The Globalization of Science: The Increasing Power of Individual Scientists?

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Professor Marek Kwiek

Institute for Advanced Studies in Social Sciences and Humanities (IAS), Director

UNESCO Chair in Institutional Research and Higher Education Policy

University of Poznan, Poland

kwiekm@amu.edu.pl

1. Global Science: Introduction (1/2)

- **Individual academics – & the academic profession! – my long-term agenda!**
- Globalization: *The University and the State: A Study into Global Transformations* (2005).
- **This presentation: more like a *future* research agenda!**
- **Science goes global:** global **collaboration, readership, problems & production**, increasingly! **Scientists go global!**
- **Universities (WCUs) – most globalized social institutions today!**
- **National science** systems are embedded in **emergent global science**.
- Countries always want **to harness global knowledge** to national economic needs.
- However, accessing global knowledge can occur **only through us - scientists**.
- Consequently, **the research power of nations** relies on **the research power of individual scientists**. Their capacity to tap into the global networked science is key.
- The constantly **evolving, bottom-up, autonomous, and self-regulating** nature of global science requires **deeper understanding**.
- The best way to understand its dynamics is to understand **what drives academic scientists** in their work: **the how and the why** of their **collaborative & publishing decisions**.

2. Global Science: Introduction (2/2)

- **Why** academic scientists collaborate with other academic scientists. Simply: "**scientists collaborate because they benefit from doing so**" (Olechnicka et al. 2019, 45).
- Benefits come in terms of **promotion, tenure, prestige or access to research funding.**
- Science today is **self-organizing networks**, spanning the globe.
- These networks consist of researchers "who collaborate **not because they are told to** but because they want to … **Scientific curiosity and ambition** are the principal forces" (Wagner 2008, 2).
- The globalization of science is "**the most potent aspect of modern globalization**." (Freeman 2010, 393).
- *Note*: *science* here means *science*, *scholarship*, and *research*.

3. What Drives Global Science?

- The primary driver of global science is **individual scientists (who wish to collaborate with the best of their peers)** (Royal Soc. 2011).
- **Collaboration in research is (mostly) curiosity-driven!**
- It reflects “the ambitions of individual scientists for **reputation and recognition” (for works & ideas!).**
- Competition – within an „economy of reputation” or „prestige economy” (e.g. „top journals).
- **Scientists may be increasingly collaborating as they wish**, if they wish, and in the areas they wish. At a massive scale, **new** from a historical perspective! Free agents.
- Linking global science to **national economic competitiveness** and **national science priorities** is becoming increasingly **difficult**.
- The ”collaboration age” (Wagner 2018): radically **increasing individual autonomy** regarding the **modalities** and **intensities** of collaboration.

- **NOTE: not everywhere**! Affluent, democratic systems, upper institutional layers (world-class, research-intensive universities). Major issue: **China**? More centrally planned academic activities?
- **Studying global science** = (also) **studying the academic profession** (globally). **The academic** = the **unit of analysis**! See next slide!


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5. Globalization of Science: Academic Careers, Collaboration & Big Data

- **Big data & very large surveys** expected! (Planned now).
- Large-scale research possible today: the **Golden age of social sciences, including HE research.**
- **Academic careers can be studied with 1000s (or hundreds of thousands) of observations** (disclaimers here!)
- **Big Data** in **academic profession studies** – can **accompany traditional surveys** & **interviews**.
- **Macro-studies** can accompany **micro-studies**! **Complementarity**…
- **Traditionally: very *small* samples generalized to *huge* populations**.
- **Computational social science:** looks differently at classical statistics & its methods.
- The studies of **convenience samples** (say, 100,000 scientists) and those of traditional **representative samples** (of, say, 1,000) – just differ! Cannot be ignored.
- New **tools** and **data** – new **limitations** – new **opportunities!**
- Slowly moving into **Big Data in academic profession studies**, unknown terrains *(terra incognita*)**…**

6. The Changing Map of Science

- The global science system: **a larger, more competitive, multicentric core**.
- **A bipolar world of science led by Anglo-Saxon countries** is gradually being replaced by a **tri-polar world** (**Europe, North America, Asia-Pacific).** Consequently:
  - The **scientific workforce is differently located globally.**
  - New **trends in international collaboration** emerge.
  - The **distribution of publication impact between traditional science powerhouses** and the **new entrants** differs from decade to decade.
- The **traditional Anglo-American academic hegemony** is being **challenged** in an **increasing number of academic fields**.
- The **ties between countries are much closer than before**, leading to **decentralization of science**(Gui et al. 2019) or its **pluralization** (Marginson 2018).
- Collaboration remains **dominated by science superpowers (such as the US, the UK, Germany, and several European countries)**, but **China, Brazil and South Korea**—ever more **influential in the global network of science**.
- So – the **global map of science** changes radically!

7. Why Studying the Globalization of Science Now?

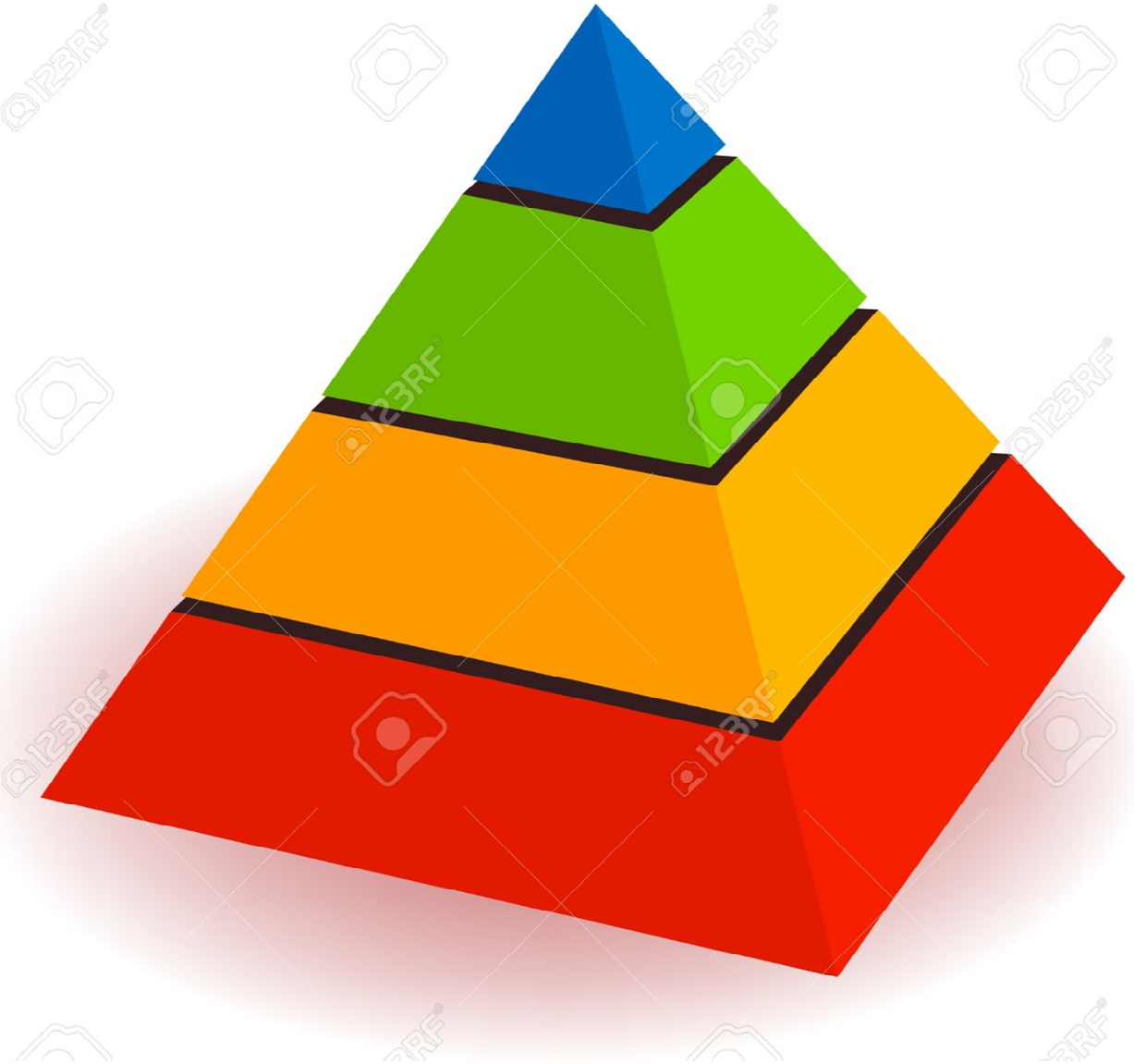
- The most important factor: **the increasing availability of digital data on scholarly inputs and outputs** (research funding, productivity, collaboration, paper citations, academic mobility etc).
- **New data and computer power at fingertips - unprecedented opportunities to explore the structure and evolution of science!**
- **The globalization of science explored under different conceptual labels and research agendas**:
  - **the science of science** (Fortunato et al. 2018; Wang and Barabàsi 2021; Clauset et al. 2017),
  - **meta-research (or research on research)** (Ioannidis 2018),
  - **computational social science** (Edelman et al. 2020),
  - **quantitative science studies**
  - **studies of science and technology (and its indicators)** (Glänzel, Moed, Schmoch & Thelwall 2020) and
  - others.
- **Complementary contributions** from related fields such as **scientometrics, informetrics, economics of science, and sociology of science**.
- **The globalization-driven Big Data revolution in science** is utilized to study **the globalization of science itself**!

8. Nationally-Funded Global Science

- **Despite globalizing pressures, science career paths, universities, and research funding** - are **overwhelmingly national!**
- There is **no global science without a national funding base for research and training**: global science requires **national funding** to keep research infrastructure running and personnel costs covered**!**
- The relationship between **science and the nation-state** **has traditionally been strong:** nation-states were the **main patrons and sponsors of research**.
- Under the pressures of globalization, **nation-states are less able than before to control their destinies** (in many areas).
- They are **more dependent upon universities** for their **knowledge production** and their **human capital.**
- Universities and **scientists** - in the center stage!

9. How do Global Networks in Science Operate? (1/2)

- The development of a global science system has its own **dynamics of network formation**.
- Both national and global science is structured by the **university hierarchy.**
- The knowledge produced in **universities with prestige and resources** has higher **visibility and status** than the knowledge produced elsewhere.
- Global science is produced in **most** institutions, countries, languages, and disciplines, but its **highest impact** is reserved for **publications originating from**:
  - World-class universities (ca. 1,000-1,200).
  - Located mostly in Anglo-Saxon countries.
  - Published in English.
  - In STEMM disciplines.



10. How do Global Networks in Science Operate? (2/2)

- Global science is a **constantly emergent system** in the sense that it **is the outcome of the numerous interdependent, individual, and decentralized normative decisions** of individual scientists.
- Science is comprised of "**interacting individuals and networks reproducing norms and standards**" (King 2011: 365).
- Clearly, **governing this heterogeneous community** and **steering its academic behaviors** (including **collaboration behavior)** is a **tricky issue.**
- What emerges through a**n accumulation of numerous individual choices** of scientists is **convergence on the global research standards**.
- Marginson on **agency**:
  - "researchers … **fulfill their individual and collective agency by creating knowledge…. Knowledge flows freely**, and science and its connections continue to grow and **spread in all directions**" (Marginson 2020, 50).

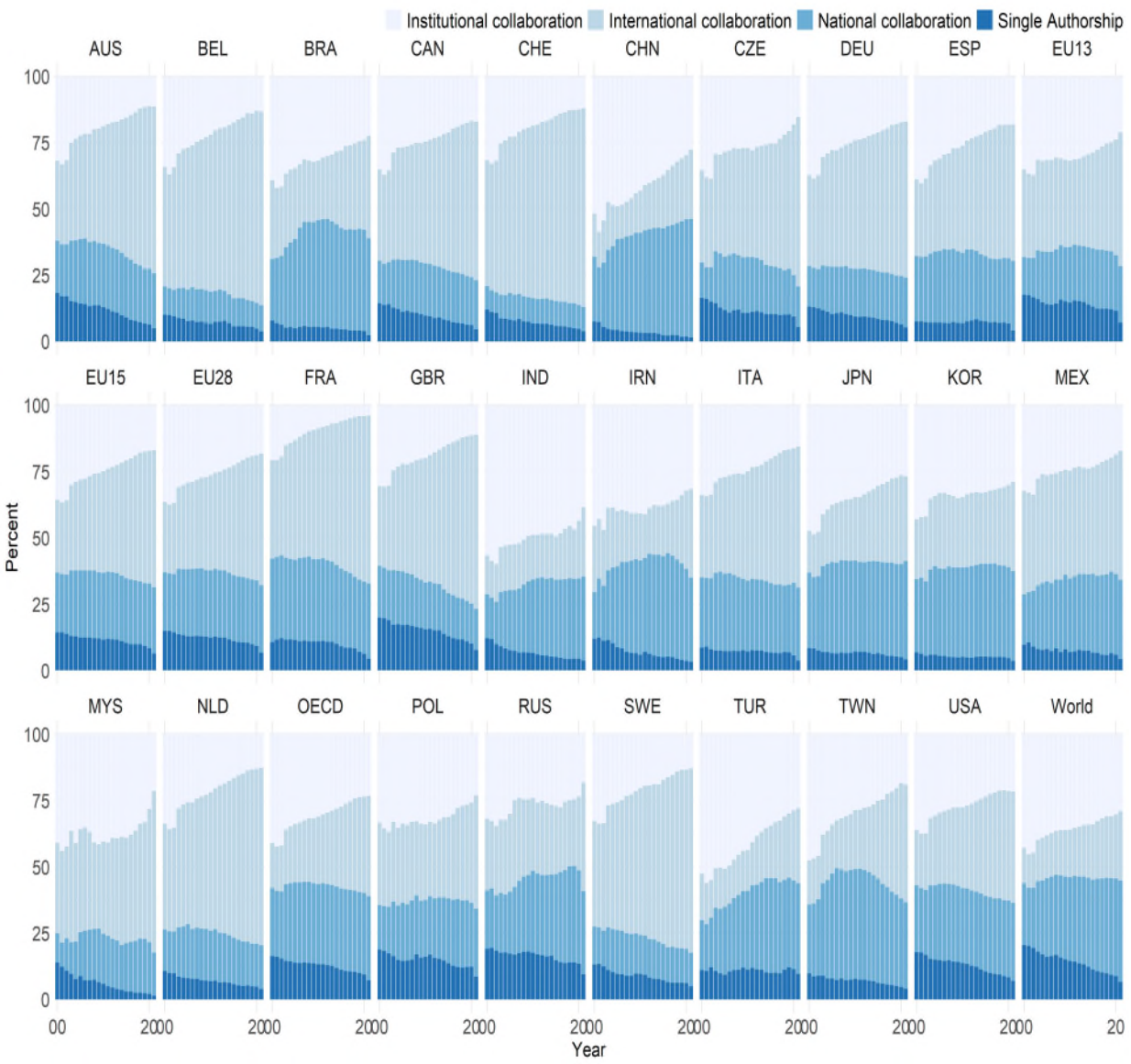
11. The Globalization of Science: Institutions, Sectors, Individuals

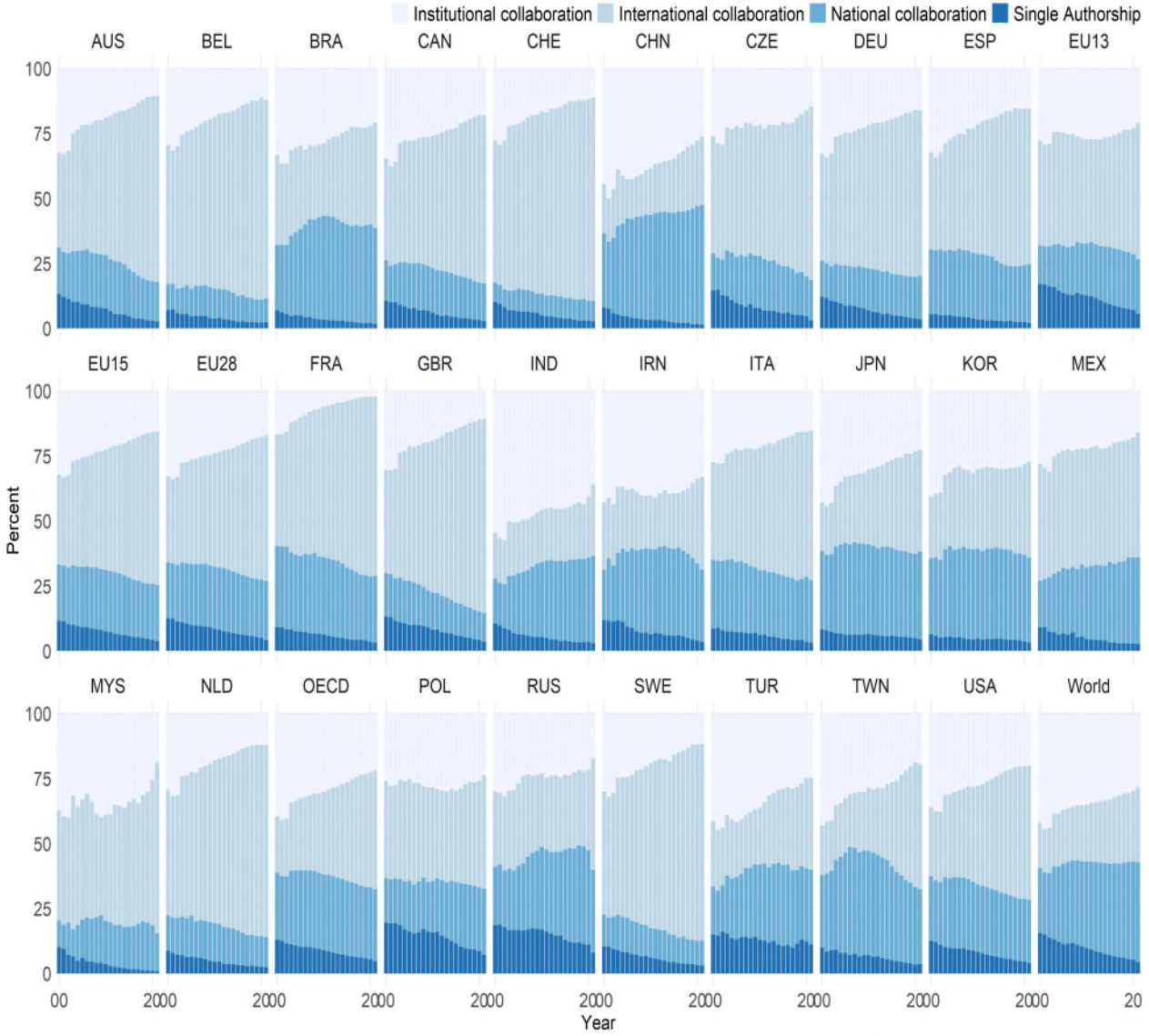
- Scientists involved in academic knowledge production **leave traces in their printed publications!** We can examine them.
- Our **knowledge regarding the globalization of science** is based on:
  - **Heterogeneous data sources** (biographical, administrative, financial, publications, citations, collaboration etc.)
  - **Data produced at different levels** (micro-level, mezo-level, macro-level)
  - **Data produced** with **different methodologies** (from interviews to surveys to analyses of bibliometric data sets).
- The globalization of science can be traced using **temporal, topical, geographical, and network analyses.**
- It can be **traced over the years, countries, and institutions, research teams and individual scientists**, as well as academic **disciplines** by the expanding databases (with all commonly discussed limitations).
- We studied **the collaboration mix (4 types)** for 6 major fields of research over the period of two decades (2000–2020).
- HUM & SOC? Among 41,462 journals listed in Scopus, there are **5,002 journals allocated to arts and humanities and 10,199 allocated to the social sciences.**

12. Knowledge Production - the Global Scene

- Total number of **academic institutions involved in global academic publishing: ca. 9,000** (8,633) (SciVal, 2021)
- **Plus corporate** (6,130), **government** (2,523), **medical** (1,859), and **other** (797) sectors.
- The **academic sector** is the key knowledge producing sector and a **key participant in the globalization of science**.
- If a **threshold of 5,000 publications within the decade** of 2010–2019 is used, then the number of all institutions above the threshold **shrinks to 1,590** and these could be called **world class universities**.
- The research-focused rankings:
  - the **Leiden Ranking 2020** lists **1,176 universities (with at least 100 publications** in the 2015–2018 period);
  - the **ARWU** World University Ranking 2020 lists **1,000 universities**.

13. Panorama (1/2): Collaboration (and Publishing) Patterns: All Fields combined and Natural Sciences



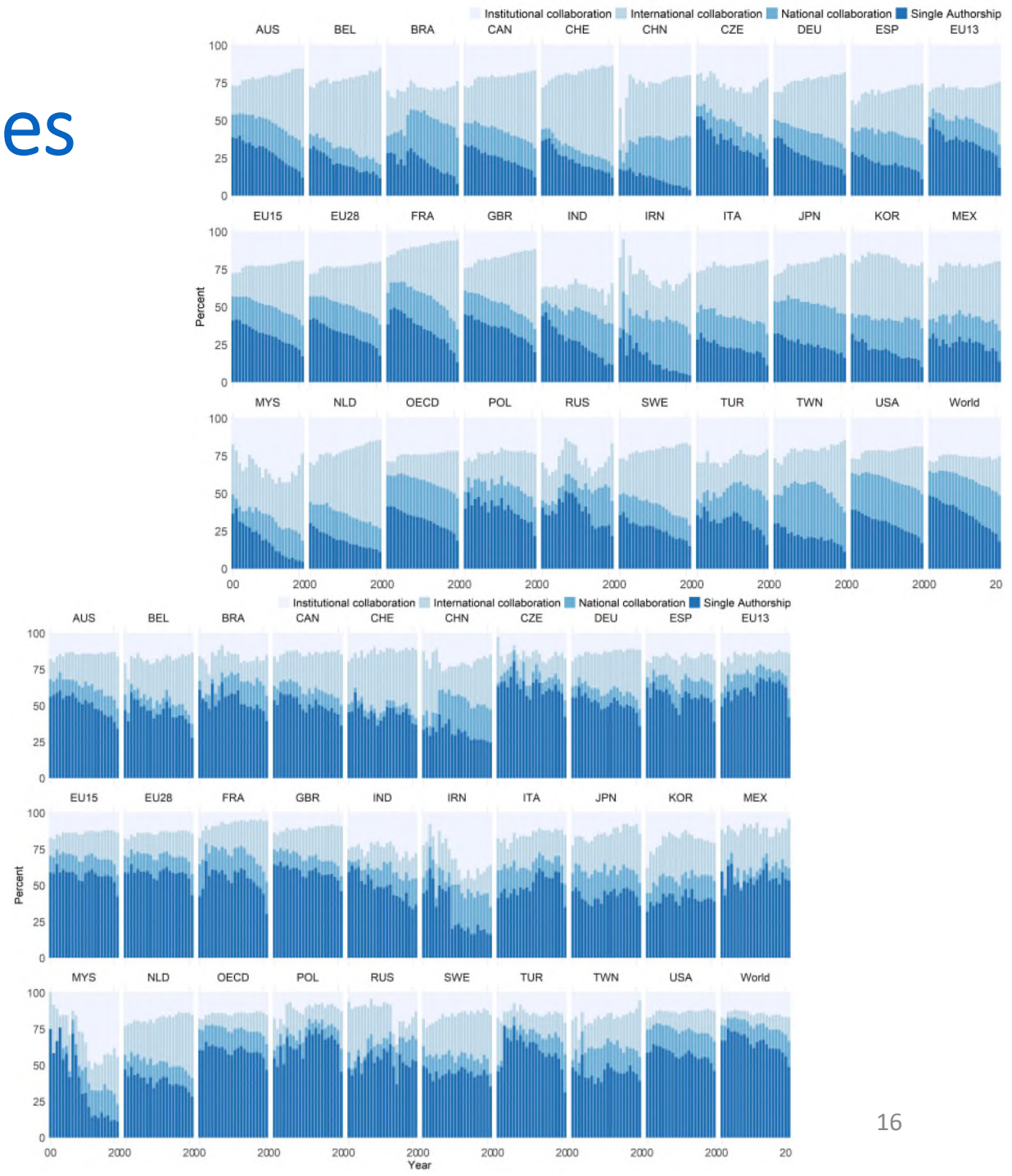


14. Panorama (2/2): Collaboration (and Publishing) Patterns: Social Sciences vs. the Humanities (1)

- The role of international collaboration in the **humanities** is **marginal**.
- In contrast, in the **social sciences**, the most important trend is **the increase in international collaboration**, predominantly at the expense of single-authored research.
- The share of **solo research** in the humanities in almost all countries still **exceeds 50%.**
- The **powerful divergence**, increasing over time, between social sciences and humanities and has **not been emphasized in current literature on the globalization of science**.
- **Single authorship** is the dominating mode of publishing in the humanities and its share exceeds 50% in the most advanced economies: **the percentage of solo articles in 2020 was 55% for EU-28, 55% for the OECD, and 51% for the US.**

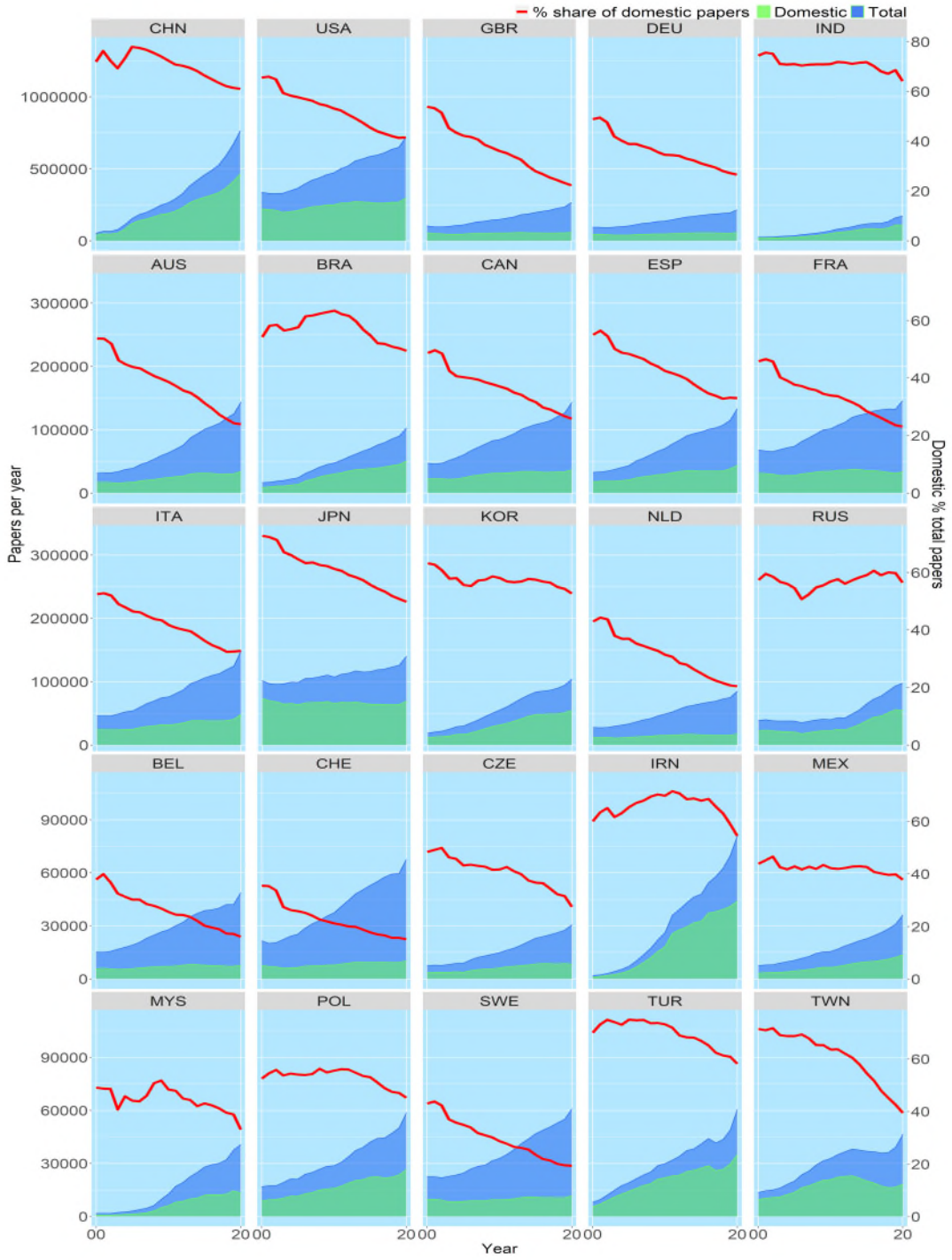
15. Soc. Sci. vs. the Humanities

- Collaboration (and publishing) patterns, top 25 global knowledge producers in 2020 (plus EU-28, EU-15, EU-13, OECD and the World), articles only, SciVal data, 2000–2020 (%).
- **International collaboration in the humanities** has been **relatively insignificant** in most countries, except for several European systems.
- **Social sciences:** increasing **international collaboration**; radically declining single-authorship (no collaboration); stable national collaboration.
- **The humanities:** powerfully **dominating single-authorship**; with a marginal role of international collaboration; stable national and institutional collaboration.



16. Soc. Sci. vs. the Humanities: Implications

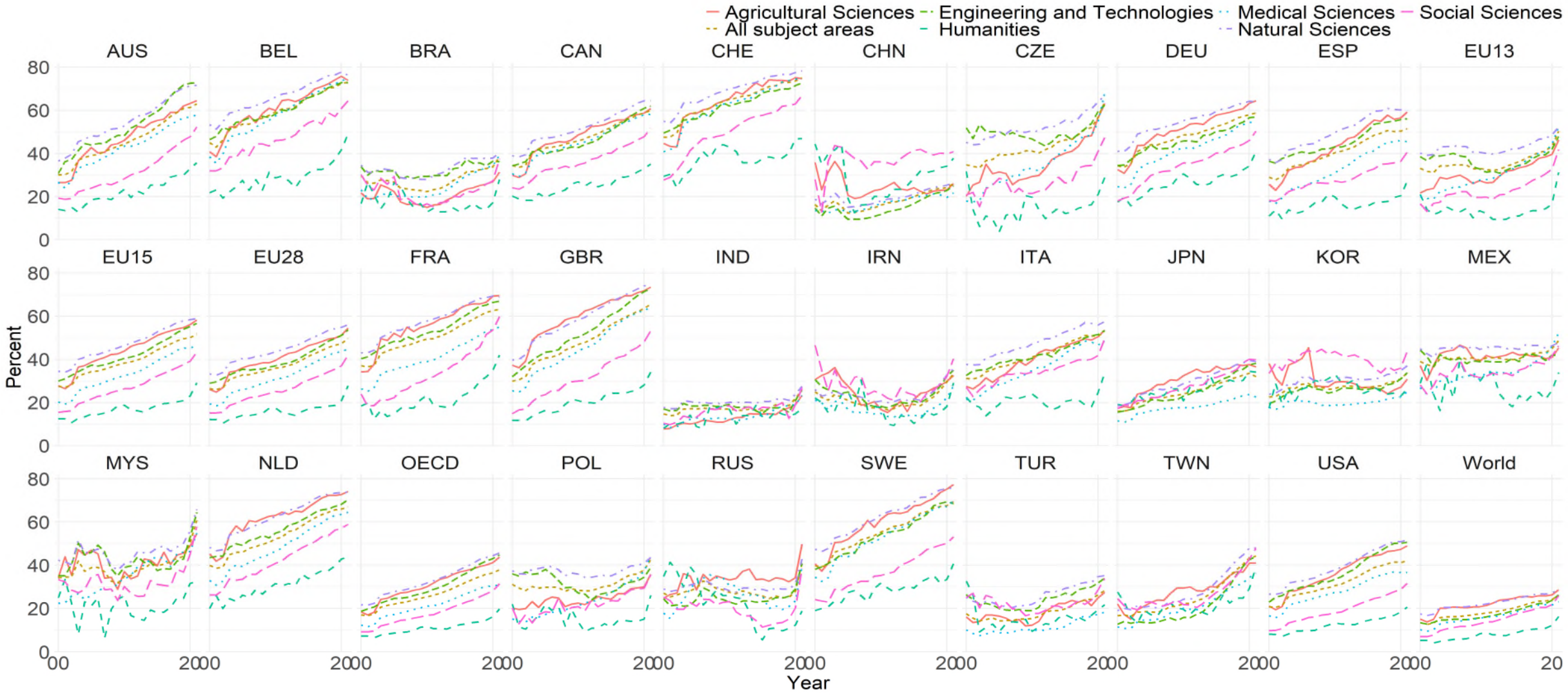
- **Humanities are clearly non-collaborative, and clearly non-internationally collaborative**! Unique.
- **Powerful implications for academic metrics**:
  - # publications
  - # citations
  - at the **micro level** of individual academics.
- Without using fractional counting methods, with single authorship as a dominating publishing pattern, **individual output** in HUM **may appear small by comparison**; citations to single-authored articles are lower than those to collaborative articles.
- The **social sciences/humanities divide**, practical implications:
  - **disadvantaging humanists whenever they are in a head-on competition (for research grants and awards) with social scientists**;
  - clearly promoting social scientists wherever the emphasis on publication and citation **metrics** dominates in the **assessment of grant proposals**.
- The traditional expression "**social sciences and humanities**" in the globalizing scholarship - loses its traditional sense.
- **Mixing HUM with SOC** can lead to **unfair results** in competitions among individuals, departments, and institutions.



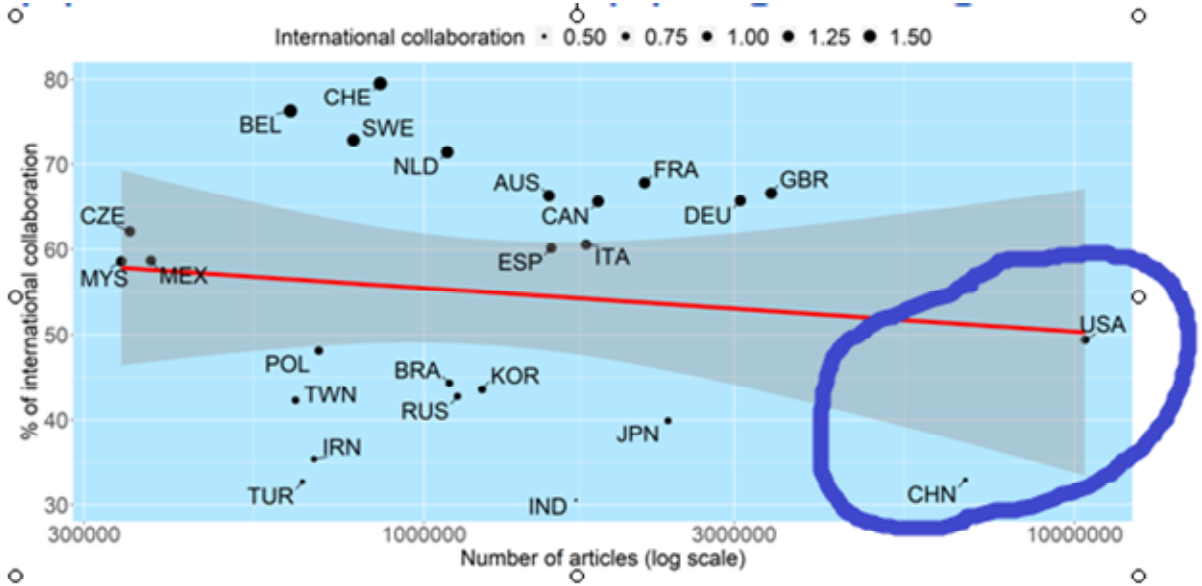
17. Data (1/4): Collaboration Types

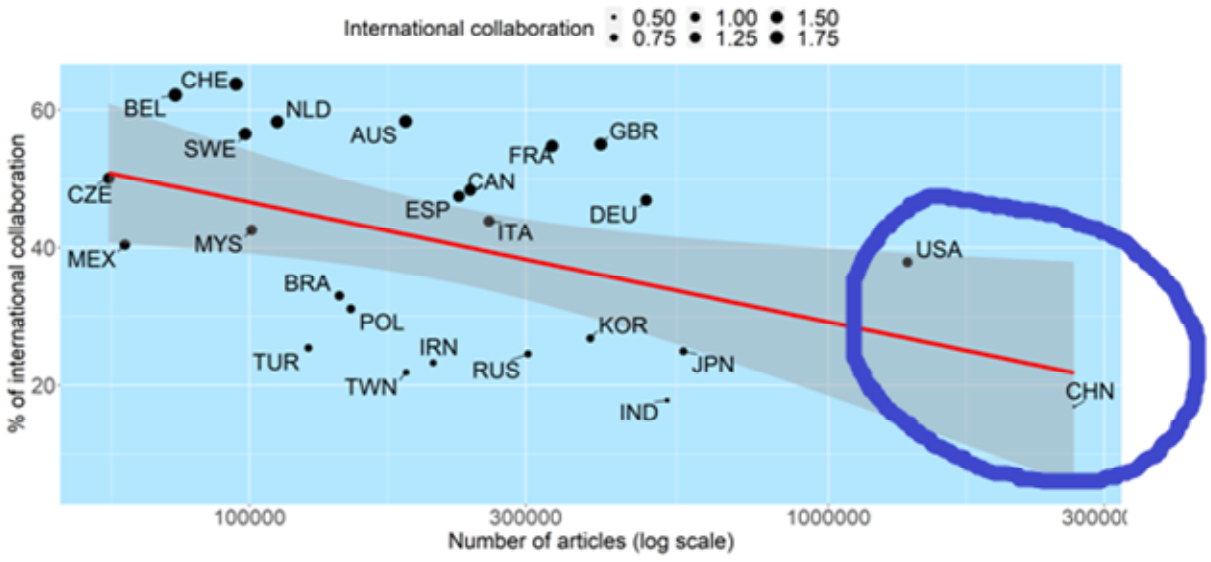
- A major finding: **the increase in annual output in the period 2000–2020 in major European systems** is **almost entirely accounted for by international collaborations** (See green sections).
  - the UK, France, the Netherlands, Switzerland, Finland, Belgium, Sweden, and Germany; as well as the US, Australia, Canada, and Japan.
- Globalization implies **two different processes in two different system types**:
  - the growth of science in the **Western** world is almost entirely attributable to **internationally co-authored publications**, and
  - its growth in the **developing** world is driven by both **internationally co-authored and domestic publications**, with different mixes in different systems.

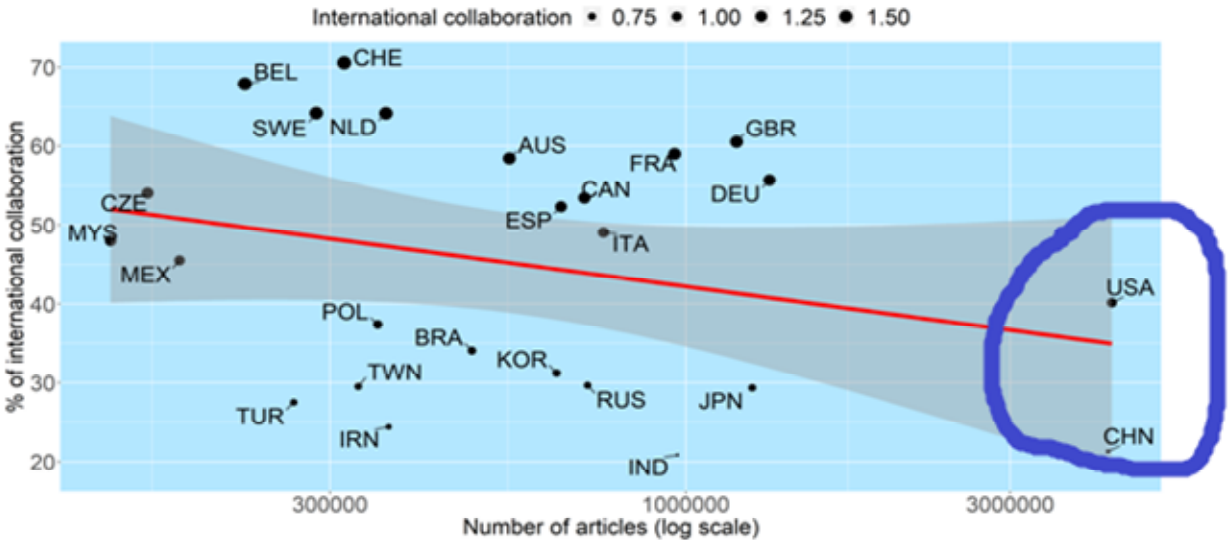
18. Data (2/4): International Collaboration Rate. Huge field differentation!

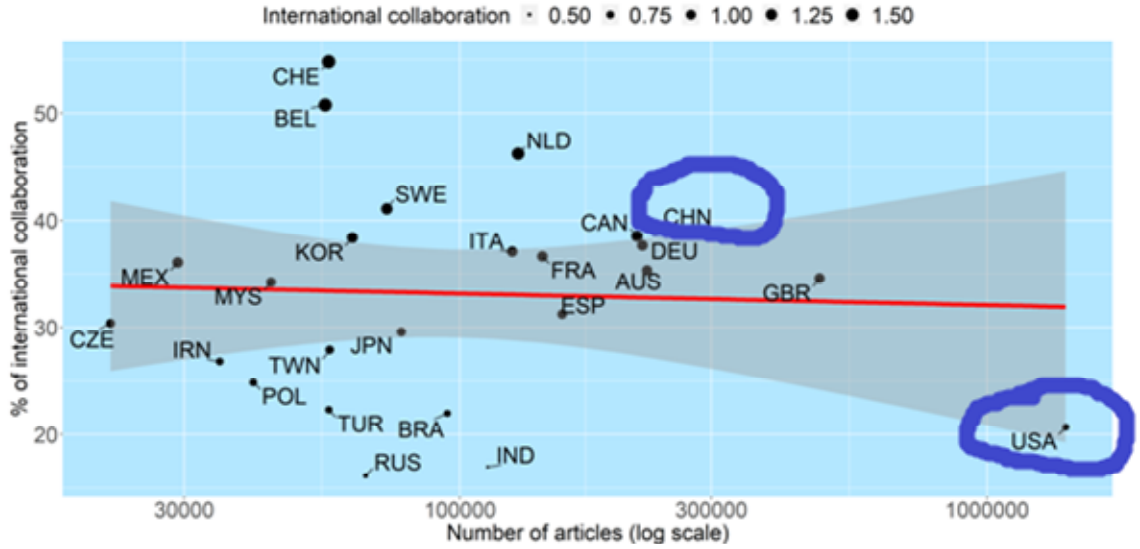


19. Data (3/4): Correlation between total national output 2000–2020 (articles only; log number) and percentage share of publications in international collaboration, averaged for 2000–2020 (bubble size reflects average FWCI for the period). (1) All fields (2) Engineering & Technol. (3) Natural Sciences (4) Social Sciences









20. Data (4/4): The Globalization of Science vs. Global Academic Innovations

- **Tracing global transformations** through **high-quality publications.**
- Specifically (top 1%):
  - (1) **the top 1% of highly cited publications** (used as a proxy of high quality, with all limitations,
  - (2) **publications published in the top 1% of highly ranked journals**.
- **Publications in the upper 1% of journals** are on average **at least good candidates** to become **global innovations in the future**.
- **China already produces more top publications than the US. And will probably overtake the US** in the **next few years** in the number of articles in the top 1% of journals.
- **The largest remaining gap in article production** in top journals between the USA and China is in:
  - **medical sciences**
  - **humanities and**
  - **social sciences** (HUM & SOC not national priorities).
- The **left panels indicate the changes in the percentages** and the **right panels in the numbers of publications over time**.

Table 1. High-impact publications, proportion (%) of publications in the top 1% of publications by citations: output in top 1% citation percentiles by country and publication year, 2000-2020, all publication types included, all fields of research and development combined, in descending order for 2020, top 15 countries in each panel only, in percent (left panel, world average = 1) and publication number (right panel). Source: own calculations based on SciVal dataset (2021).

Country	Average 2000–2020	2000	2010	2015	2020	Country	Total 2000–2020	2000	2010	2015	2020
CHE	2.9	2.1	3	3.5	2.4	CHN	67,497	107	1,561	4,550	10,900
BEL	2.3	1.2	2.3	2.8	2.3	USA	167,559	5,944	8,233	9,536	8,064
AUS	2.0	1.2	1.9	2.1	2.2	GBR	48,174	1,250	2,214	3,091	3,343
NLD	2.7	1.8	2.8	3	2.2	DEU	36,889	832	1,845	2,476	2,179
GBR	2.1	1.6	2.2	2.4	2.1	ITA	19,659	327	874	1,278	2,014
ITA	1.6	0.9	1.6	1.8	2.0	AUS	20,650	291	827	1,420	1,972
SWE	2.2	1.3	2.3	2.5	2.0	CAN	24,465	551	1,193	1,547	1,668
CAN	2.0	1.6	2.1	2.2	1.9	IND	9,000	62	266	559	1,529
CHN	1.2	0.2	0.7	1.2	1.8	FRA	23,919	565	1,151	1,535	1,511
IRN	0.8	0.1	0.4	0.6	1.8	ESP	15,373	194	715	1,068	1,311
FRA	1.7	1.1	1.7	1.9	1.7	NLD	18,538	358	923	1,231	1,128
DEU	1.8	1.2	2	2.1	1.6	IRN	4,655	2	78	246	1,101
USA	2.1	2.1	2.3	2.2	1.6	KOR	10,618	82	412	762	1,070
ESP	1.4	0.8	1.4	1.6	1.5	JPN	17,669	548	761	998	1,069
TWN	0.9	0.5	0.7	1	1.4	CHE	15,148	301	681	1,105	924

Table 2. Publications in high-impact journals, proportion (%) of publications in the top 1% of journals: publications in top 1% journal percentiles (by Scopus CiteScore percentile) by country and publication year, 2000–2020, all publication types included, all fields of research and development combined, in descending order for 2020, top 15 countries in each panel only, in percent (left panel, world average = 1) and publication number (right panel). Source: own calculations based on SciVal dataset (2021).

Country	Average 2000–2020	2000	2010	2015	2020	Country	Total 2000–2020	2000	2010	2015	2020
CHE	5.1	4.5	5.4	5.4	5.1	USA	339,080	1,1441	16,337	18,199	21,343
NLD	5.3	5.1	5.6	5.8	4.9	CHN	110,039	363	2,676	7,095	17,646
AUS	3.8	3.5	3.6	3.9	4.3	GBR	95,466	2,945	4,405	5,599	6,954
CAN	4.1	4.2	4.1	4.1	4.3	DEU	70,781	1,853	3,421	4,213	4,810
GBR	4.4	4.2	4.5	4.6	4.3	CAN	48,851	1,313	2,275	2,821	3,816
USA	4.5	4.6	4.7	4.4	4.3	AUS	38,068	725	1,502	2,545	3,730
BEL	4.4	4.0	4.8	4.7	4.2	FRA	47,307	1,343	2,400	2,813	2,874
SWE	4.3	3.4	4.2	4.9	4.2	ITA	35,611	965	1,666	2,152	2,515
DEU	3.6	3.0	3.9	3.7	3.6	NLD	35,891	920	1,748	2,318	2,482
FRA	3.5	3.2	3.7	3.6	3.2	ESP	31,612	531	1,549	2,090	2,385
CHN	2.0	0.9	1.2	1.9	2.9	KOR	24,742	245	1,001	1,892	2,301
KOR	2.7	1.8	2.4	2.9	2.9	JPN	38,464	1,792	1,712	1,856	1,981
ESP	3.0	2.4	3.2	3.3	2.7	CHE	25,368	563	1,189	1,632	1,961
ITA	3.0	3.2	3.2	3.1	2.6	SWE	20,362	492	861	1,380	1,497
TWN	2.7	2.5	2.8	2.9	2.3	BEL	16,297	371	800	1,065	1,172

21. Finally: Tensions of Global Science

- **Developing countries can access the knowledge of developed countries** more easily **than ever before in the history of science**!
- **Predominantly win-win collaboration types** are certainly dominant (Wagner 2008), but **free-riding behavior** in developing economies is also possible.
- Possibly negative consequences for the **global balance in the labor market for academic scientists** (Freeman 2010): newcomers can **do more for less?**
- What is at stake is **public funding** in the future: the core policy issue is **why states should** fund **highly internationally collaborative academic research.**
- The **rationale presented by national governments** may not fit **the new reality of globally interconnected network science** as conducted by **highly internationalized scientists**.
- National governments **seek national benefits and local applications** in international **collaborative cutting-edge research**.
- But they may be not fully aware of the increasingly globalized & networked nature of science.

CONCLUSIONS

1.

2.

3.

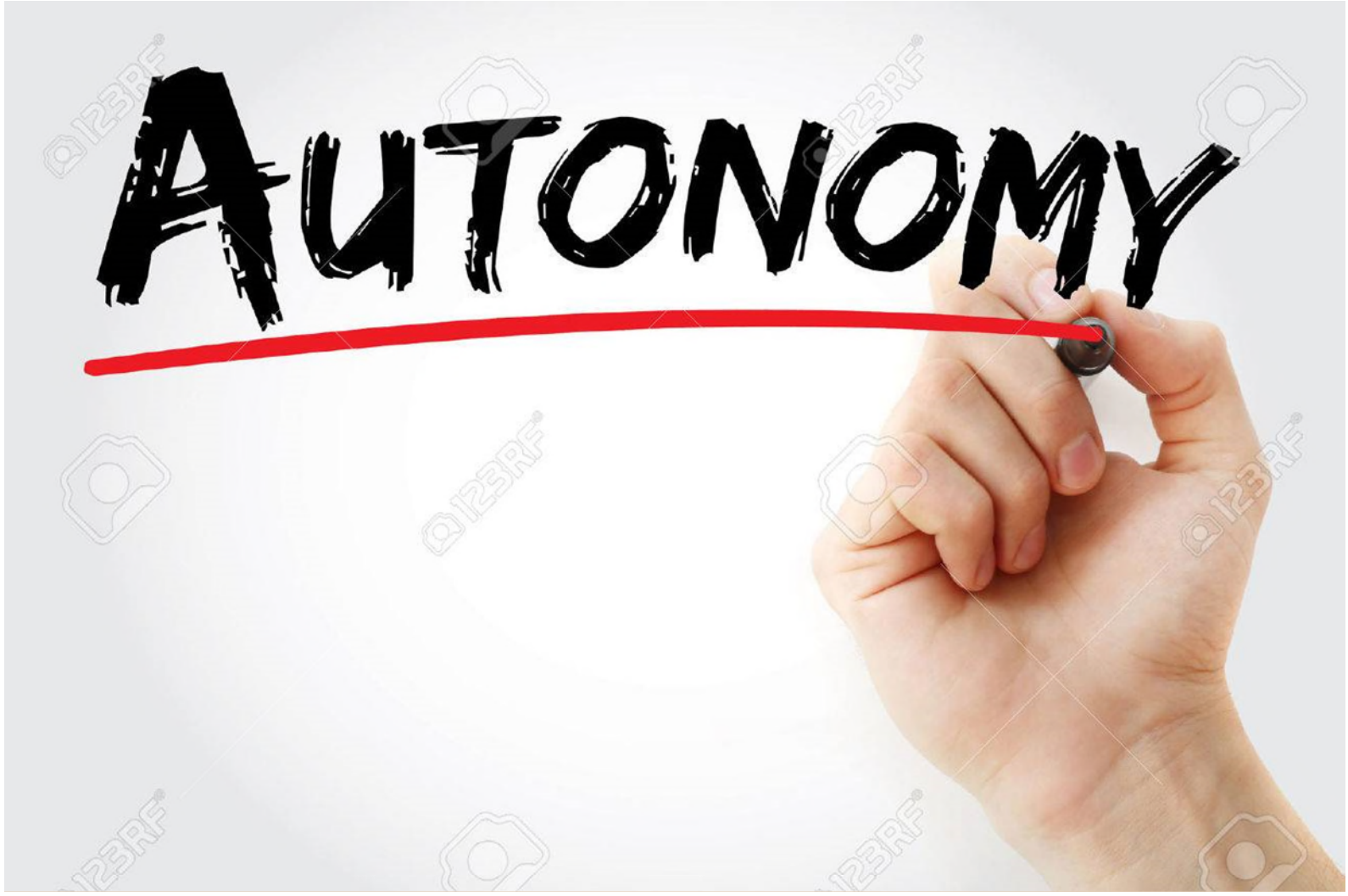
23. Lessons from the Dynamics of Global Science (1/3)

- It is increasingly the **researchers**, rather than national authorities, who **set the rules of how science is conducted**.
- **The global science system** is **self-organized**: embedded in the rules created by scientists themselves.
- The networked model of science is an **open system**, with **opportunities open to new entrants**.
- Collaborative networks emerge from the **choices of hundreds of thousands of scientists** who shape the evolution of science networks.
- **Self-organization and individual autonomy** has never been so powerful in the history of science!

- However:
- **New tensions** emerge: global networks in science are **privately governed and self-regulatory in nature**.
- Scientists "**seek to maximize their own welfare**" (Wagner 2008, 10); with implications.
- Scientists satisfy their "**individual curiosity and the career desire for esteem, reputation, and scientific autonomy**" (King 2011, 370).

24. Lessons from the Dynamics of Global Science (2/3)

- **Networks in science cannot be (easily) controlled!**
- Networks evolve continuously according to the **needs of scientists** (and the **incentives** made available to them).
- **Incentives matter**: harnessing global science to local needs important! How to achieve this?
- **Scientists need to use their autonomy in research** (historically, the best time ever) - and **protect** internal, academic, recognition-related mechanisms!
- **Policymakers need to**:
  - Understand **what drives** academic scientists in their work;
  - Understand the mechanisms of **academic recognition.**
  - Remember that recognition in science is a rather **fragile social** and professional mechanism.



25. Lessons from the Dynamics of Global Science (3/3)

- The **future of global science** is in the **hands of millions of scientists**, who make **individual decisions** on **whether or not** to collaborate (e.g. **with whom**).
- **Individual motivations drive scientists** to collaborate, shaping global science.
- **The role of individual scientists** in the globalization of science is **underestimated** and deserves more scholarly attention!
- The **micro-level** studies matter (expanding data sources, global surveys)!
- **The future, the next few years**: huge global **surveys**; datasets **integration**, **biographical**, administrative, **publishing**, citation and funding data combined – cloud computing and access to big data (preparatory studies: **Poland**, **HCRs** etc.).
- Therefore the **global academic profession studies** have a **fascinating future**!

More in:

The Globalization of Science: The Increasing Power of Individual Scientists

Forthcoming in: *The Oxford Handbook of Education and Globalization*. Edited by Paola Mattei, Xavier Dumay, Eric Mangez & Jacqueline Behrend.
Oxford: Oxford University Press. 2021.