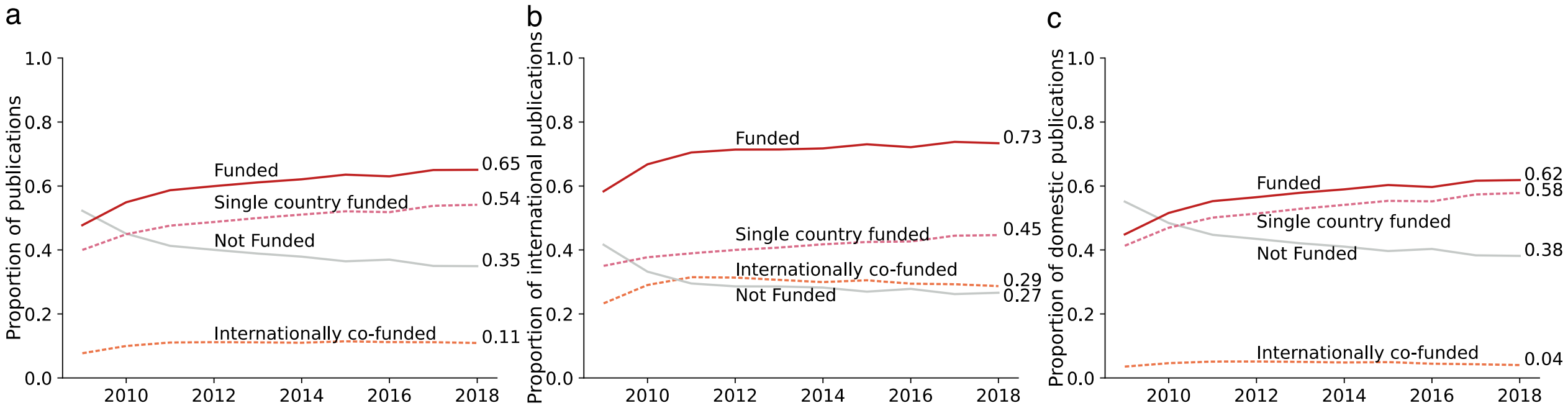
2018

12,241

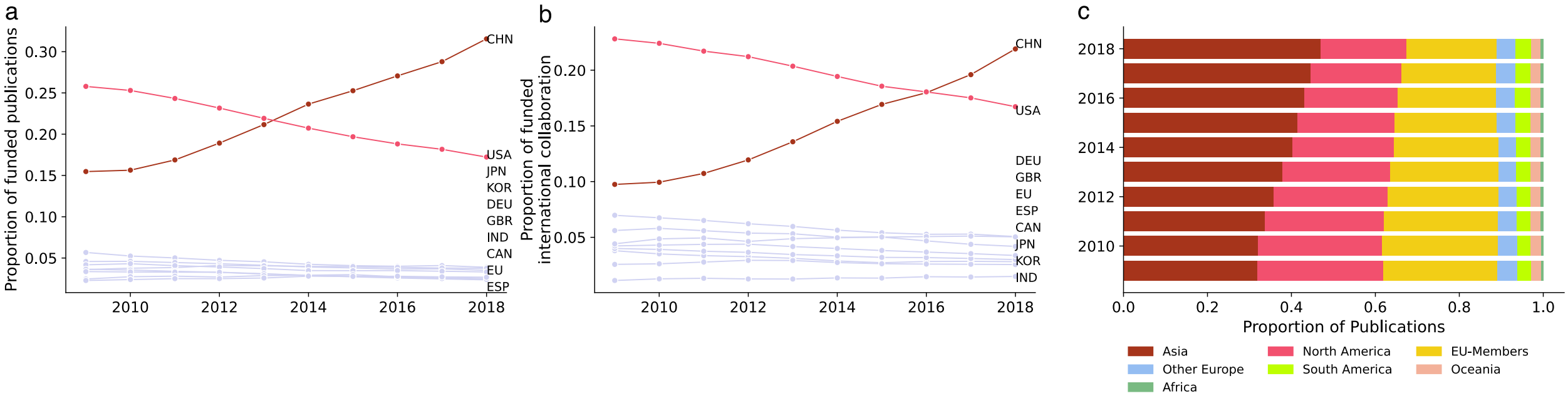
Country-funder strings and # of papers

Country	Number of funder strings	Number of papers
USA	169,885	5,734,714
PEOPLES-R-CHINA	156,624	6,725,029
GERMANY	29,109	829,099
SPAIN	28,922	792,460
ENGLAND	27,360	885,574
CANADA	25,025	722,574
FRANCE	24,128	502,738
JAPAN	23,136	931,328
SOUTH-KOREA	22,158	648,276
AUSTRALIA	19,476	484,922
EU	18,509	606,310
ITALY	15,702	261,725
BRAZIL	15,356	597,210
INDIA	13,778	366,075
SWEDEN	12,318	322,049
NETHERLANDS	11,400	213,796
BELGIUM	8,215	181,734
SWITZERLAND	7,956	266,750
TAIWAN	7,110	321,086
DENMARK	7,021	158,181

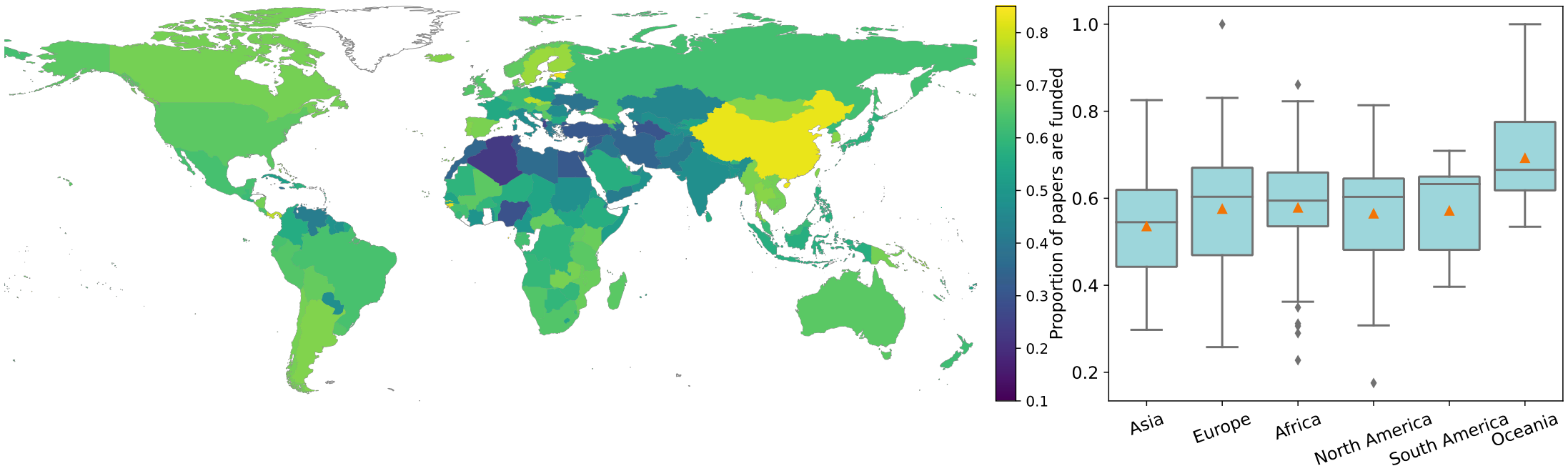
How is global science funded?



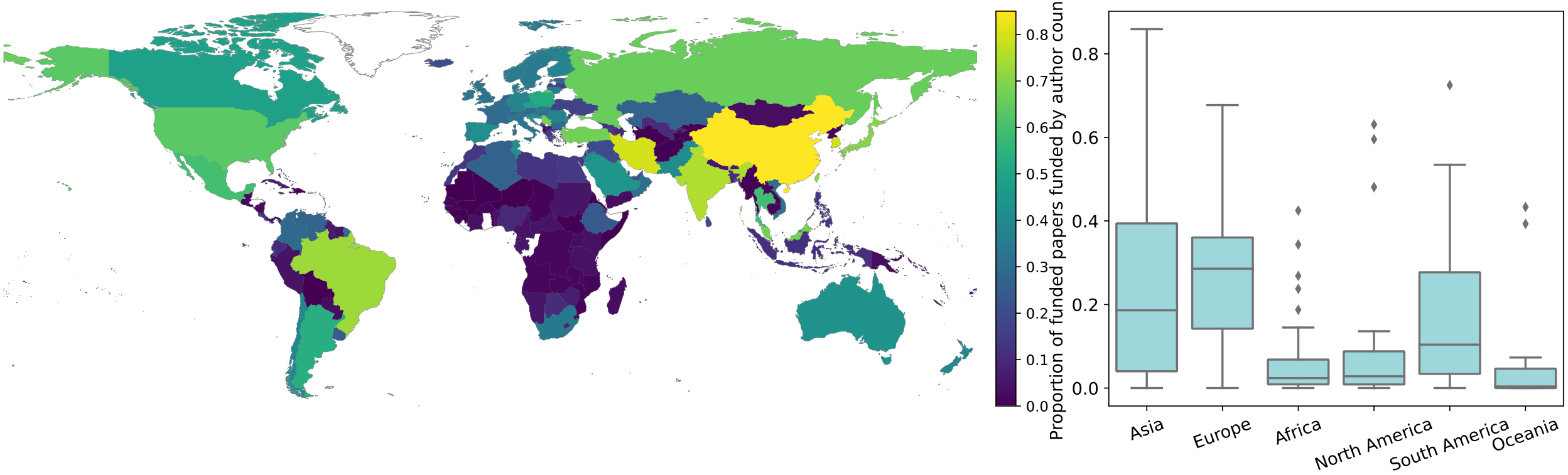
Which countries are funding global science?



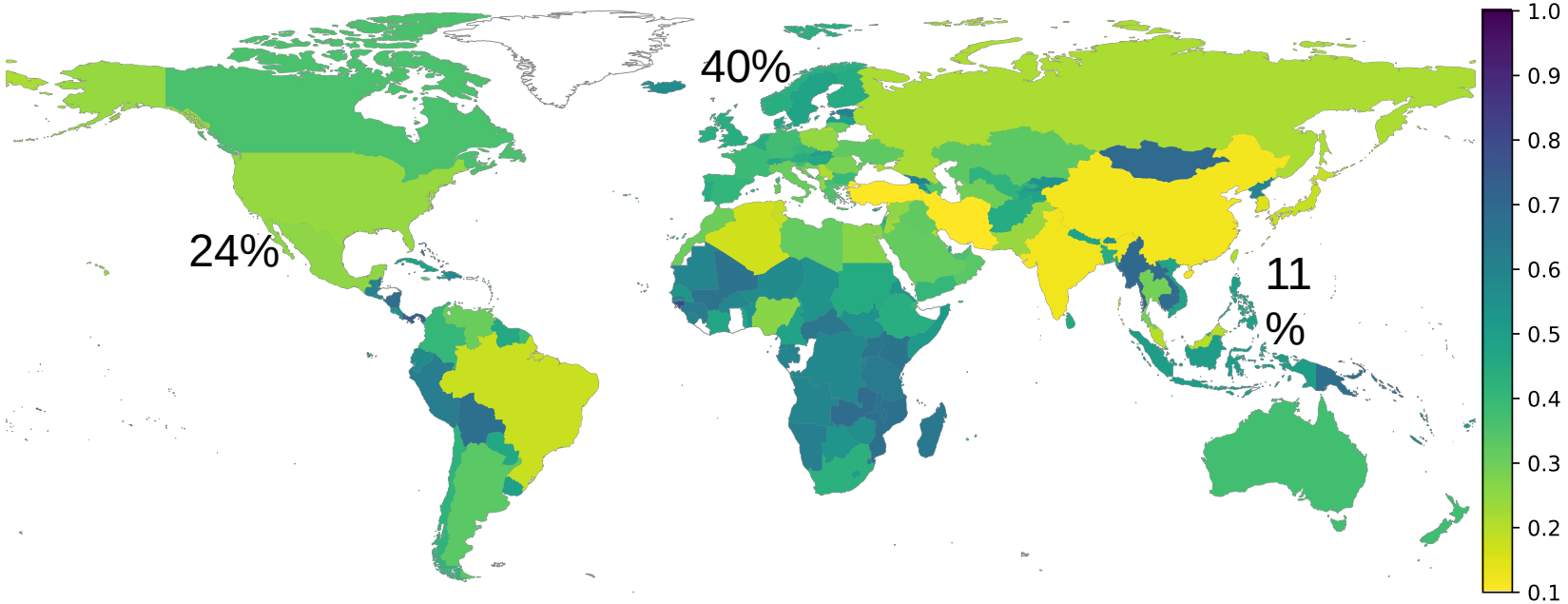
Funding intensity across countries

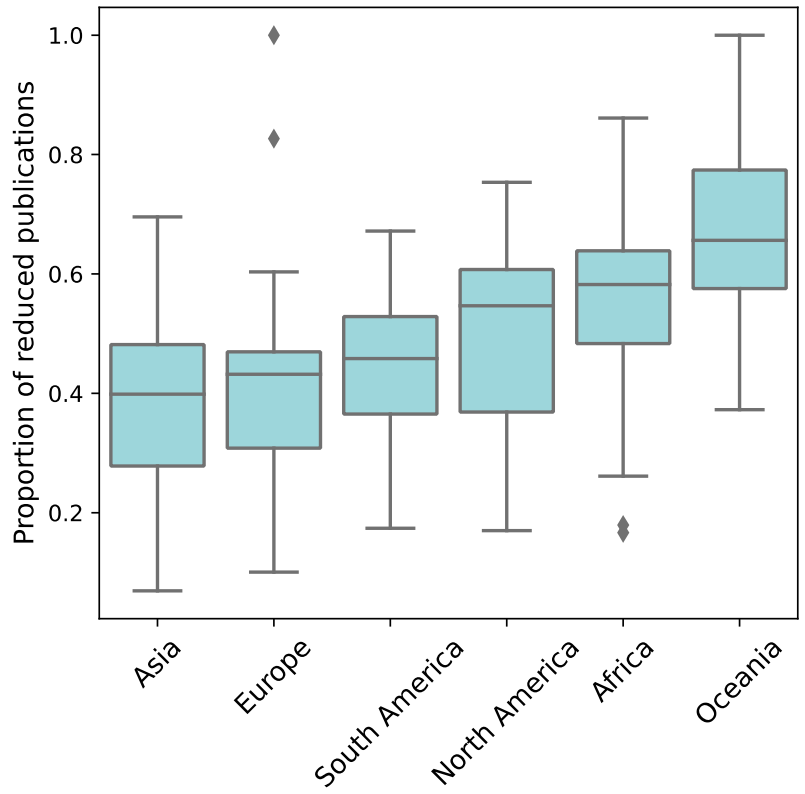


Exclusively funded by authorship country

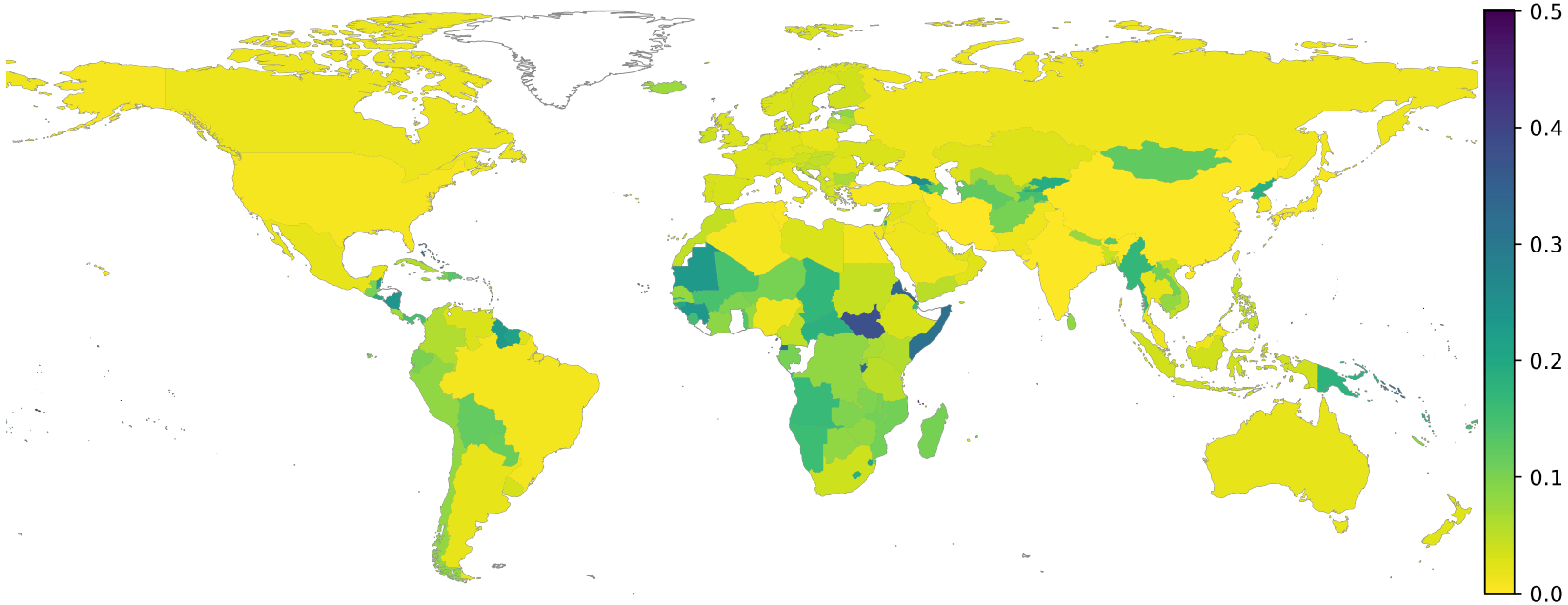


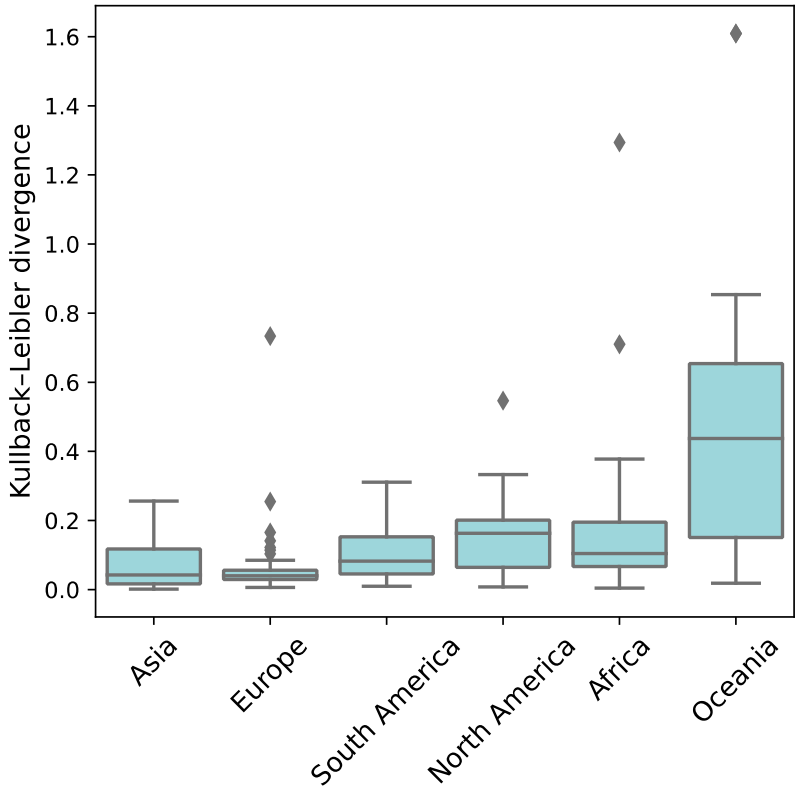
Publication reduction





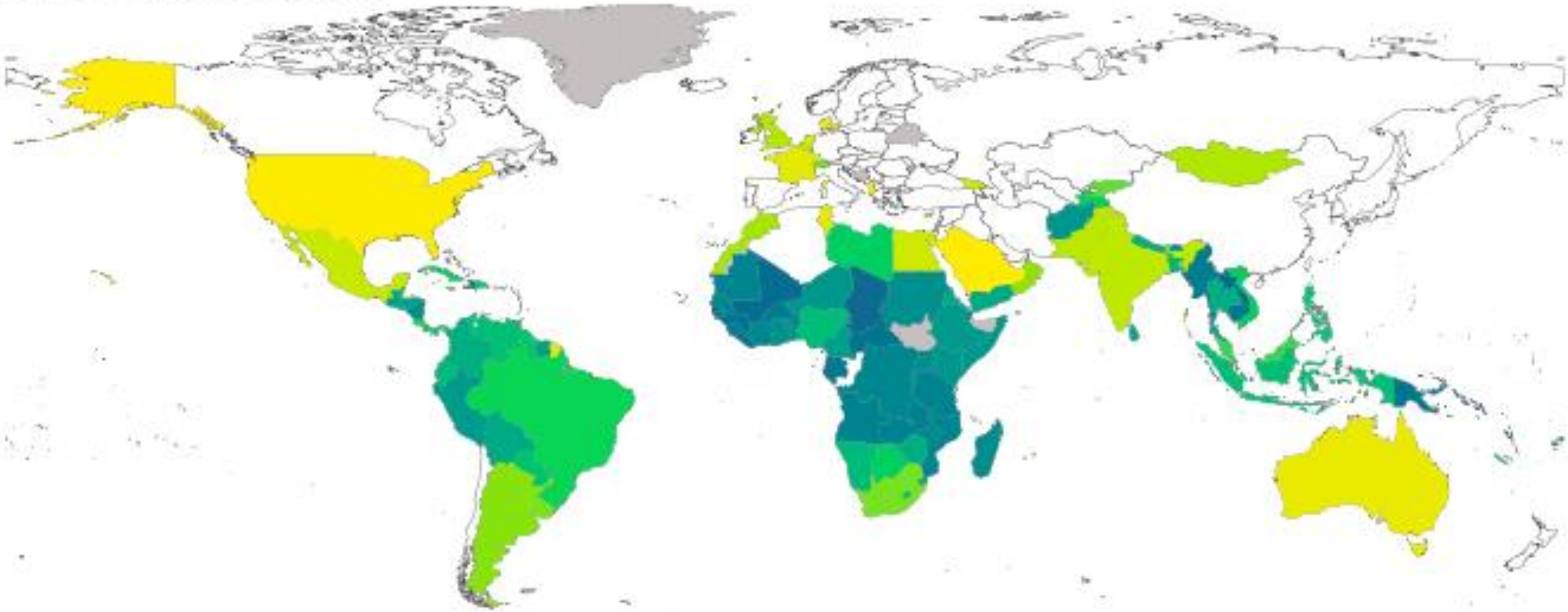
Change of portfolio



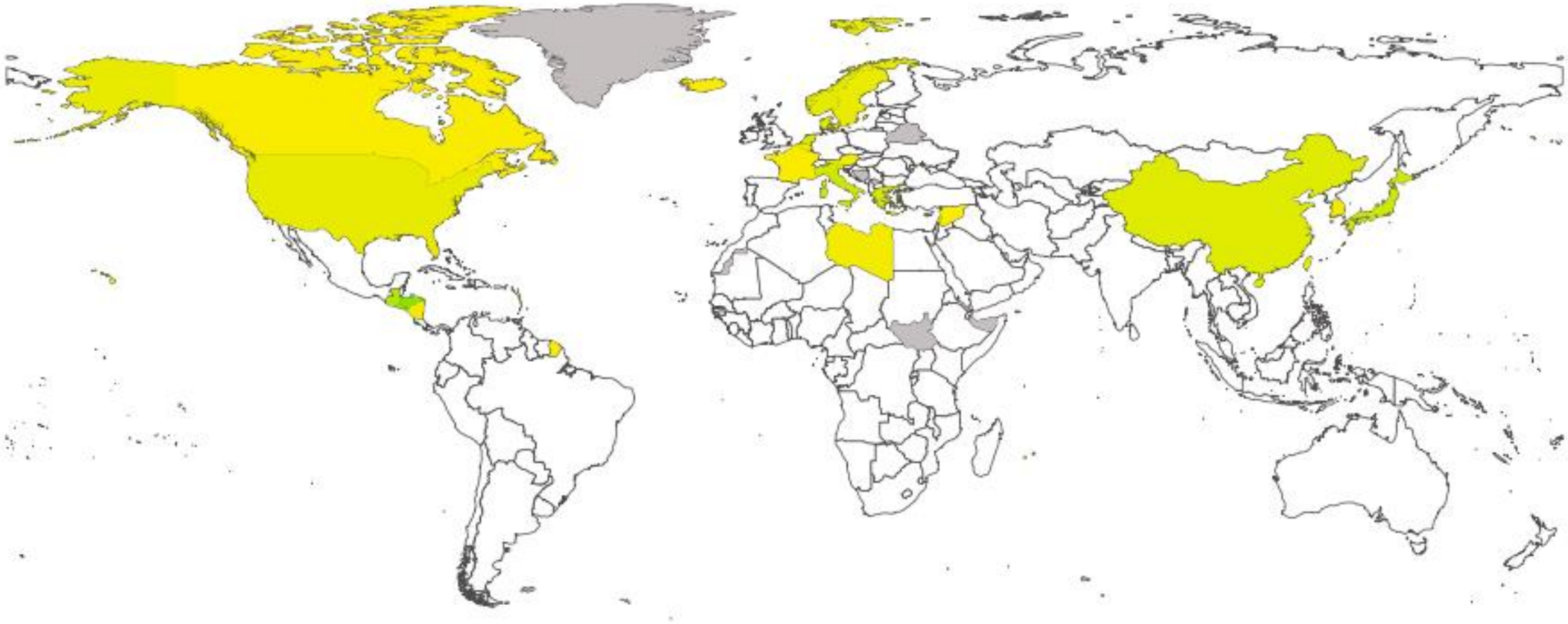


EPISTEMIC CONSEQUENCES

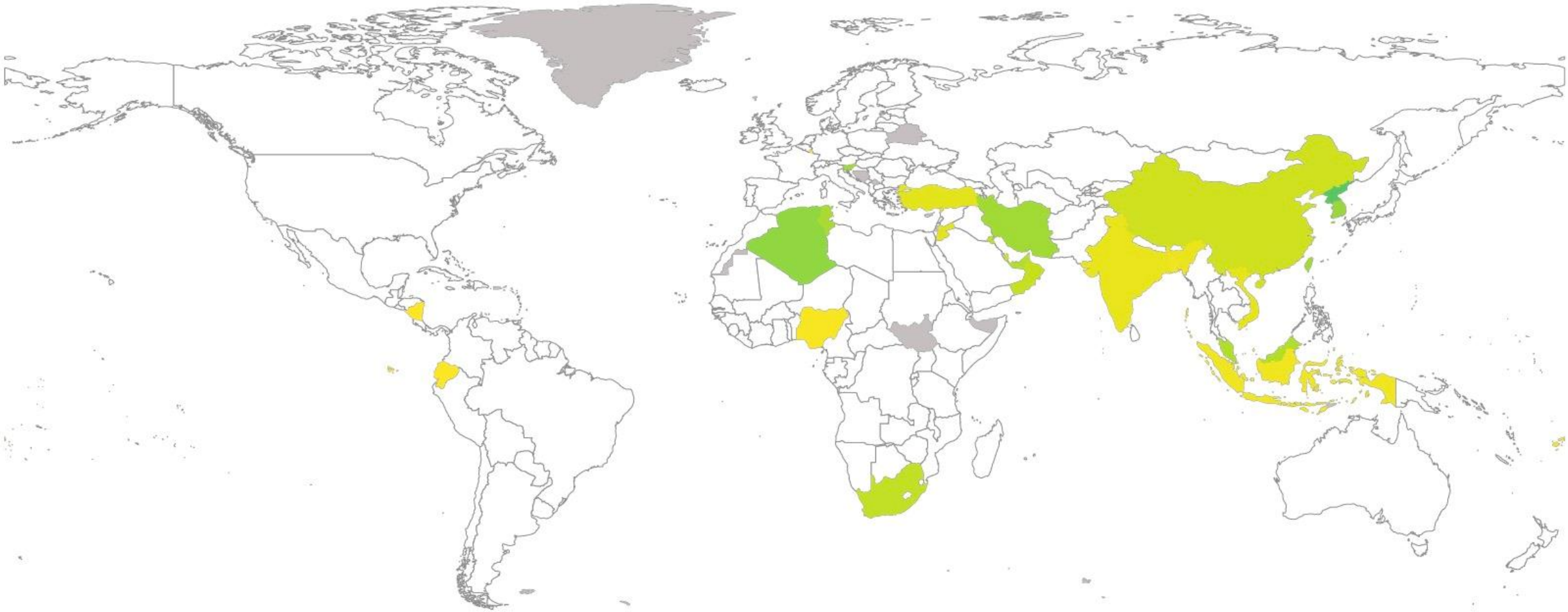
Tropical Medicine



Cancer



Industrial Engineering



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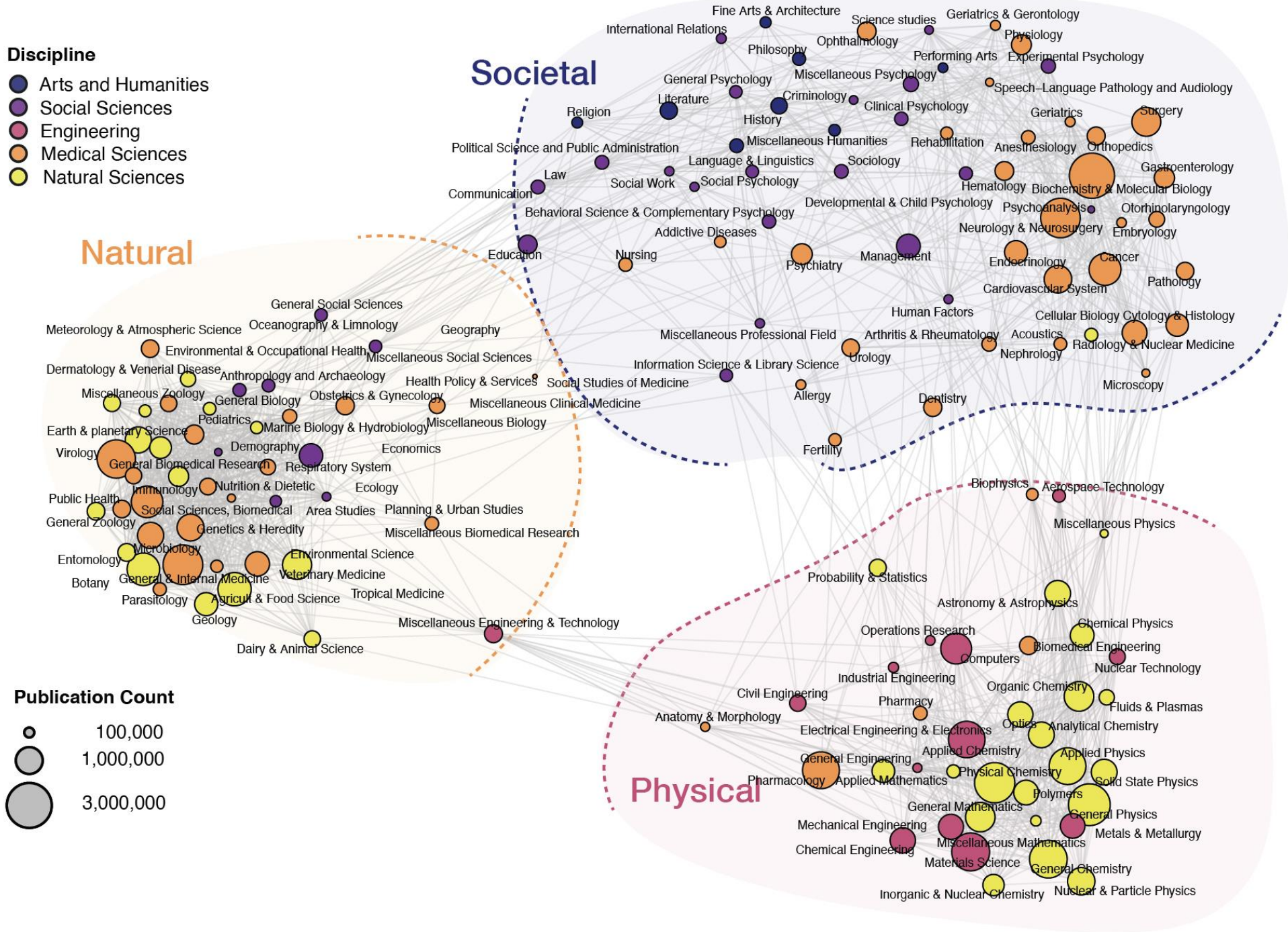
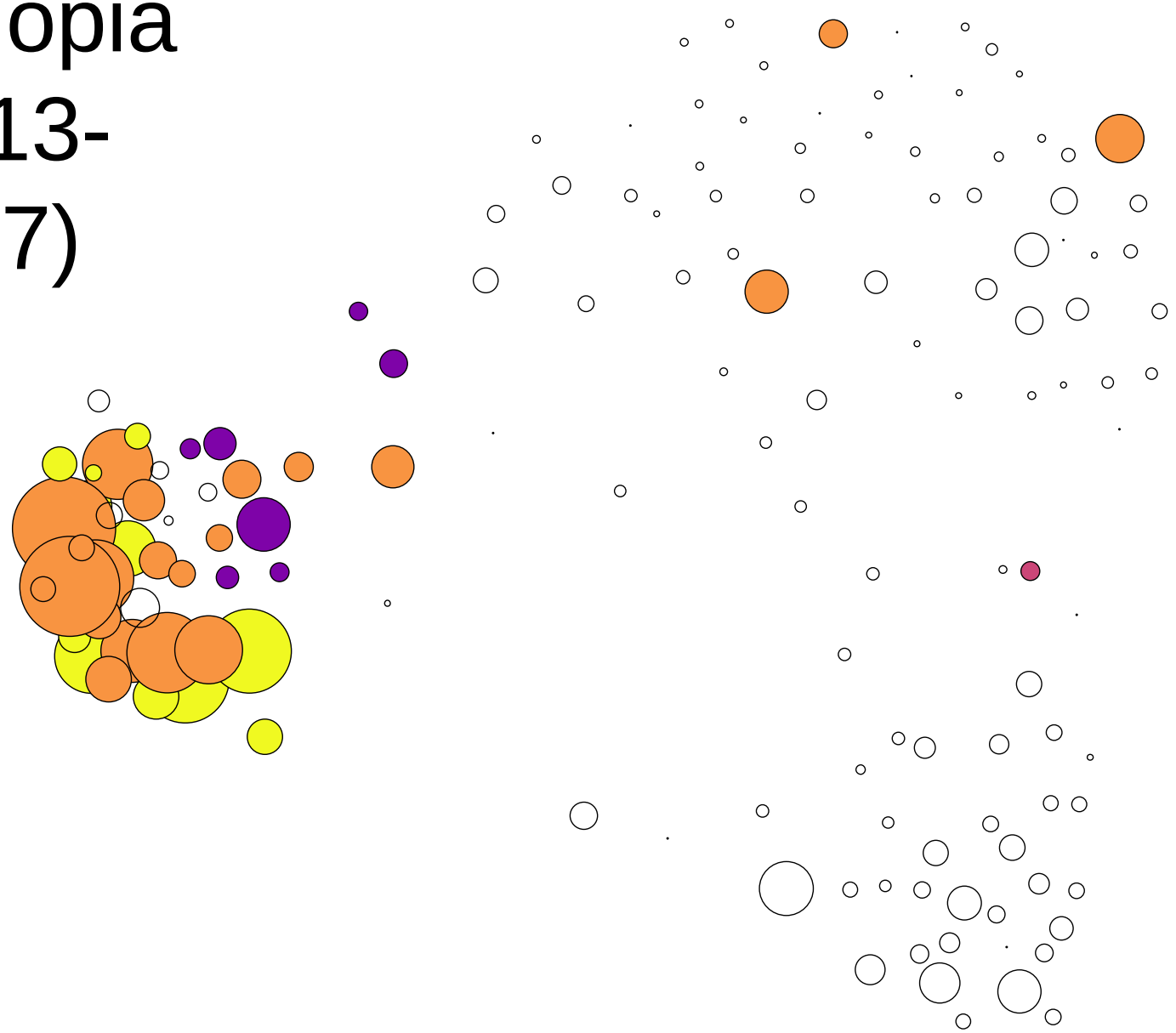

Discipline
Arts and Humanities
Social Sciences
Engineering
Medical Sciences
Natural Sciences
Societal
Natural
Physical
Publication Count
100,000
1,000,000
3,000,000
Fine Arts & Architecture
Science studies
Geriatrics & Gerontology
International Relations
Ophthalmology
Physiology
Philosophy
Performing Arts
Experimental Psychology
Miscellaneous Psychology
General Psychology
Speech–Language Pathology and Audiology
Criminology
Literature
Clinical Psychology
Religion
History
Geriatrics
Surgery
Miscellaneous Humanities
Rehabilitation
Anesthesiology
Orthopedics
Political Science and Public Administration
Language & Linguistics
Sociology
Gastroenterology
Law
Social Work
Social Psychology
Hematology
Biochemistry & Molecular Biology
Communication
Developmental & Child Psychology
Psychoanalysis
Otorhinolaryngology
Behavioral Science & Complementary Psychology
Neurology & Neurosurgery
Embryology
Addictive Diseases
Education
Nursing
Psychiatry
Management
Endocrinology
Cancer
Cardiovascular System
Pathology
Human Factors
Cellular Biology Cytology & Histology
Miscellaneous Professional Field
Arthritis & Rheumatology
Acoustics
Radiology & Nuclear Medicine
Nephrology
Information Science & Library Science
Urology
Microscopy
Allergy
Dentistry
Fertility
General Social Sciences
Meteorology & Atmospheric Science
Oceanography & Limnology
Geography
Environmental & Occupational Health
Miscellaneous Social Sciences
Dermatology & Venerial Disease
Anthropology and Archaeology
Health Policy & Services
Social Studies of Medicine
Miscellaneous Zoology
General Biology
Obstetrics & Gynecology
Miscellaneous Clinical Medicine
Pediatrics
Miscellaneous Biology
Marine Biology & Hydrobiology
Earth & planetary Science
Demography
Economics
Virology
General Biomedical Research
Respiratory System
Nutrition & Dietetic
Immunology
Ecology
Public Health
Social Sciences, Biomedical
Area Studies
Planning & Urban Studies
General Zoology
Genetics & Heredity
Miscellaneous Biomedical Research
Microbiology
Entomology
Environmental Science
Veterinary Medicine
Botany
General & Internal Medicine
Tropical Medicine
Parasitology
Agricult & Food Science
Geology
Miscellaneous Engineering & Technology
Dairy & Animal Science
Biophysics
Aerospace Technology
Miscellaneous Physics
Probability & Statistics
Astronomy & Astrophysics
Operations Research
Chemical Physics
Biomedical Engineering
Computers
Nuclear Technology
Industrial Engineering
Organic Chemistry
Civil Engineering
Pharmacy
Fluids & Plasmas
Anatomy & Morphology
Optics
Analytical Chemistry
Electrical Engineering & Electronics
Applied Chemistry
Applied Physics
General Engineering
Pharmacology
Applied Mathematics
Physical Chemistry
Solid State Physics
Polymers
General Mathematics
General Physics
Mechanical Engineering
Metals & Metallurgy
Miscellaneous Mathematics
Chemical Engineering
Materials Science
General Chemistry
Inorganic & Nuclear Chemistry
Nuclear & Particle Physics

Ethiopia (2013-2017)



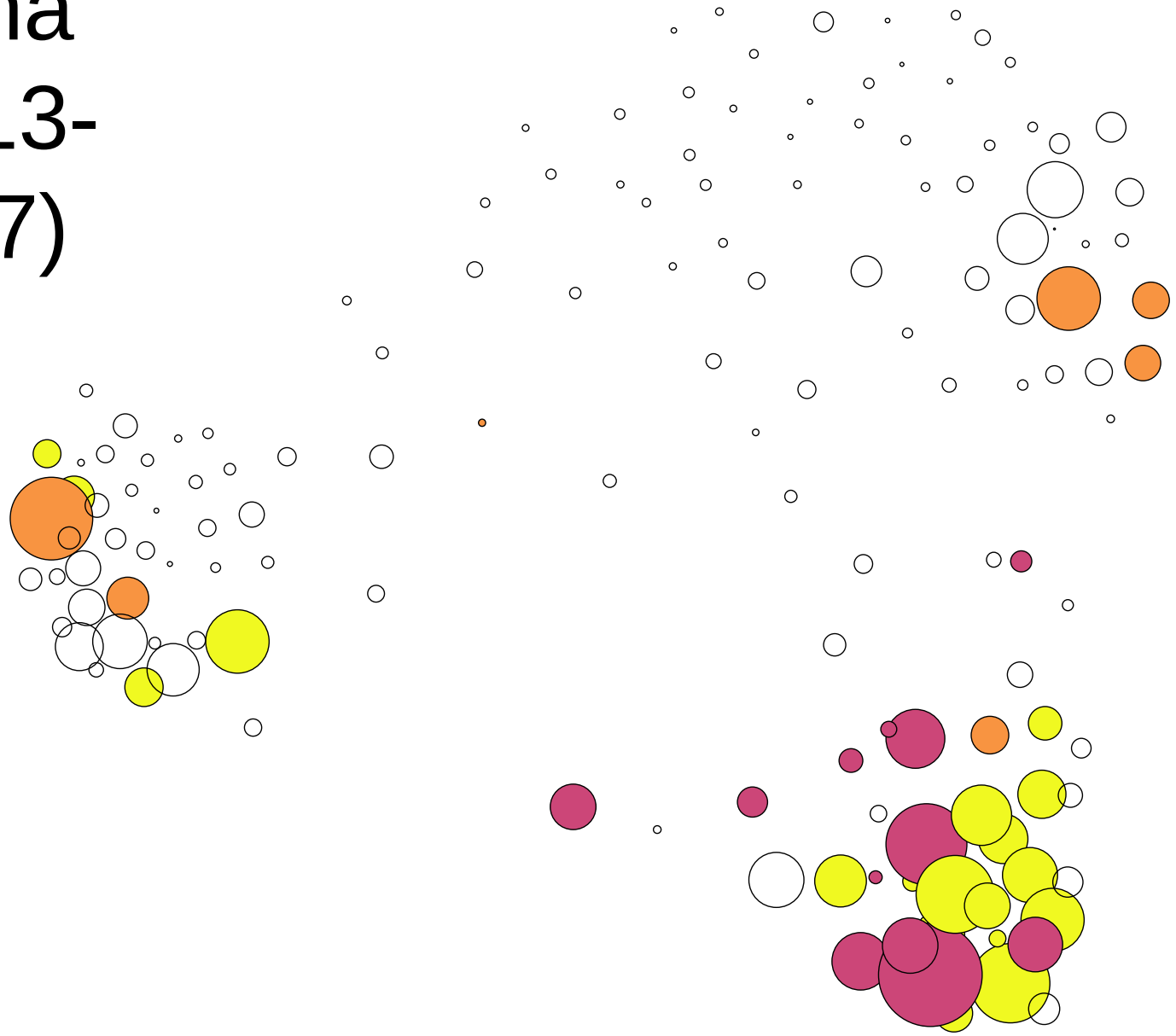
Discipline

- Arts and Humanities
- Social Sciences
- Engineering
- Medical Sciences
- Natural Sciences

Publication Count

- 0
- 100
- 200
- 300
- 400
- 500

China (2013-2017)



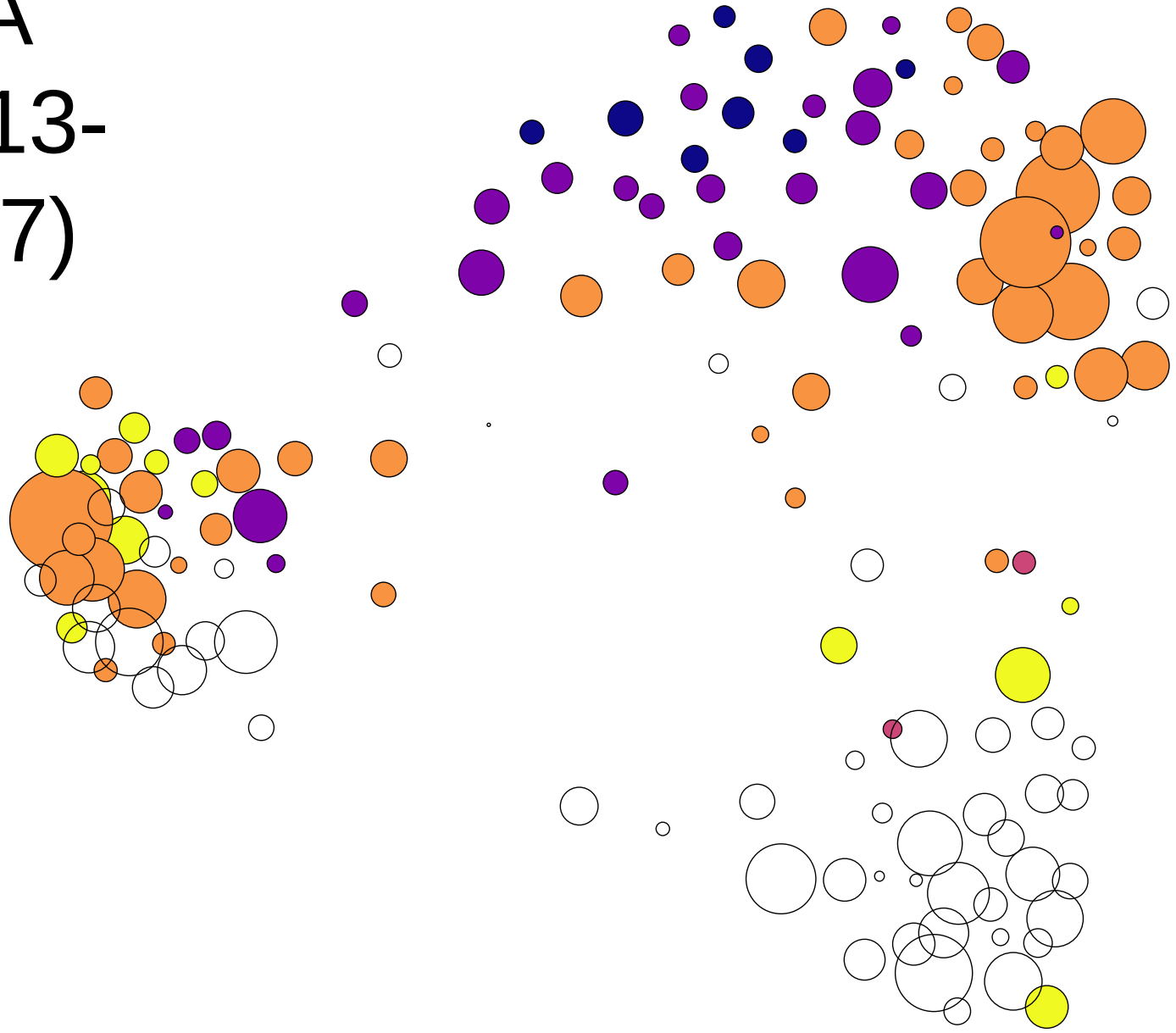
Discipline

- Arts and Humanities
- Social Sciences
- Engineering
- Medical Sciences
- Natural Sciences

Publication Count

- 30,000
- 60,000
- 90,000

USA (2013-2017)



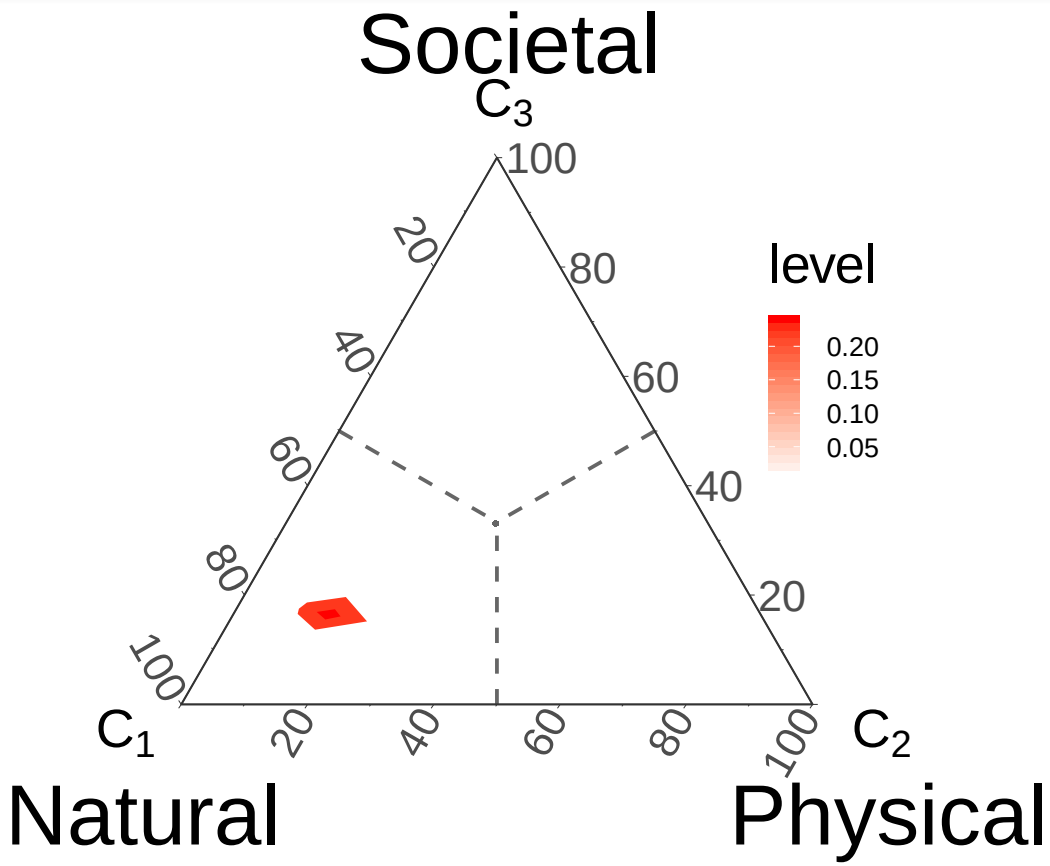
Discipline

- Arts and Humanities
- Social Sciences
- Engineering
- Medical Sciences
- Natural Sciences

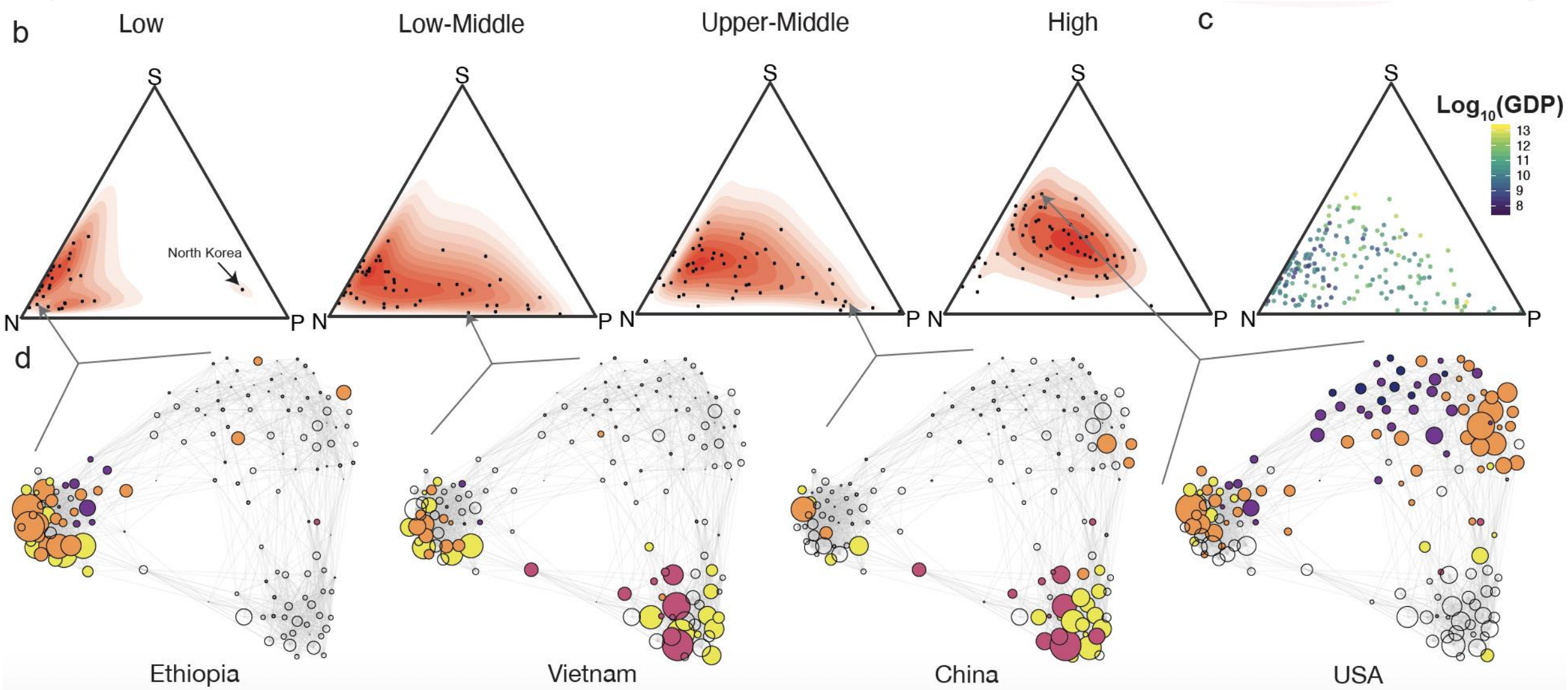
Publication Count

- 25,000
- 50,000
- 75,000
- 100,000

Three Clusters ⟶ Simplex



Aggregated by Income Level



CONCLUDING THOUGHTS

Can scientometrics provide the empirical base for science diplomacy?

Diplomacy for science	The use of diplomatic action to facilitate international scientific collaboration, e.g., by negotiating R&D agreements and exchange programmes or enabling the establishment of international research infrastructures
Science for diplomacy	The use of science as a soft power to advance diplomatic objects, e.g., for building bridges between nations and creating good will on which diplomatic relations can be built
Science in diplomacy	The direct support of diplomatic processes through science, e.g., by providing scientific advice and evidence to inform and support decision-making in foreign and security policies

MADRID DECLARATION (2019)

BENEFITS OF SCIENCE DIPLOMACY

- Address global challenges (e.g., SDGs)
- Productive and sustainable IRs
- Evidence-informed foreign policy
- Improved scientific conditions (e.g., joint programs, capacity)
- Bridging science and policymaking

PRINCIPLES TO FOSTER SCIENCE DIPLOMACY

- Value for citizens
- Methodological diversity
- Demonstrable impact
- Evidence-informed
- Collaboration and inclusion
- Capacity building
- Independence

What are the limitations?

Aargaard et al. (2021)

Issue	Explanation
Availability	Not always present because some publishers and funders do not mandate them.
Correctness	Self-reported by authors with possibly imperfect recall, which can be compounded by weak oversight or accountability regarding FA accuracy and consistency. Possibilities arise for potential indexing errors in publication databases.
Standardisation	Neither uniformly structured nor all-encompassing, because different publishing outlets apply differing acknowledgement practices and templates or even provide no guidance about FAs at all.
Quality	Often require manual cleaning and disambiguation of misspelled and/or inconsistently abbreviated or translated funder names, and may have similar errors for grant numbers. Funder names also change, new funders enter and old ones exit over time.
Completeness	Information about funding amount(s) and specific grant numbers is often missing.
Usage	Offer limited reliability to link funding with performance/impact of publications, e.g. via citations, or to attribute specific outputs to particular grants, because published findings may follow after funding or vice versa, and most grants are usable in highly flexible ways (e.g. in what research and publications are pursued versus what was promised).
Scope	Largely available only for papers published after August 2008, when Web of Science (WoS) began to index FAs, then with more consistency from 2009 (Scopus began to index in July 2013). FAs indexed in databases still often have limited coverage of non-English paratexts.

https://doi.org/10.1371/journal.pone.0251488.t002

COVID AND OPEN ACCESS

30 publishers, including Elsevier, the American Chemical Society, Springer Nature, Science Journals, Taylor & Francis, and Wiley signed

Sharing research data and findings relevant to the novel coronavirus (COVID-19) outbreak

The outbreak of the novel coronavirus (COVID-19) represents a significant and urgent threat to global health.

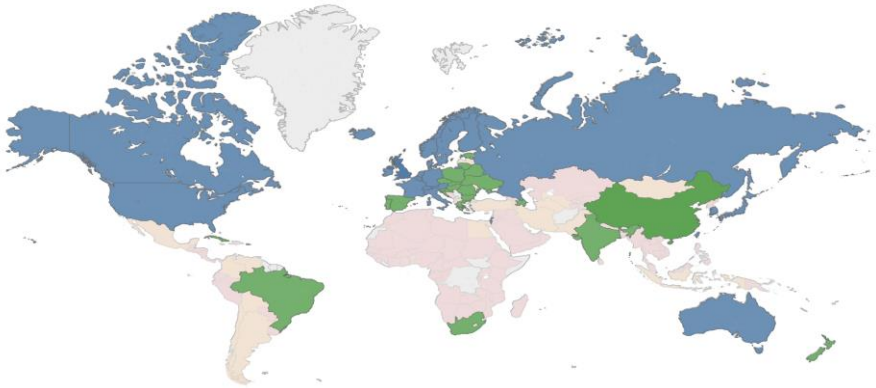
We call on researchers, journals and funders to ensure that research findings and data relevant to this outbreak are shared rapidly and openly to inform the public health response and help save lives.

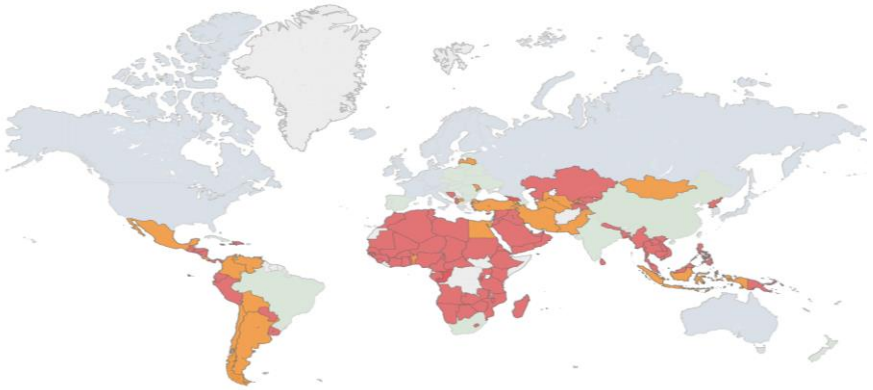
We affirm the commitment to the principles set out in the 2016 Statement on data sharing in public health emergencies, and will seek to ensure that the World Health Organization (WHO) has rapid access to emerging findings that could aid the global response.

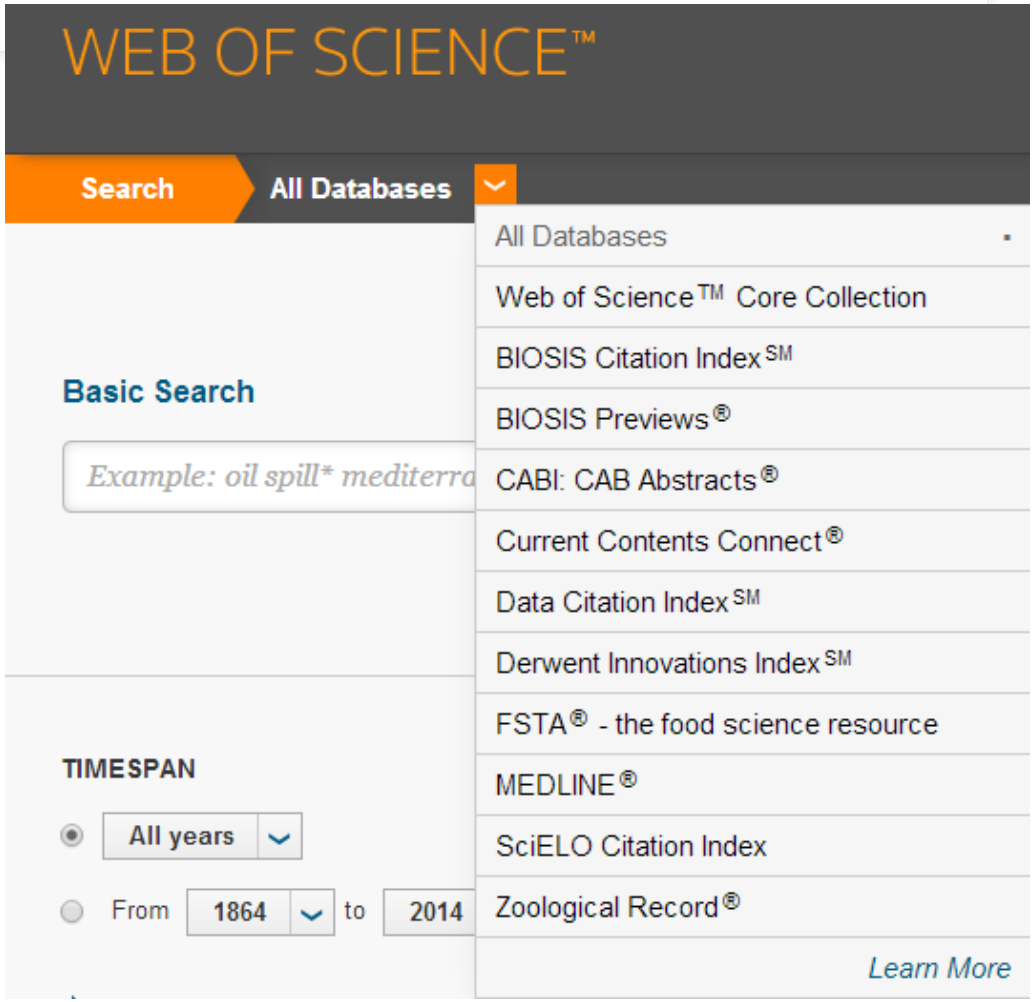
Specifically, we commit to work together to help ensure:

- all peer-reviewed research publications relevant to the outbreak are made immediately open access, or freely available at least for the duration of the outbreak
- research findings relevant to the outbreak are shared immediately with the WHO upon journal submission, by the journal and with author knowledge
- research findings are made available via preprint servers before journal publication, or via platforms that make papers openly accessible before peer review, with clear statements regarding the availability of underlying data
- researchers share interim and final research data relating to the outbreak, together with protocols and standards used to collect the data, as rapidly and widely as possible - including with public health and research communities and the WHO
- authors are clear that data or preprints shared ahead of submission will not pre-empt its publication in these journals

Avoid reinforcing “core/periphery”







Reclaiming indicators for social good

An **indicator** is a measure of a concept.

In research evaluation, that concept should **represent values**.

Interdisciplinarity
Diversity
Collaboration
Societal Impact

The indicators, therefore, provides evidence of values, but **should not replace values**.

Citations
H-indices
JIFs
Altmetrics

Indicators can provide an assessment of past achievements and be **used to motivate future decisions and policies**.

GLOBAL SCIENCE: RECOMENDATION

To understand the global system of science, we must move away from fragmented, isolated, and elitist models of science and towards a comprehensive analysis of international scientific relationships

This requires networking across science observatories to ensure scientific data is open, inclusive, and comprehensive; science observatories should work towards collective good in building capacity and creating standardization.

Thank you!
Questions?

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