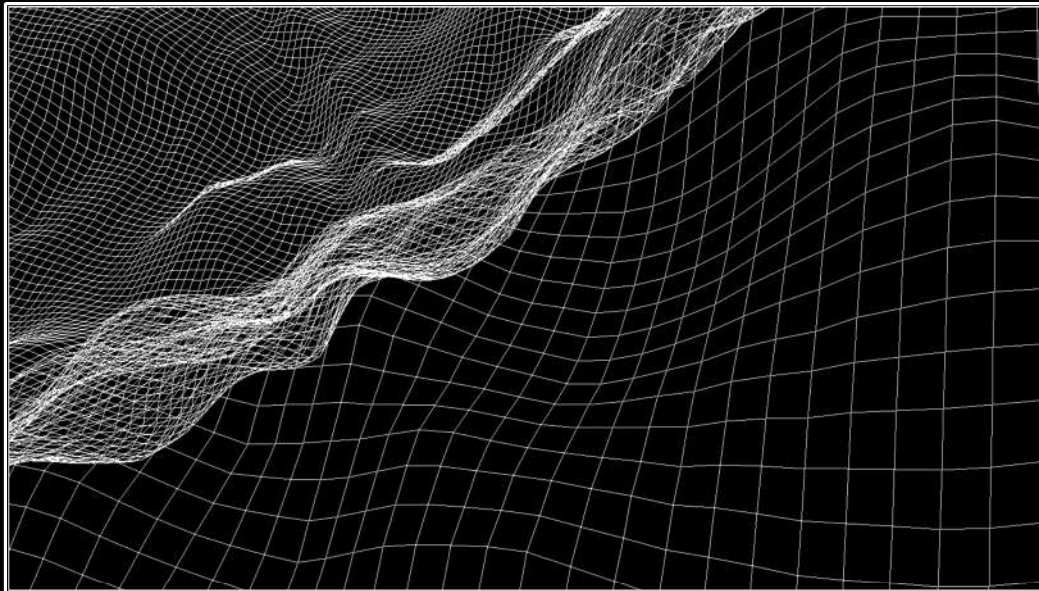


What drives global science? The four competing narratives

Simon Marginson, University of Oxford
University of Padua, Italy, 9 June 2021





After 1990 the Internet made possible the global science system

In *Theory of Society* Luhmann (2012) notes that the decisive step towards world society was 'the full discovery of the globe as a closed sphere of meaningful communication' (Volume 1, p. 85).

Electronically-mediated communication has made possible the birth and rapid expansion of a global science system, not driven by technology as such but by human agents.

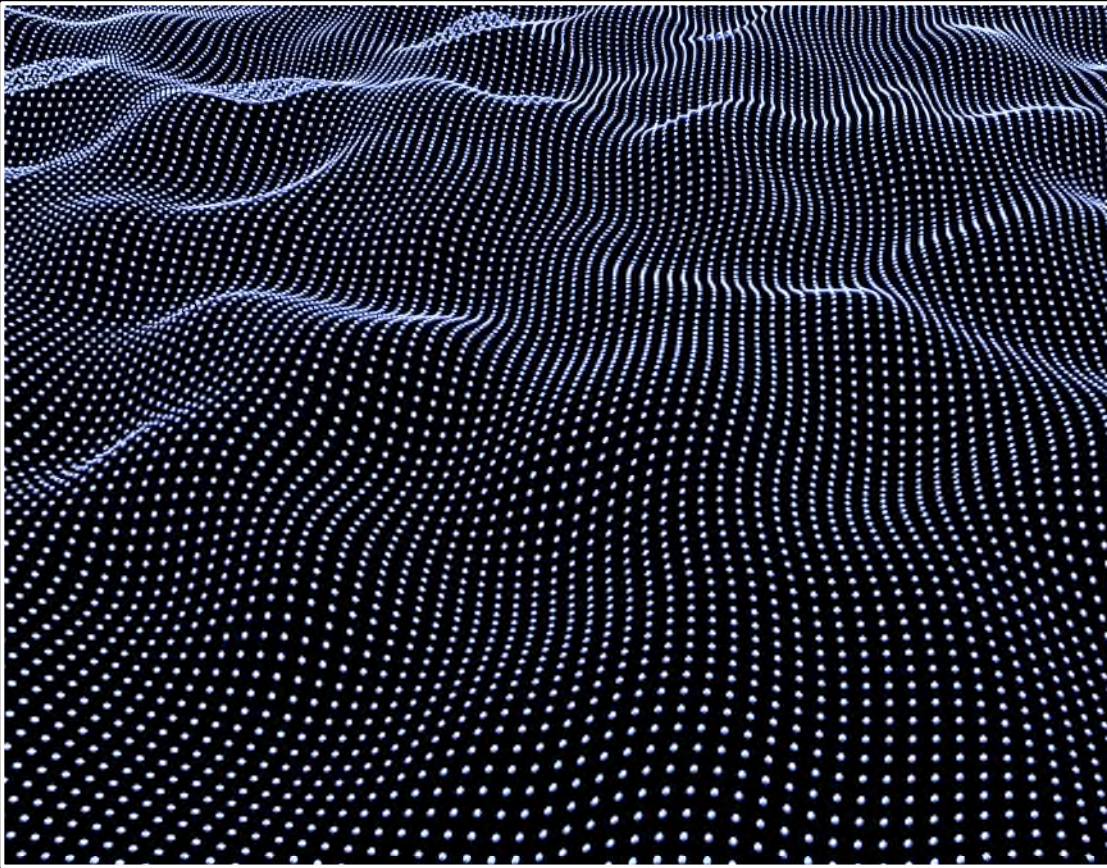


Not all
knowledge is
English-language
or Western
global science

- ‘... the understanding of the world by far exceeds the Western understanding of the world and therefore our knowledge of globalization is much less global than globalization itself... the more non-Western understandings of the world are identified, the more evident it becomes that there are still many others to be identified and hybrid understandings, mixing Western and non-Western components, are virtually infinite. Post-abysal thinking thus stems from the idea that the diversity of the world is inexhaustible and that such diversity still lacks an adequate epistemology. In other words, the epistemological diversity of the world does not yet have a form. ... Post-abysal thinking confronts the monoculture of modern science with the ecology of knowledges’
- - Boaventura de Sousa Santos (2007). Beyond abyssal thinking: From global lines to ecologies of knowledges. *Review (Fernand Braudel Centre)*, 30 (1), pp. 64-66

*Countries where over 50%
of people are English first
language speakers*





Rapid growth of science

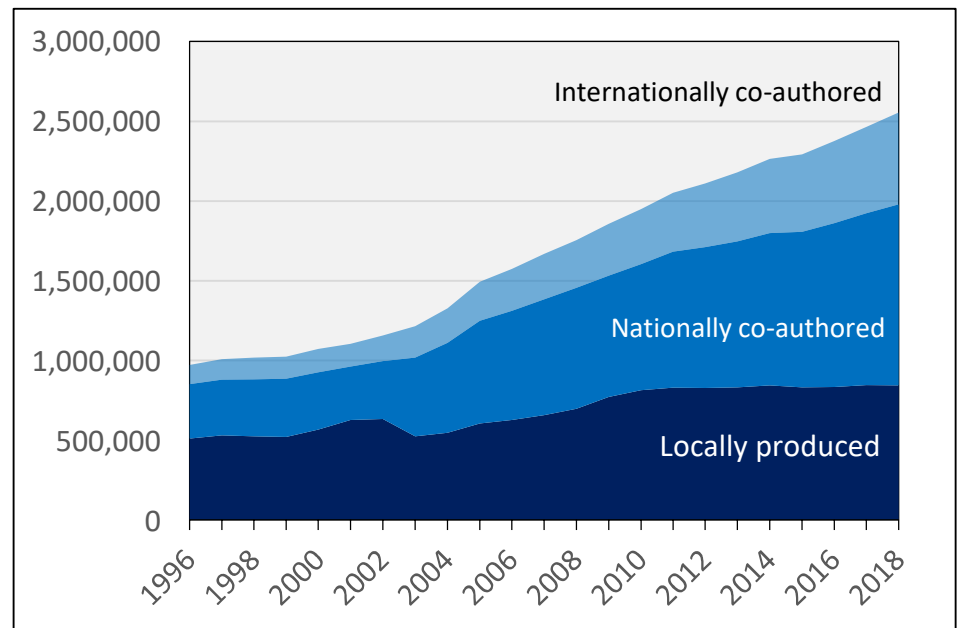
The global science system has spread in exceptionally dynamic fashion

- *Growth*: Rapid increases in many countries in R&D spending and growth of published science papers at 5 per cent a year since the year 2000
- *Diversification*: Science no longer an oligopoly of North America, Europe and Japan. Spread of national science capacity to many more countries
- *Networked cooperation*: Rapid growth of co-authorship in science at both global and national levels
- *Pluralisation*: Widening of group of leading science countries, rise of China and a range (though US science remains very strong and globally central)
- *Global integration*: Increase in the role of the global science system vis a vis national science systems – some researchers argue that the global science system has become the primary driver of science



GROWTH

Science papers in Scopus, by type of collaboration, world: 1996-2018



US National Science Board



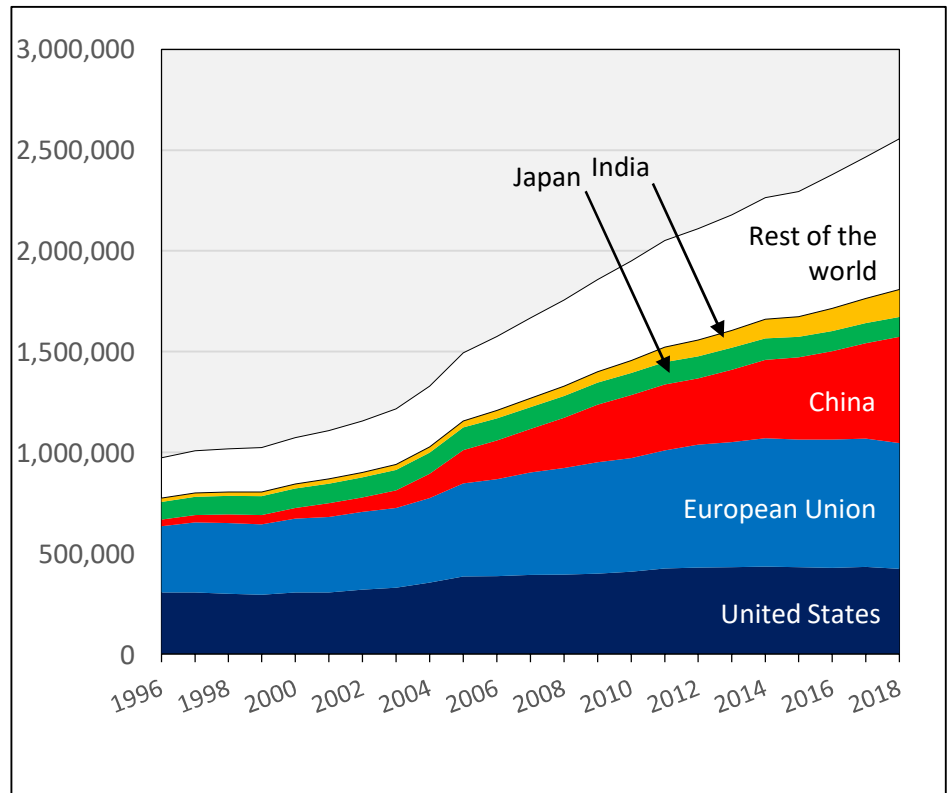
DIVERSIFICATION

The spread of research to more countries 1987-2017

	1987	1997	2007	2017
Number of countries producing 50% of world science	3 USA, UK, Germany	4 USA, Japan, Germany, UK	5 USA, China, Japan, Germany, UK	6 China, USA, India, Germany, Japan, UK
Number of countries producing 90% of world science	20	23	26	32

PLURALISATION OF POWER

Number of science papers in Scopus by world region: 1996-2018



'The new swing of the pendulum ... is going to lead to a world where no one will be dominant... What is different about our time is that globalization forces us to live all jumbled together and yet we have very different visions of what this common world should look like. [Political scientist] Charles Kupchan writes: "The next world will hardly be the first one in which the different great powers operate according to different conceptions of order. But, due to the onset of global interdependence, it will be the first time that such a diverse set of orders intensely and continuously interact with each other.'"

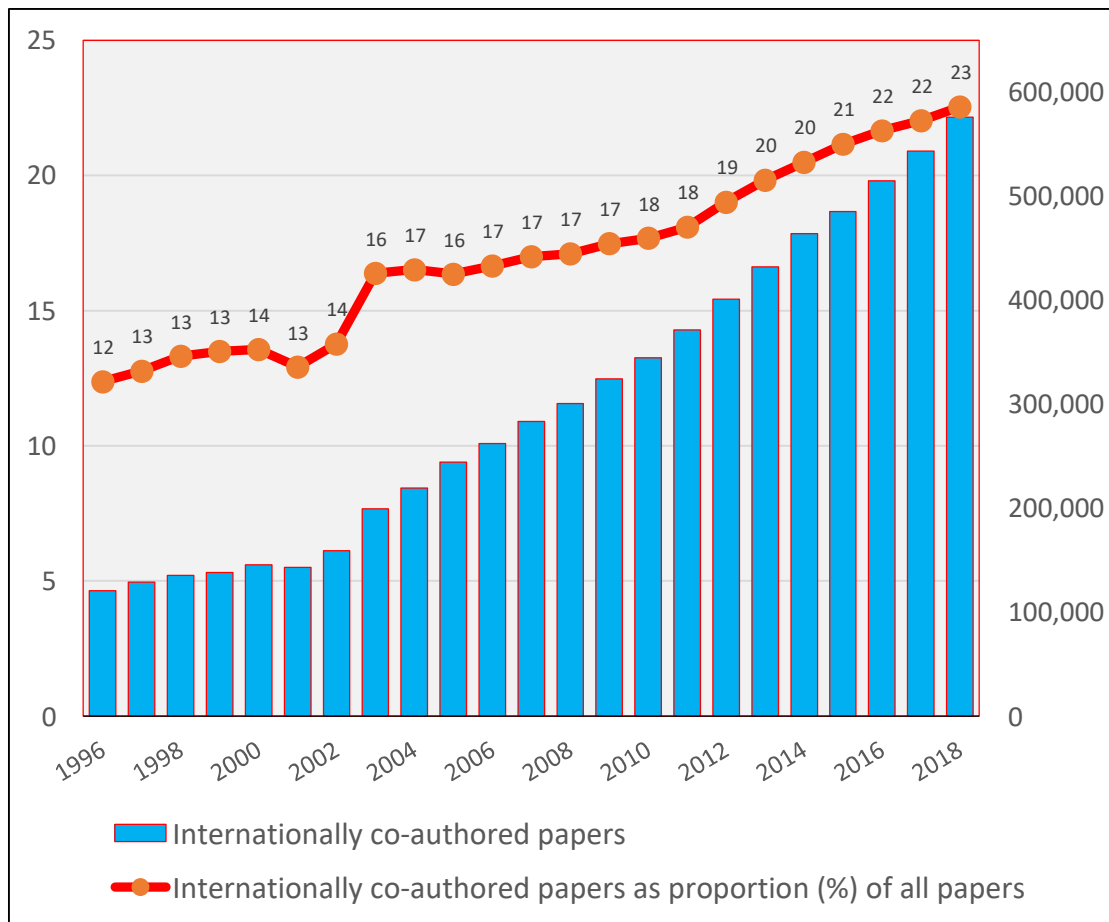
- Bruno Macaes, *The Rise of Eurasia*, 2018, p. 2.





RISING GLOBAL COLLABORATION

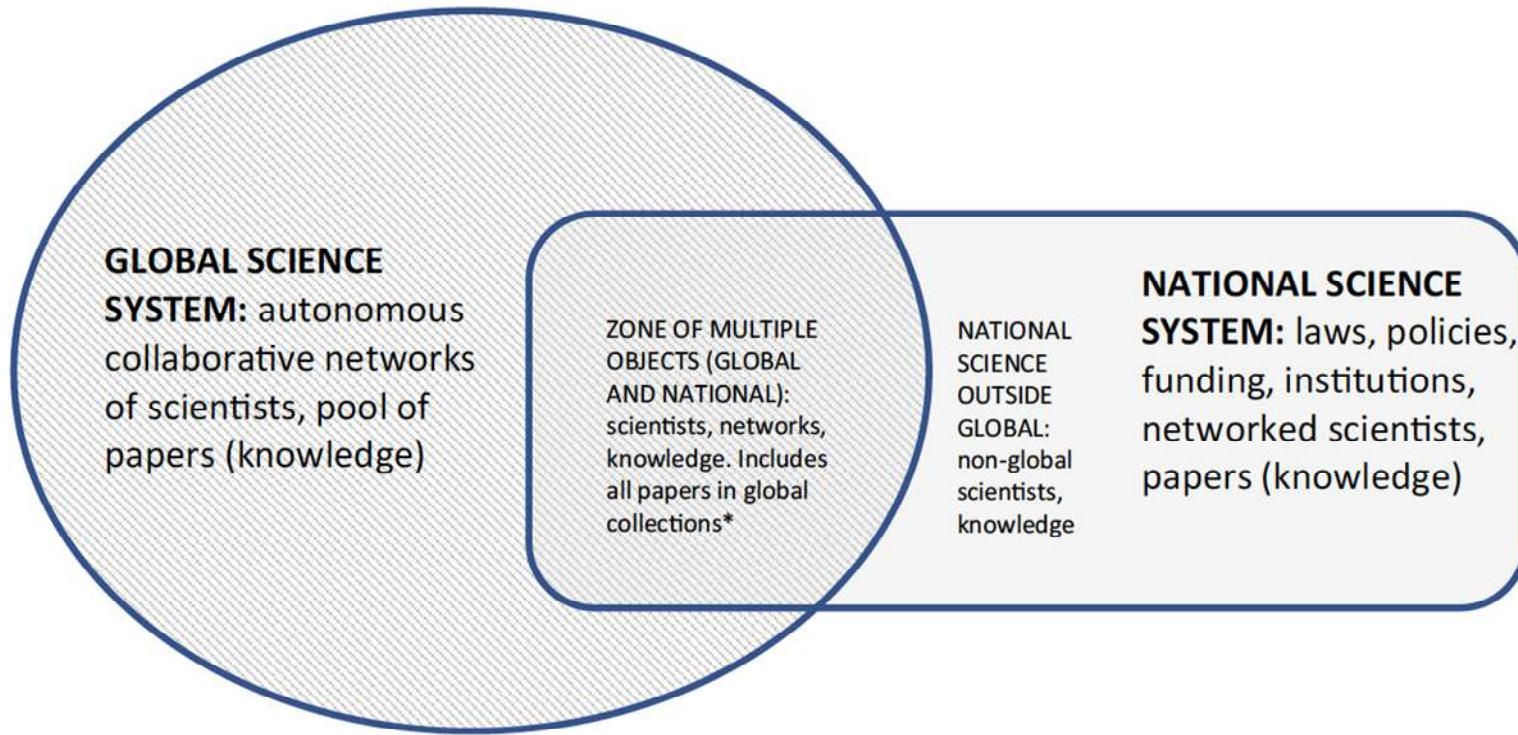
Internationally co-authored papers, all countries: 1996-2018





The nation-state factor in science



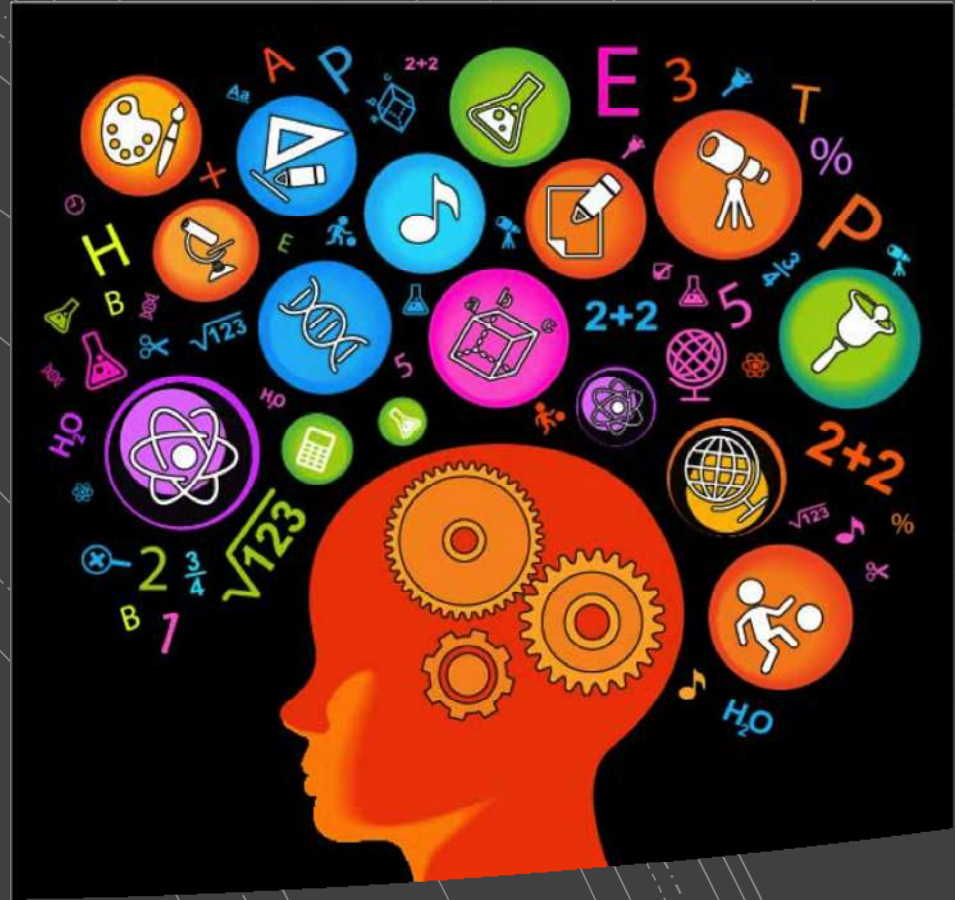


Global science and national science: two distinct and overlapping science systems

- ‘The global network has a culture, pathways, and norms of communication specific to its structure, and diverging from national, regional, or disciplinary norms’ - Wagner, Whetsell and Leydesdorff, 2017, p. 1646.

Differences between national and global science

	Global science system	National science system
Core components	Knowledge, people, networked communications, norms and practices	Nation-state ordered and resourced institutional structure of science activity
Enabling conditions	Resources, institutions, and (often national) agencies/policies/rules	Political and economic stability and policy commitment to science activity
Main functions	Production and circulation of new knowledge via networked activity	Legal, political, financial conditions of science. Some knowledge, applications
Boundary	World society	Nation-state
Normative centre	No normative centre	Nation-state
Knowledge contents	Papers published in journals admitted by Web of Scienc and Scopus	Most contents of global journals plus further nationally circulated materials
Social relational	Collegial groups of scientists operating in networks	Government agencies, research organisations, networked scientists
Collective loyalty	Diffuse: disciplinary community as persons and as shared knowledge	Concentrated: national and institutional authorities
Regulation	Local self-regulation on the basis of global collegial scientific norms	National law, official regulation, policy, financing systems, cultural norms
How this system affects the other system	Knowledge potential of global science stimulates state funding	National resources, institutions and personnel underpin global science



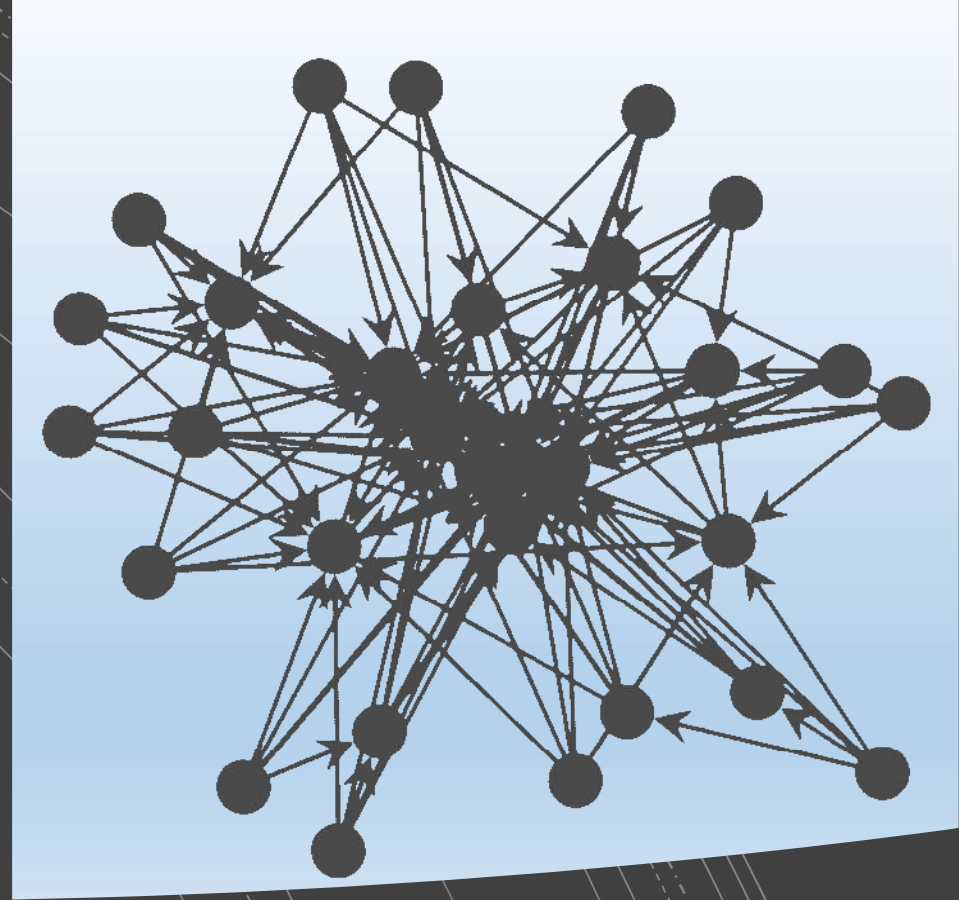
What motivates
global scientific
collaboration?

- Cognitive accumulation



What motivates
global scientific
collaboration?

- Cognitive accumulation
- Intellectual or resource affinity



What motivates
global scientific
collaboration?

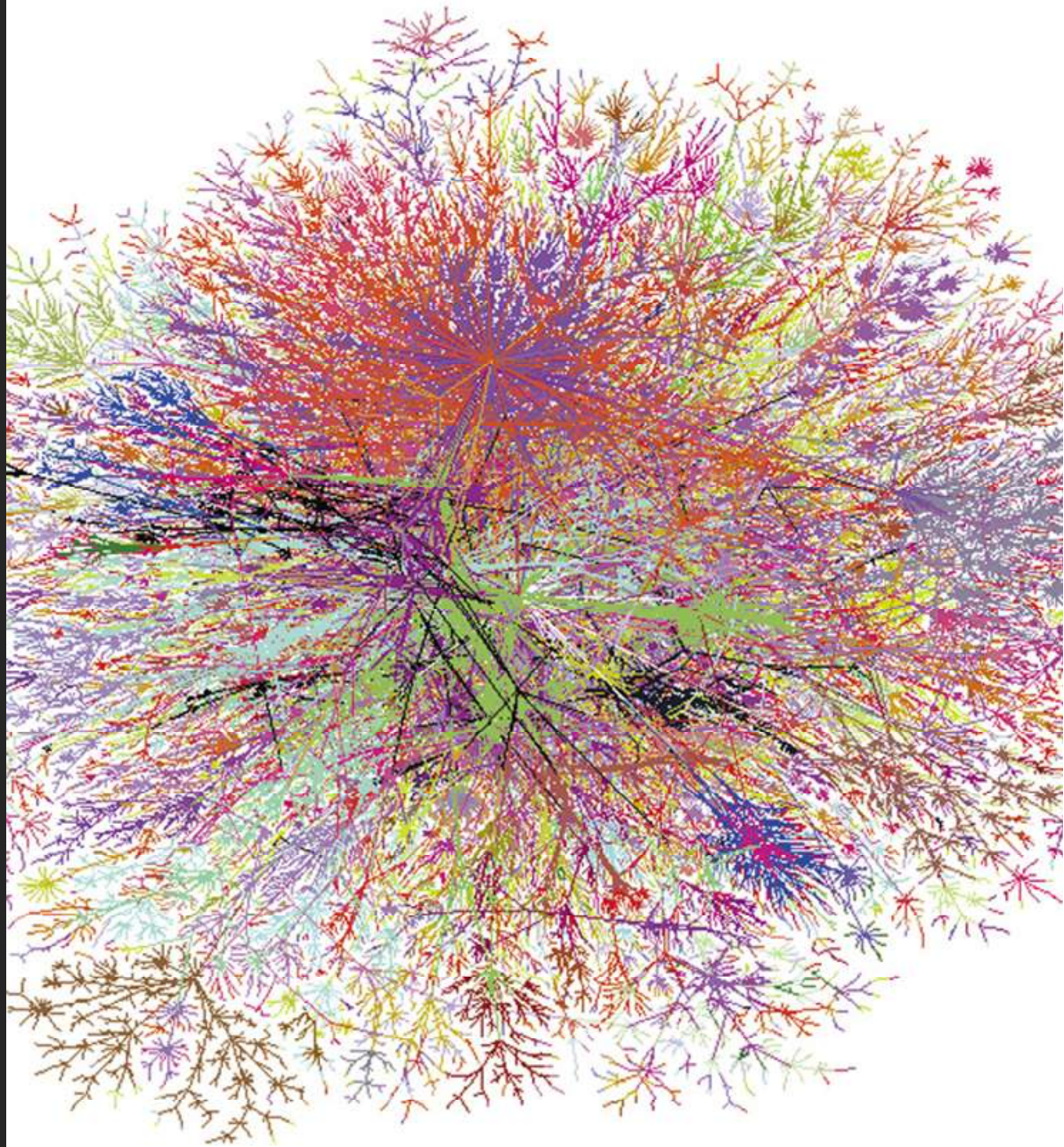
- Cognitive accumulation
- Intellectual or resource affinity
- **Preferential attachment**

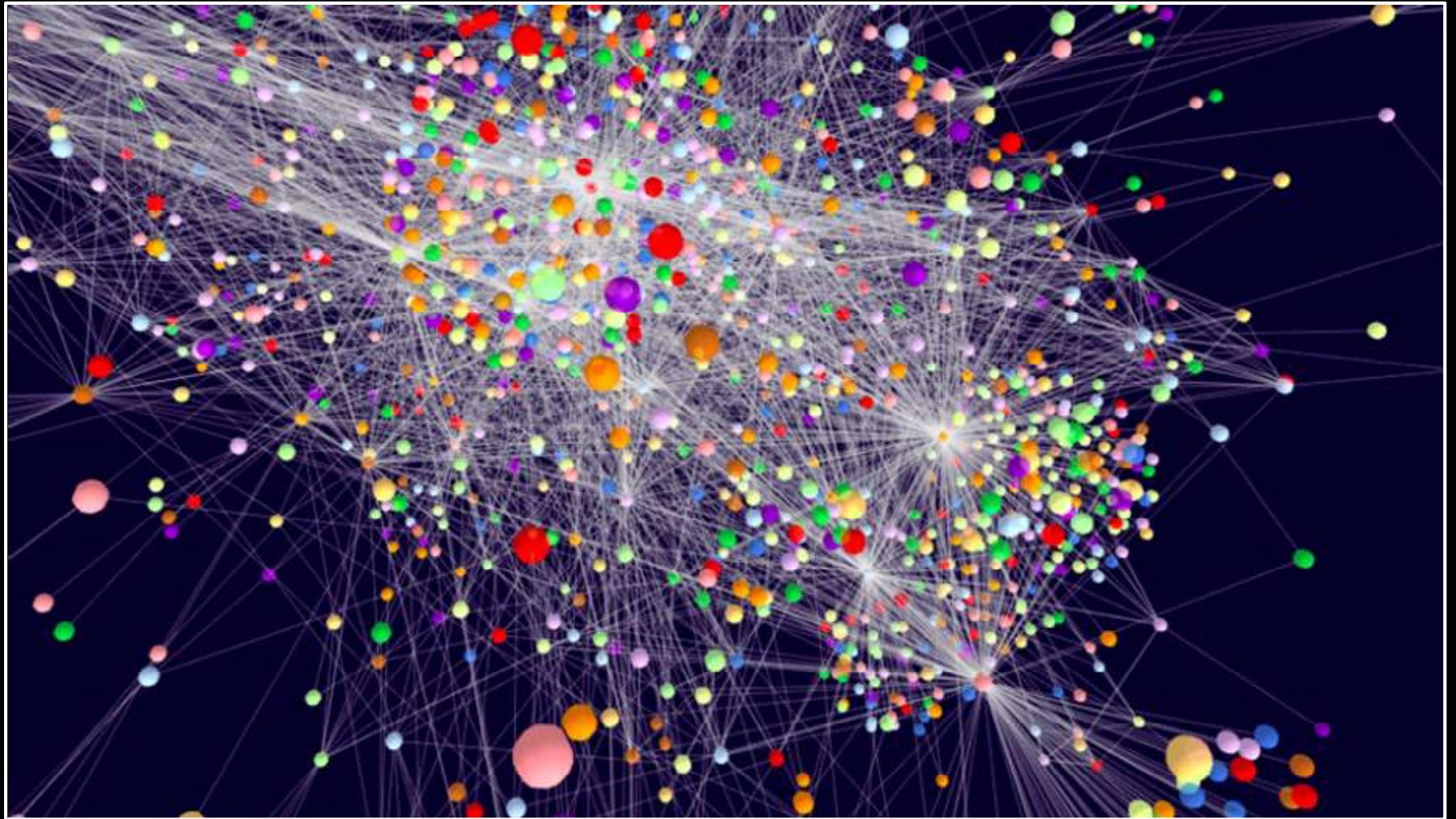
The global science system?

- An open and flat network that expands continually?
- National 'arms race in innovation'?
- Global market of competing universities (World Class Universities, WCUs)?
- A centre-periphery world systems hierarchy?

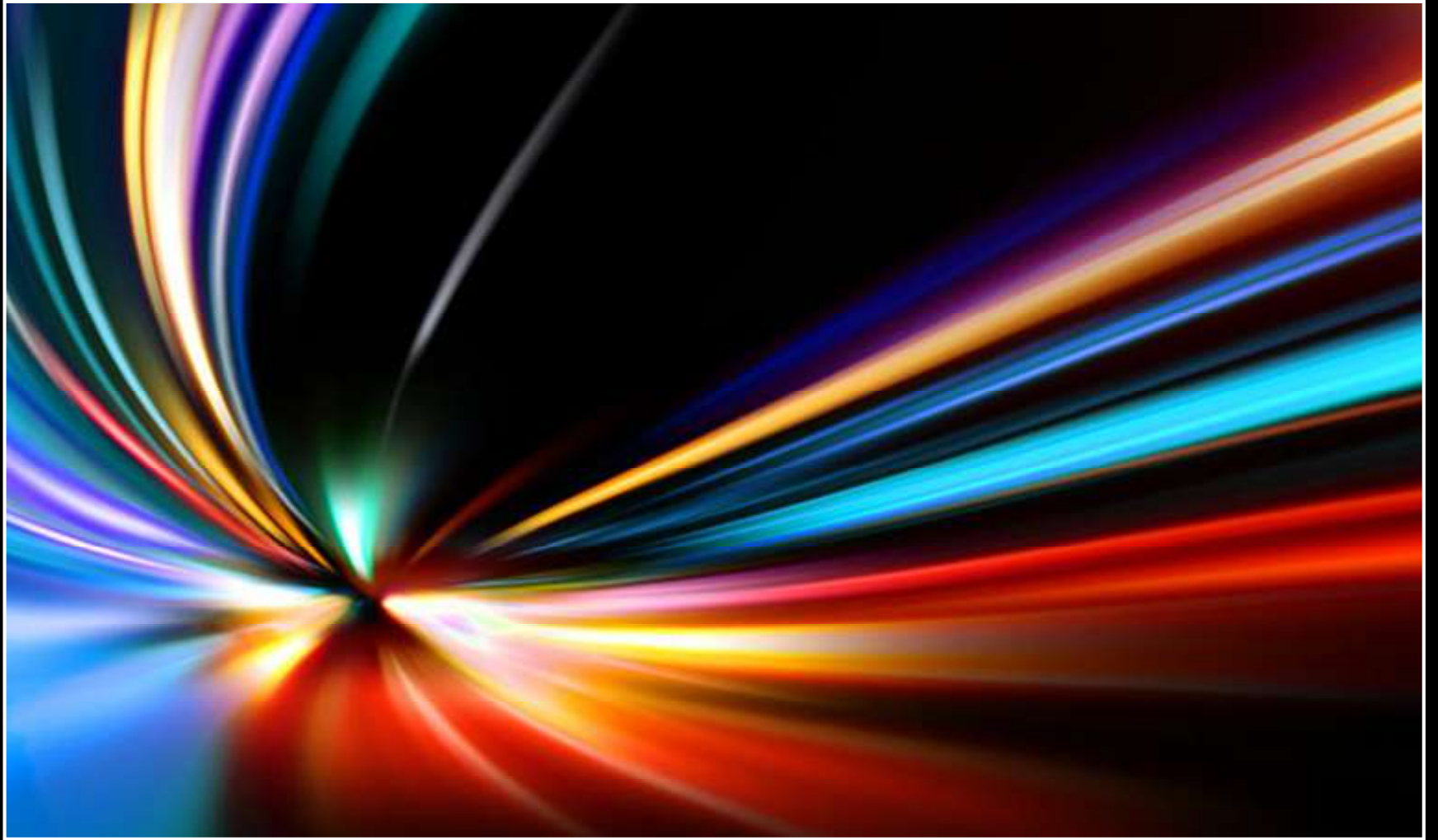


Narrative 1:
An open and
flat network
that expands
continually





Network connectivity



Network dynamism



Global science is flat?

‘The organization may be more open to new members, since greater density of the network and the lowered in-betweenness measures suggest that fewer of the communications pass through the leading nodes or countries ... international cooperation is particularly advantageous for less advanced countries ...’

- Wagner, C., Park H. and Leydesdorff, L. (2015). The continuing growth of global cooperation networks in research: A conundrum for national governments, *PLoS ONE* 10 (7)



Reasserting the vertical

‘If hierarchy is neglected, preoccupation with connections may blur an accurate understanding ... the network is embedded in structural inequalities, but the impression arises that it operates in a vacuum.’

- Conrad (2016), *What is Global History?*, pp. 70, 127.

Narrative 2:
National
arms race in
innovation





Methodological
nationalism traps us
in the national
container: we cannot
see global science

“Methodological nationalism” is grounded in the belief that the nation/state/society is the natural social and political form of the modern world’ - Wimmer and Schiller (2002), p. 301

‘Conventional social theories operate within what can be called an internalist paradigm... social theories essentially treat societies as self-generating and assume that social change is always of a society’s own making. Global history, by contrast ... recognises the impact of structures that extend past the boundaries of individual societies’ – Conrad (2016), pp. 88-89



Is it valid to arbitrarily ascribe global science data to individual nations?

'The sciences develop internationally, but the funding is mainly national' - Bornmann, Adams and Leydesdorff, 2018, 931

'Comparisons are to a degree confounded because a large and growing fraction of scientific work involves international collaborations ... Another concern is that there is an English language bias in the ISI data base, both in the journals included and in patterns of citation... Could this explain why the United States, United Kingdom and Canada do so much better than France, Germany, Italy and Japan?'

- Robert May 1997), The scientific wealth of nations, *Science*, 275, p. 795 – the article that launched international comparisons in science

Science to innovation to business profit?

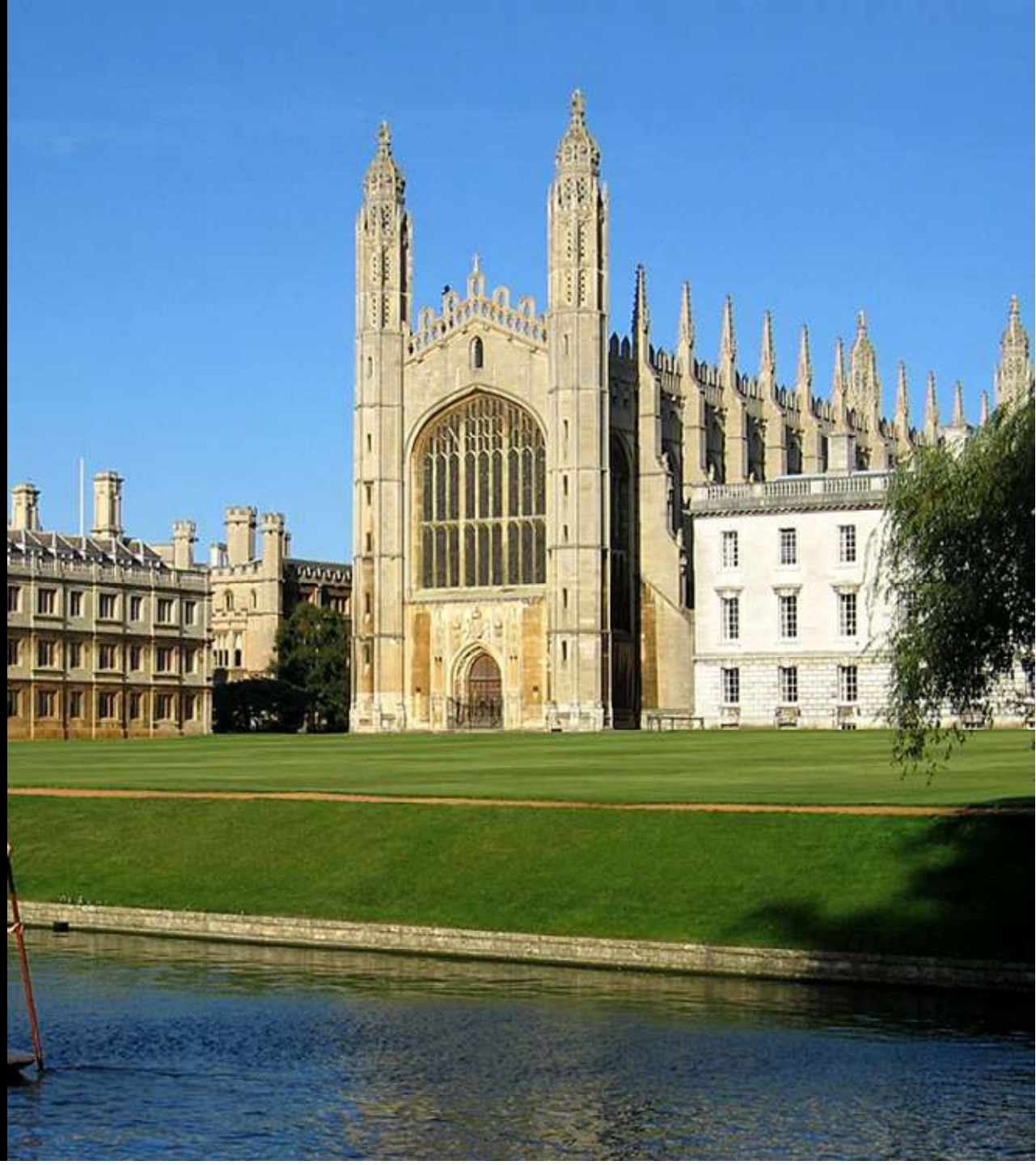
The myth of nation-based linear causality

- Science enters a global pool:
national science can be used by
foreign not local capital
- Innovations by national industry
can be sourced in foreign origin
science
- Most research is 'altruistic', not
focused on national economic
development (e.g. research in
medical and health sciences,
social sciences)

- Richard Klavans and Kevin Boyack (2017).
The research focus of nations: Economic vs.
altruistic motivations. PLOS ONE, 12 (1)



Narrative 3:
Global
market of
'World-Class
Universities'





The key role of science in global university rankings



Rankings	Publication-related indicators as proportion %	Databases
Shanghai Jiaotong Academic Rankings of World Universities (China)	70.0	Clarivate Analytics' Web of Science
Times Higher Education World University Rankings (UK)	38.5*	Elsevier's Scopus
QS World University Rankings (UK)	20.0*	Elsevier's Scopus
Leiden Ranking (Netherlands)	100.0	Clarivate Analytics' Web of Science
Best Global Universities (US)	72.5	Clarivate Analytics' Web of Science

Source: The methodology pages on above rankings' websites, updated on 21-January-2021.

* Research performance has a further, indirect but important, effect through its impact on the surveys used by Times Higher and QS

Rankings approach to competition in science – when extended to World Cup in football

BACKWARD OLD APPROACH

The winner is determined by -

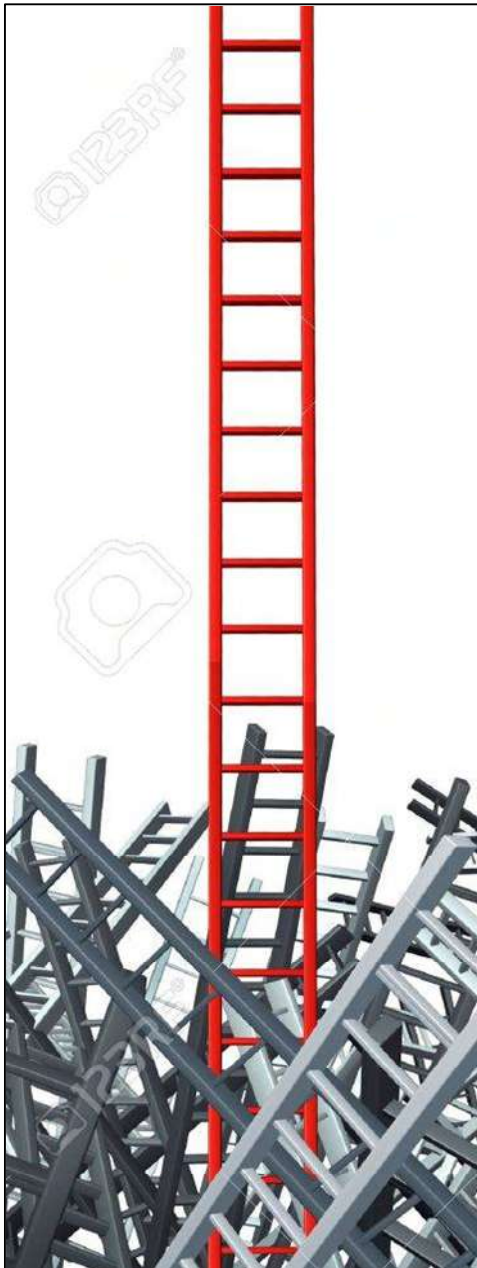
100.0% whichever team
scores the most goals

BRILLIANT RANKINGS APPROACH

The winner is determined by -

40.0% whichever team scores
the most goals
20.0% size of team's fan-base
12.5% player endorsement
revenues
12.5% amount of media
coverage for team
15.0% how much was spent on
consultancy fees for QS

Composite multi-indicator rankings use arbitrary weightings of different elements of institutional activity. These weightings are untheorised. Why should, say, PhD student numbers be 5%, or high citation researchers 10%? Reverse those percentages and a very different rank order appears – which is the 'true' hierarchy in science?



University rankings explain nothing about science, yet they order it

Papers in the top 5% of the field by citation rate, 2016-19, Leiden ranking

university	country	Top 5% papers	all papers	% of all papers in top 5%
Harvard U	USA	4230	34,234	12.4%
Stanford U	USA	2117	16,454	12.9%
U Oxford	UK	1696	16,088	10.5%
U Toronto	CANADA	1691	23,454	7.2%
MIT	USA	1586	10,507	15.1%
Tsinghua U	CHINA	1574	21,225	7.4%
U Michigan	USA	1490	18,756	7.9%
U Cambridge	UK	1440	14,080	10.2%
Johns Hopkins U	USA	1439	17,337	8.3%
U College London	UK	1430	14,923	9.6%
Zhejiang U	CHINA	1427	25,964	5.5%
U Pennsylvania	USA	1290	13,568	9.5%
U Washington , Seattle	USA	1288	14,807	8.7%
Columbia U	USA	1234	12,558	9.8%
U California, Berkeley	USA	1225	10,006	12.2%

Narrative 4: Global
science as a
centre-periphery
hierarchy



Wallerstein's world-systems theory and the centre-periphery model

- All nations are incorporated into an expanding Euro-American world-system grounded in the capitalist world-economy
- World-system is based on a three-way division of labor between countries (1) world 'centre' in US, parts of Western Europe, perhaps Japan, with strong states; (2) nations on 'periphery' where states are endemically weak or non-existent, controlled by foreign capital; and (3) nations of the intermediate 'semi-periphery', China, Korea, Russia, Australia, other Europe, etc
- Countries in the periphery and the intermediate semi-periphery are locked into position. It is very difficult to move from one category to another, because there is a zero-sum contest over a limited 'world-surplus'
- Individual nations do not have autonomy: 'There is no such thing as "national development"' (Wallerstein, 1974, p. 390).
- The world level solely consists of nation-states. There are no autonomous global relations that crisscross and combine nations (so an autonomous global science system as such is impossible)

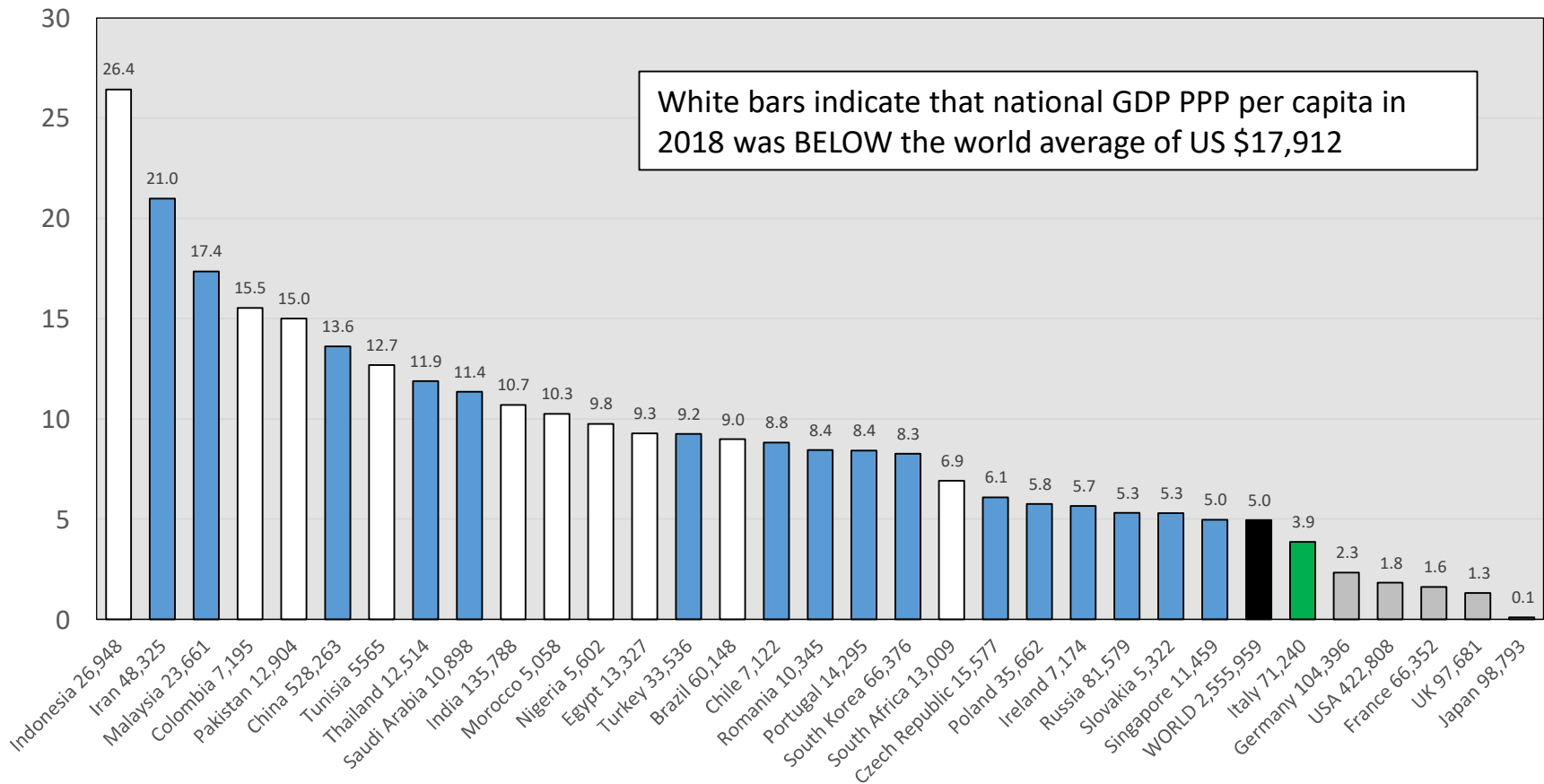


But many countries in the 'periphery' are successfully developing science systems



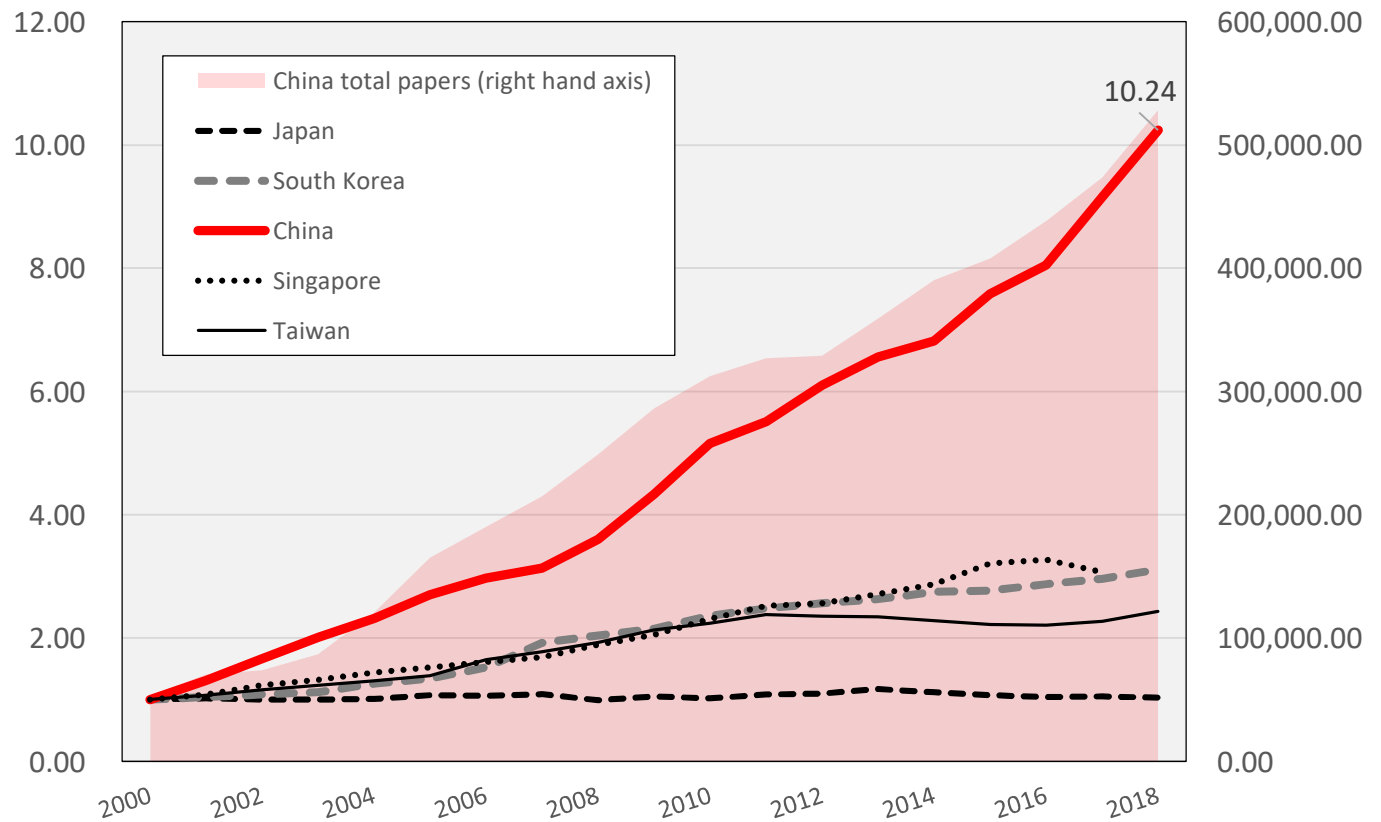
Average annual growth (%) in science papers: 2000-2018

Countries with science growth rate *above world average* of 4.95% per year and producing more than 5000 papers in 2018, plus six major science countries



China has destroyed beliefs that science is necessarily Euro-American centric

Spending on R&D in higher education, constant prices, East Asia: 2000-2018 (2000 = 1.00)



Top universities in STEM research

(1) physical sciences and engineering, and (2) mathematics and complex computing, Papers in top 5 per cent of their field by citation rate, World: 2016-2019 (*Leiden ranking*)

University	System	Physical sciences & engineering
Tsinghua U	CHINA	909
MIT	USA	683
Zhejiang U	CHINA	622
Nanyang TU	SINGAPORE	566
U Science & T.	CHINA	556
Harbin IT	CHINA	545
Stanford U	USA	541
Shanghai JT U	CHINA	513
Xi'an Jiaotong U	CHINA	512
Huazhong U S&T	CHINA	502
Harvard U	USA	487
National U	SINGAPORE	455
U Calif., Berkeley	USA	449
Peking U	CHINA	444

University	System	Maths & computing
Tsinghua U	CHINA	292
U Electronic S&T	CHINA	275
Harbin IT	CHINA	269
Huazhong U S&T	CHINA	231
Xidian U	CHINA	221
Beihang U	CHINA	215
MIT	USA	205
Zhejiang U	CHINA	194
Southeastern U	CHINA	193
Nanyang TU	SINGAPORE	187
Shanghai JT U	CHINA	178
Northwestern P. U	CHINA	164
Wuhan U	CHINA	161
Beijing IT	CHINA	159

The centre-periphery model in science studies: *Ignoring reality*

- The singular world-economic structure of world-systems theory negates: (1) the autonomy of global relations, (2) the autonomy and agency of nations and persons, and (3) the potency of context and culture, as distinct from economics
- The centre-periphery model --
 - Does not usefully explain rapid growth of scientific papers and networked collaboration, and the element of 'flatness' in scientific networks that enables the building of scientific initiatives in new and developing science countries
 - Does not explain explosive and simultaneous growth of science in many countries on the named 'periphery' and 'semi-periphery'
 - Does not explain the rapid development of free-standing links between countries in the 'periphery'
 - Does not explain the rise of China and East Asia in science, and India which is now the third largest producer of science after China and US
 - Cannot adequately explain the motivations of scientists, who have epistemic projects and personal values in common, across borders
- Nations are not locked in by Euro-American power, the scientists and their agency are also not wholly contained by nations. Centre-periphery theory gives all power to neo-imperialism and underestimates the different agencies of both emerging nations, and scientists themselves.



The four narratives of global science: the test of explanation

Narrative	Characteristic of global science that requires explanation				
	Rapid growth of papers	Spreading to many nations	Growth of co-authorship	Multi-polarity	Hierarchy, inequality
Global science as a pan-national network of scientists	YES	YES	YES	WEAK	NO
Global science as an arms race in innovation between nations	WEAK	WEAK	NO	WEAK	YES
Global science as a global market of 'World-Class Universities'	WEAK	WEAK	NO	WEAK	YES
Global science as a centre-periphery hierarchy of nations	NO	NO	NO	NO	YES

Conclusions

- The global science system is naturally open and partially autonomous
- Both its horizontal and vertical dimensions are essential to understanding global science: it can be theorised as a network articulated by
 - scientific nodes of unequal capability, whose agency is a function of nodal resources, connectedness, and scientific activity/production
 - hegemonic power that stratifies, and includes/excludes, knowledge
 - arbitrary state and regional interventions, through funding, policy and regulation; and episodic interventions by market forces
- States affect science through (1) actions that directly shape the network and its connections (e.g. US migration policy, or Internet in China), and (2) actions that shape local nodes and activity (e.g. resourcing)
- Neither politics nor economics permanently suborn collegial scientific conversations, which are sustained by networked epistemic sociability
- In the firm Anglo-American hegemony that grips global science, it is the science communities themselves, plus the commercial bibliometric companies, that exercise the homogenising role, locking out more diverse knowledge, agendas and agents
- If linguistic plurality and reciprocal translation were normalised, and bibliometrics began to open up to a fuller range of disciplines and forms of output, much could change in global science.

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