

'This world-order [*kosmos*], which is the same for all, did none of gods or men make.

'But it always was, and is, and shall be: an everliving fire, kindling in measures and dying down in measures.'

-- attributed to Heraclitus of Ephesus (544-484 BCE)



# Everliving fire: China in global science

An Oxford Department of Education lecture

Simon Marginson /2 November 2020



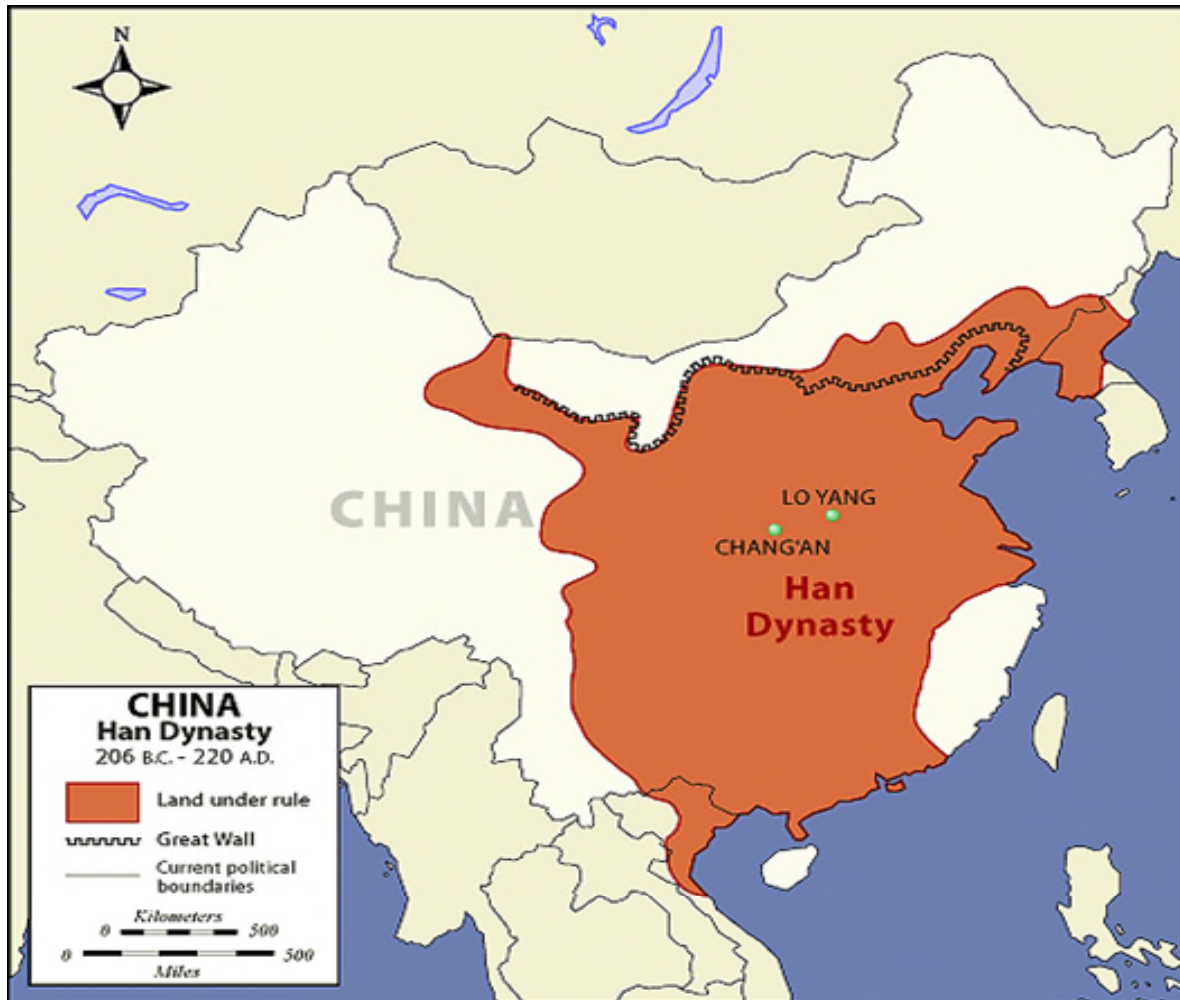
# The comprehensive Sinic state begins

First effectively centralised Chinese state (Qin), 221-206 BCE



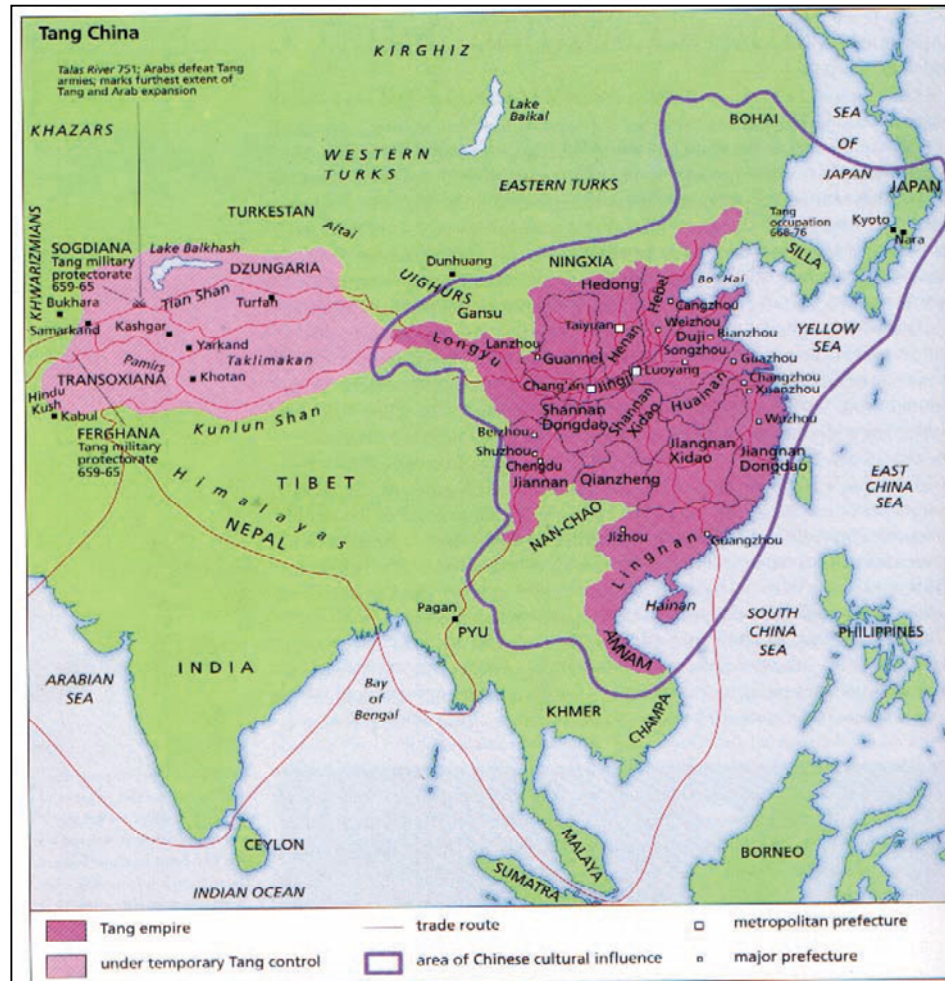
# The Sinic state is consolidated

## Han dynasty China 206 BCE – 220 CE



# Sinic cultural sphere extends in East Asia

## Tang Dynasty 618-907 CE



# Song Dynasty 960-1279 CE



# Yuan Dynasty 1280-1365 CE



# Ming Dynasty 1368-1644 CE





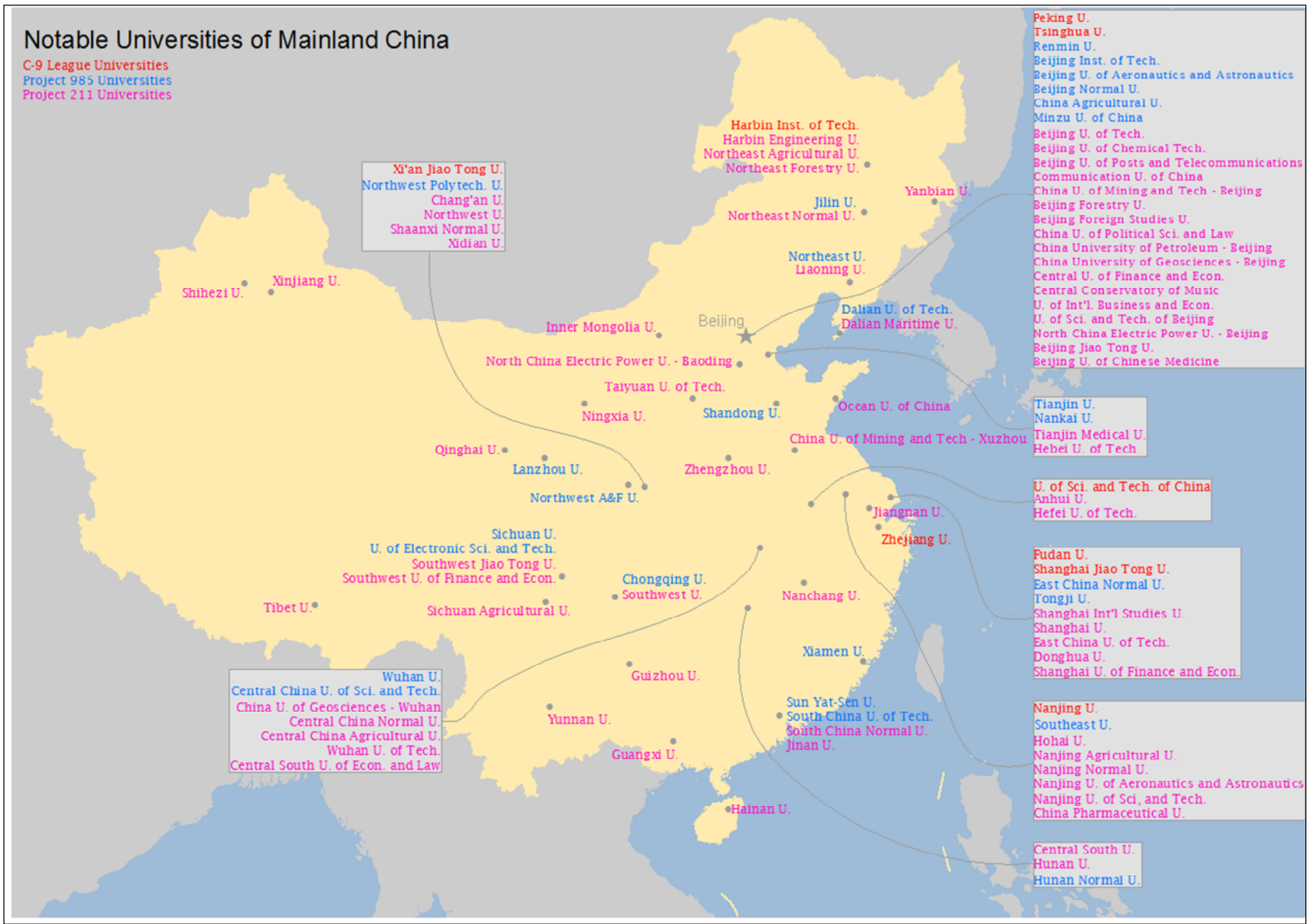
# Qing Dynasty 1644-1912 CE





# Notable Universities of Mainland China

C-9 League Universities  
 Project 985 Universities  
 Project 211 Universities

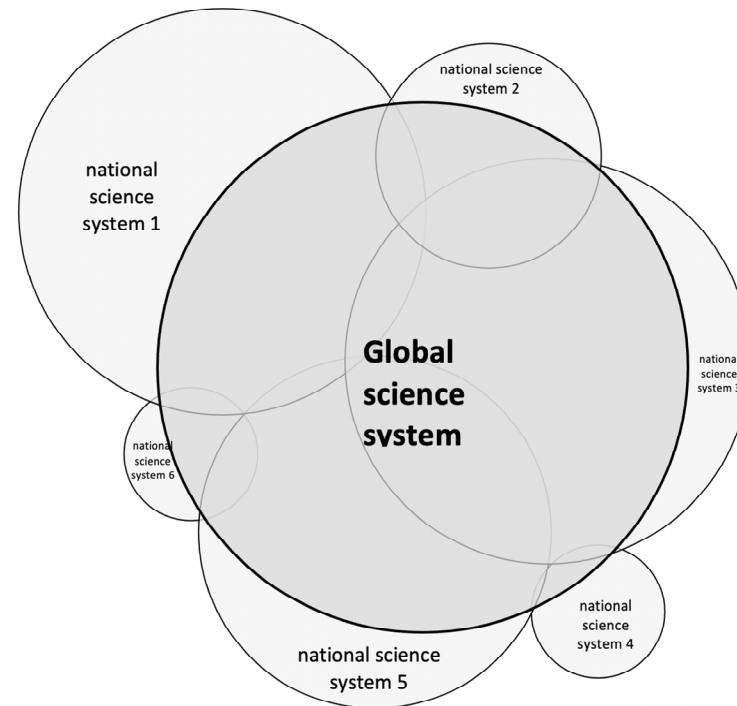


# Science system as assemblage

- Researchers and research groups
- Communications and information
- Organisations such as universities,
- Machinery and equipment as technologies
- Knowledge published
- Informal knowledge, conversations, data
- Government, policies, rules, conventions, codes

Since the 1990s a global science system has formed, based on the common pool of papers, and held together by extensive and growing cross-border citation and collaboration (joint papers) –

- the global science system is based on grass roots collaboration and has significant autonomy from national governments and national science systems – but the global system is ultimately supported by national and institutional funding and infrastructure
- many leading scientists wear two hats, (1) institutional/national and (2) disciplinary/global
- in a nation-bound world, the longer-term future of the global science system is not certain



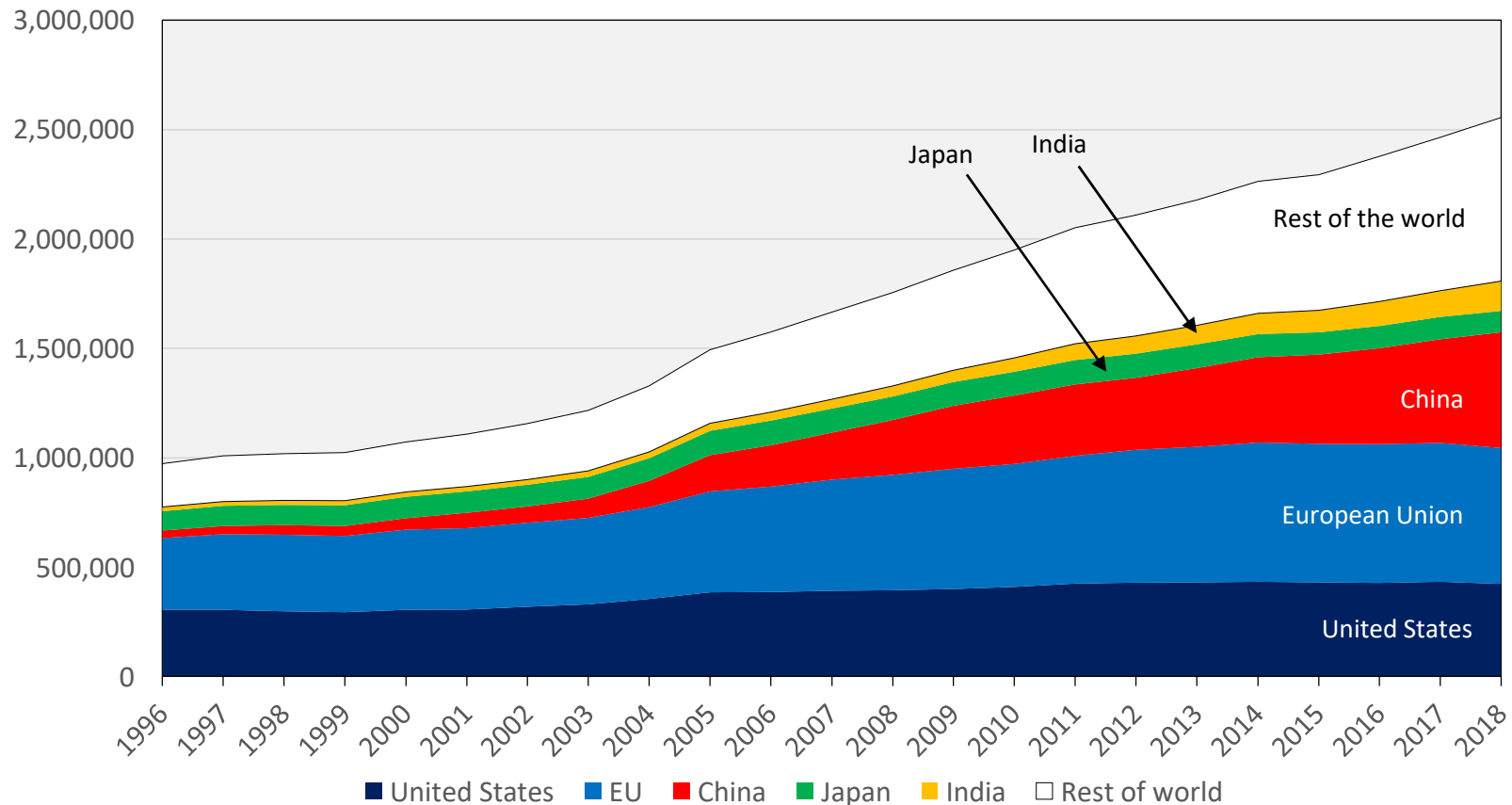
# Opening up science after 1978

- Deng Xiaoping “considered science to be the most crucial of the four modernisations, the one that would drive the other three (industry, agriculture and national defense).” (Vogel, 2011, p. 197)
- *Depoliticisation*: “Deng said that science had no class character; it could be used by all classes and all countries despite their different political and economic systems” (Vogel, 2011, p. 201). It was enough that scientists were loyal to country and party (p. 202)
- Catch up was essential but China needed original and basic science: Deng saw *internationalisation* not as a source of borrowed science but a guide to building China’s own capacity

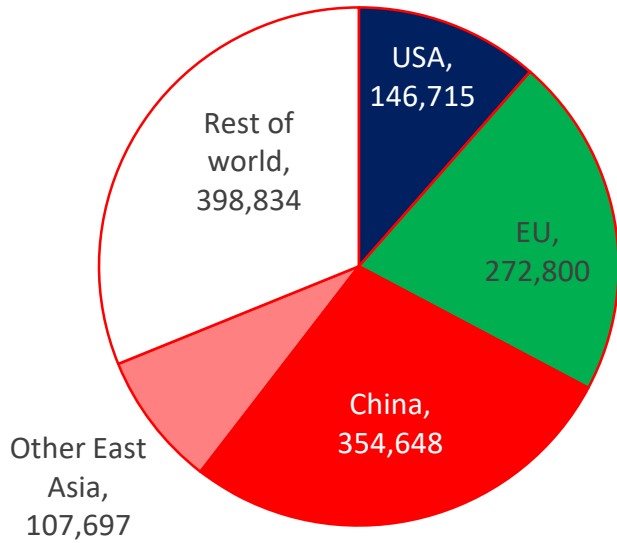
Vogel, E. (2011). *Deng Xiaoping and the transformation of China*.  
Cambridge, MA: Belknap Press



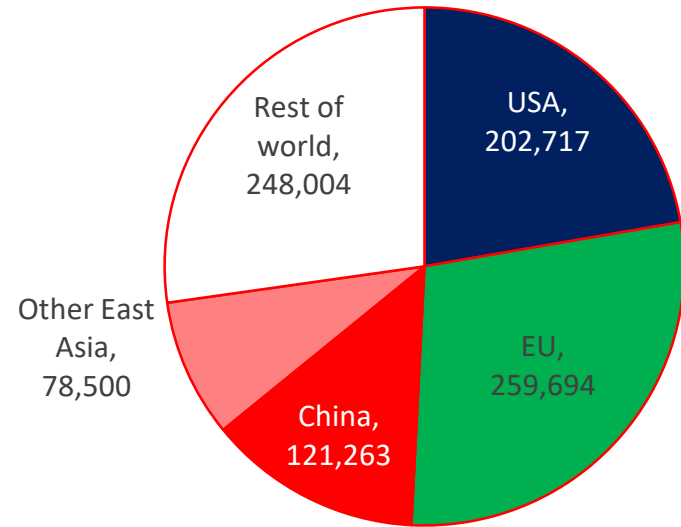
# Number of science papers in Scopus by large world region: 1996-2018



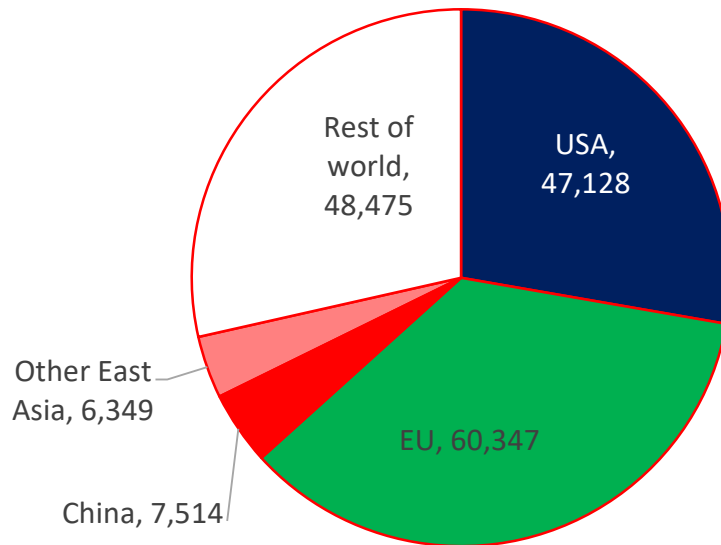
## Physical sciences STEM



## Biological and Health



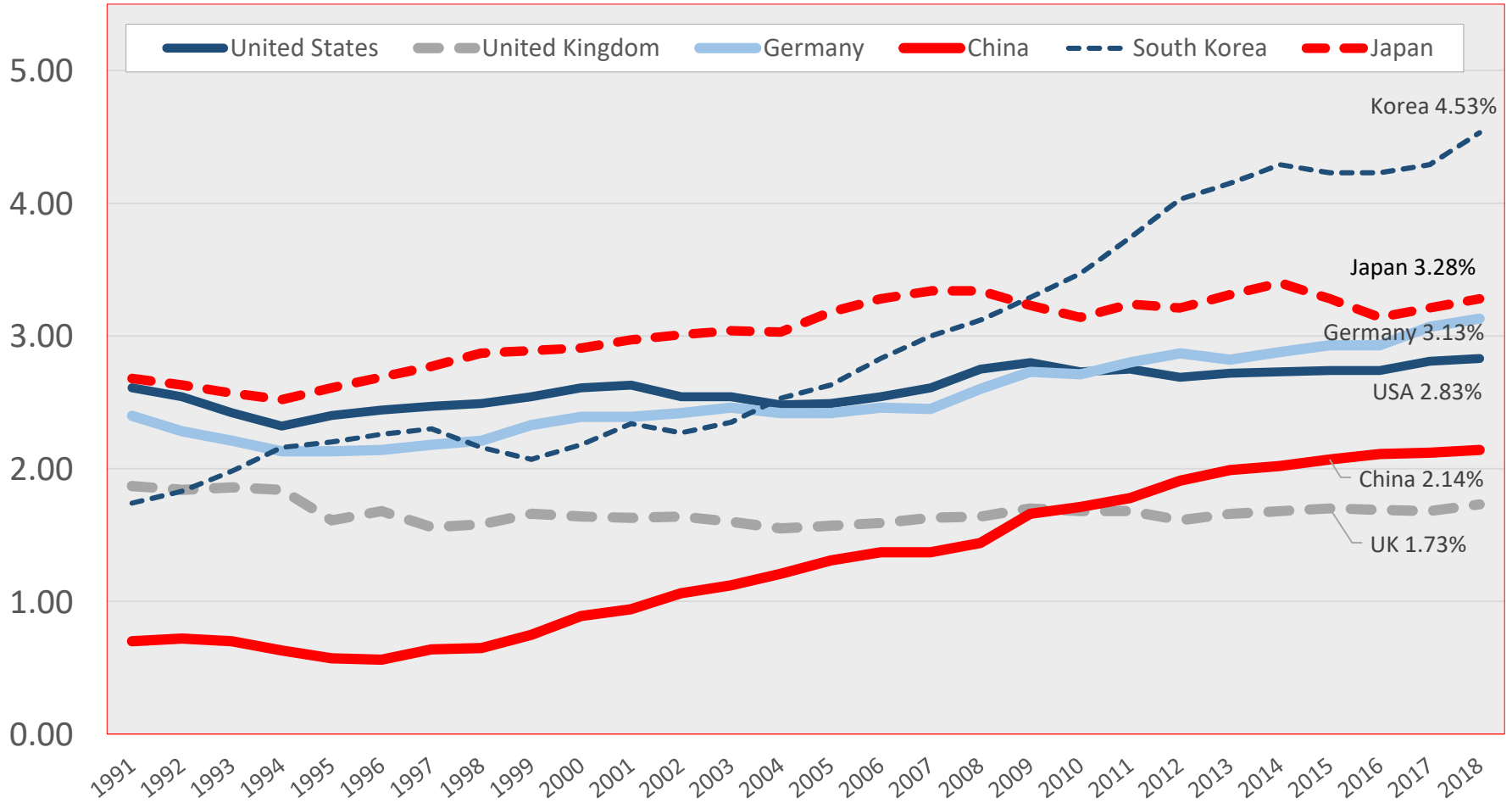
## Social sciences and Psychology



Total papers, by large discipline cluster, 2018

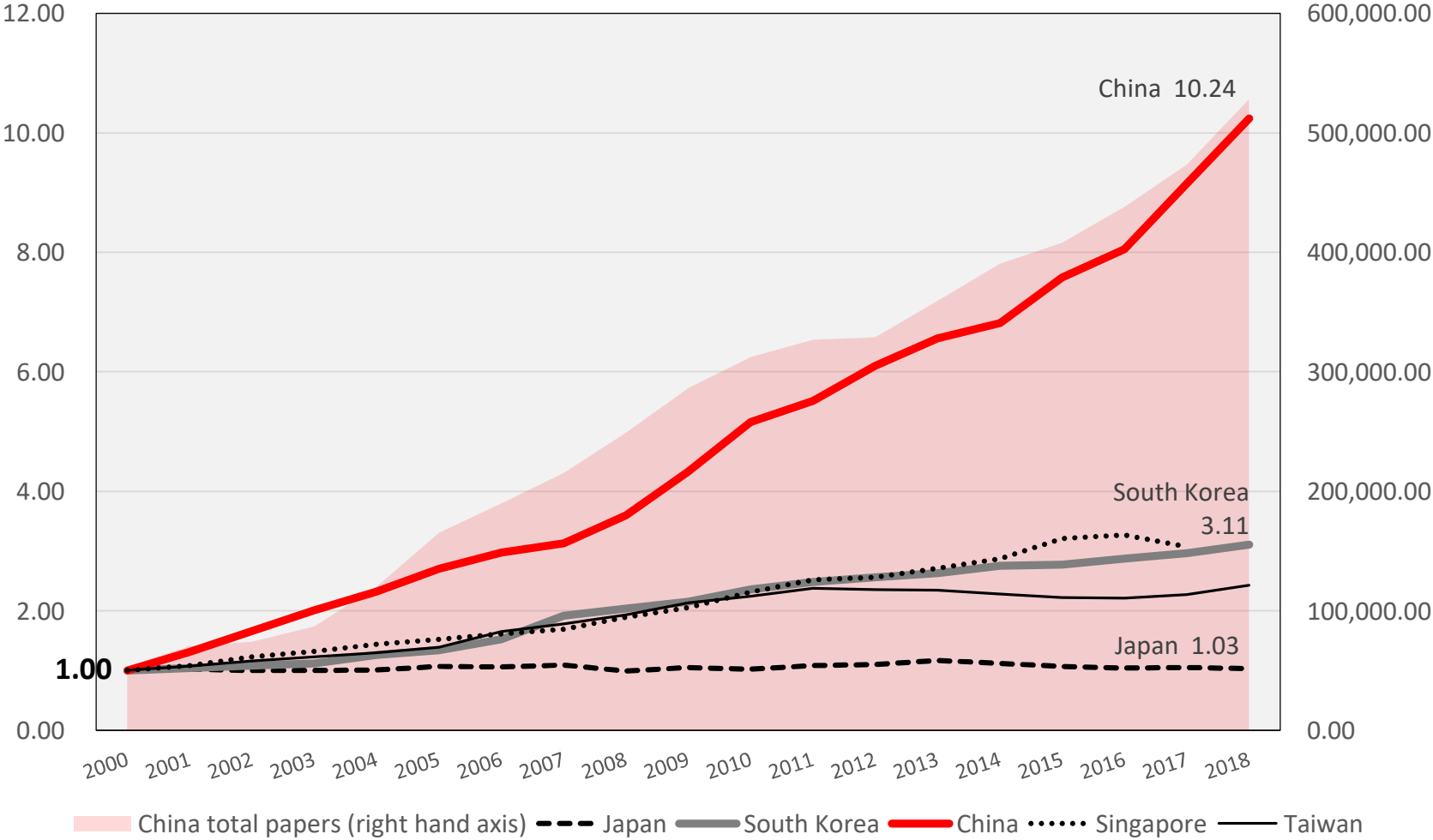


# R&D as proportion (%) of GDP, 1991-2018: USA, UK, Germany, China, Japan, South Korea

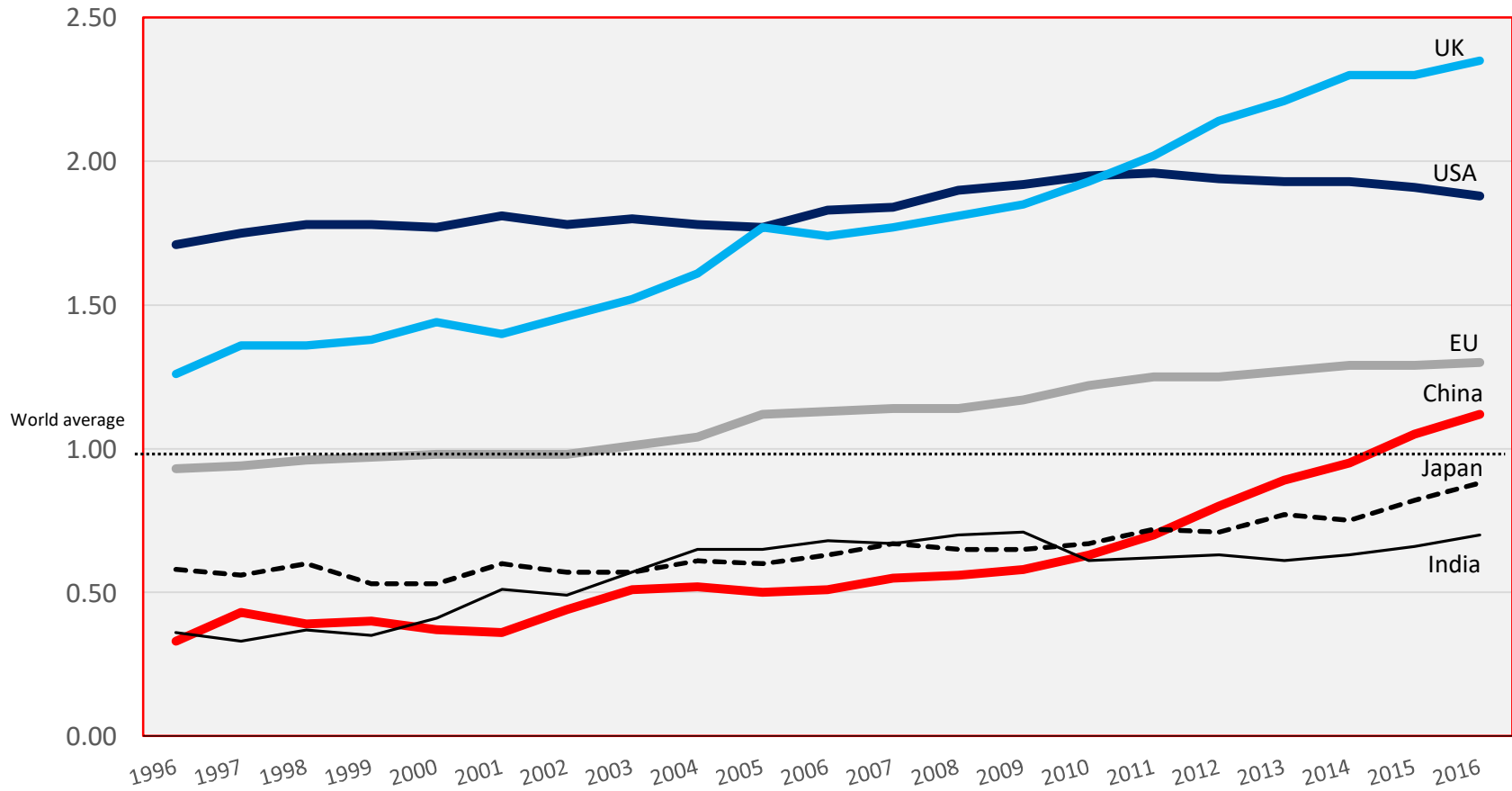


Data: OECD

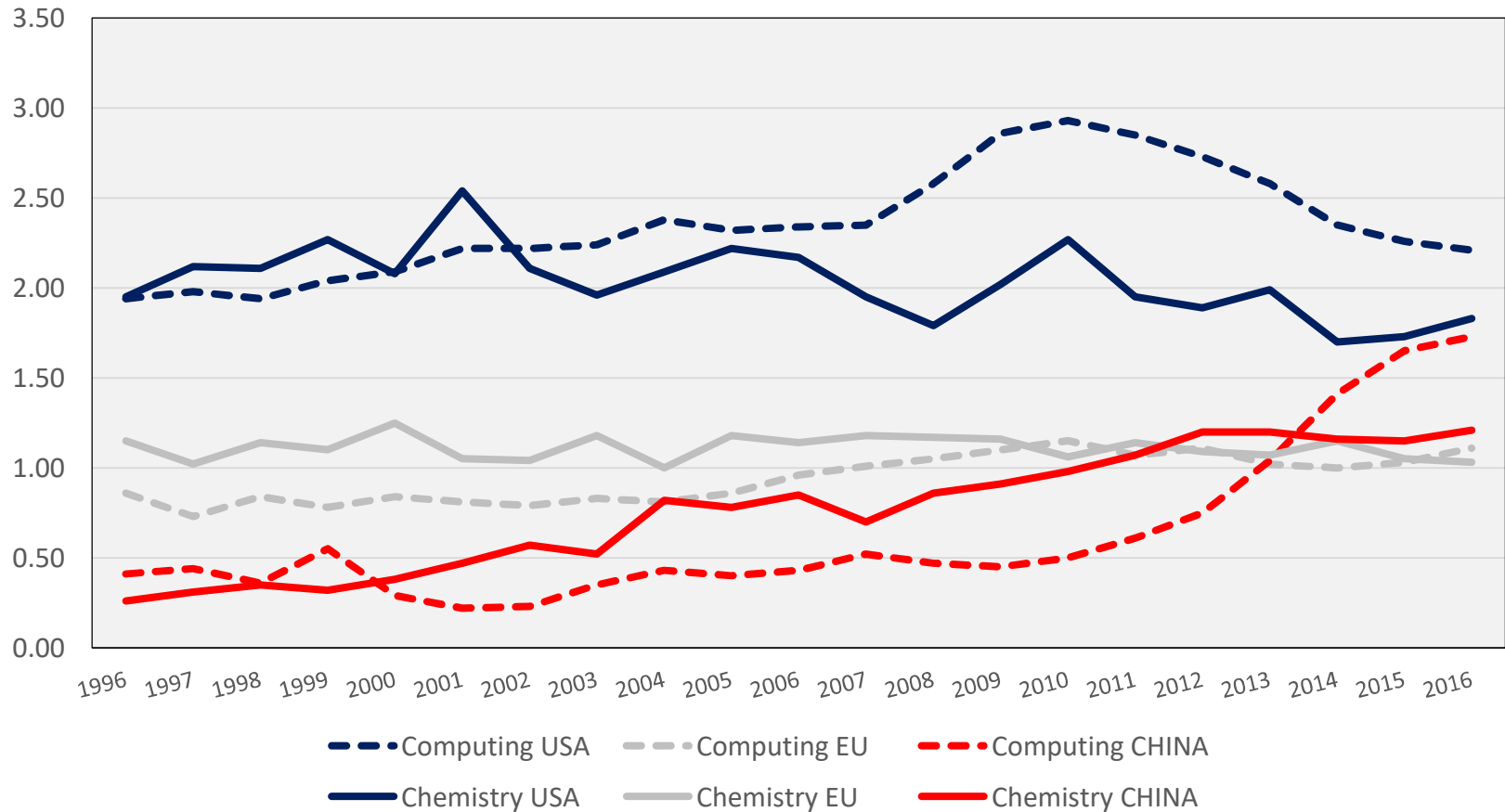
# Growth in spending on R&D in higher education, East Asia: 1996-2018



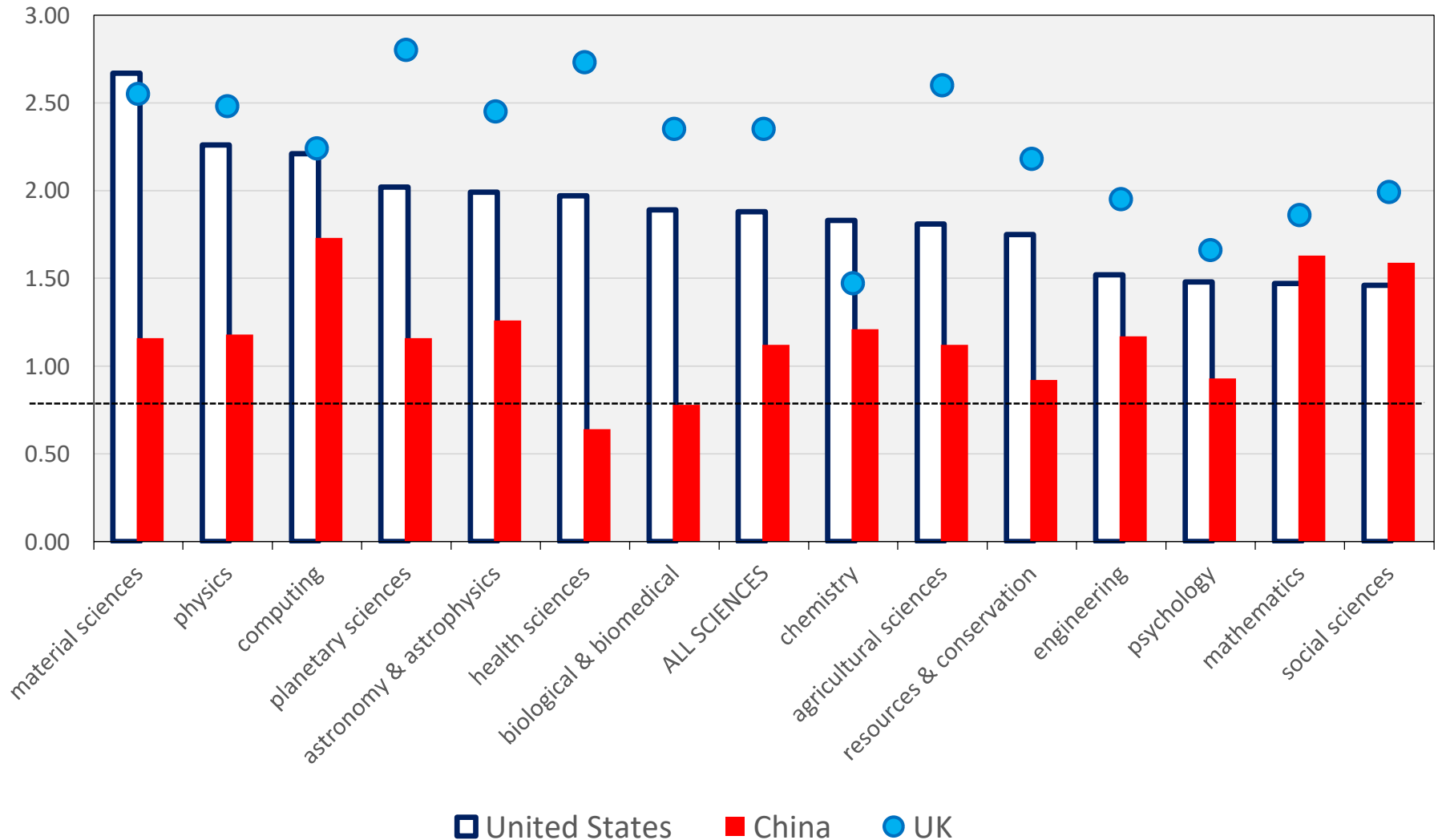
# Proportion (%) of all papers in world top 1% in field on basis of citations, leading countries/regions, 1996-2016 (world average = 1.00)



# Papers in top 1% in computer sciences and chemistry, US, EU and China: 1996-2016 (world average = 1.00)



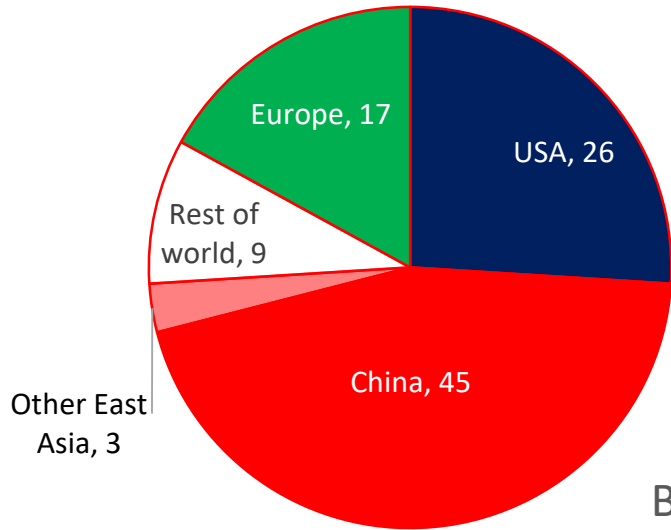
# Proportion (%) of papers in top 1% of field, US, China, UK: 2016 (world average = 1.00)



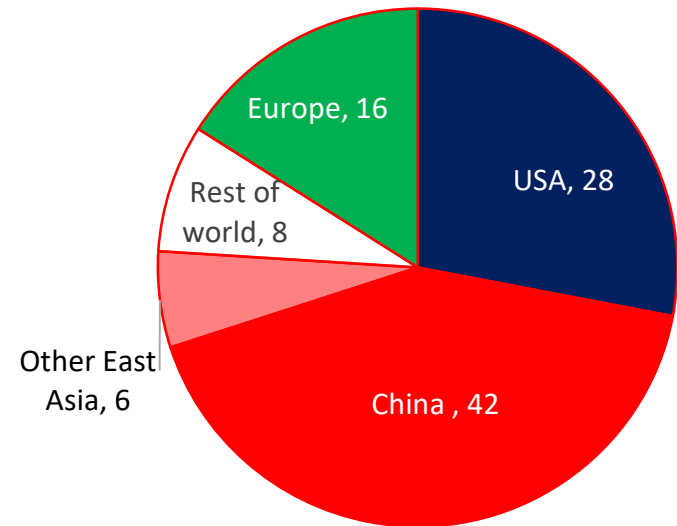
# Growth in high citation (top 5%) papers in leading East Asian universities in each system: 2006-09 to 2015-18

University		Top 5% papers 2006-2009	Top 5% papers 2015-2018	Growth 2006-09 to 2015-18 p.a.
Tsinghua U	CHINA	401	1451	15.36%
Zhejiang U	CHINA	335	1263	15.89%
Shanghai Jiao Tong U	CHINA	299	1050	14.98%
National U Singapore	SINGAPORE	511	948	7.11%
Peking U	CHINA	302	910	13.04%
Huazhong U S&T	CHINA	117	874	25.04%
Nanyang Technological U	SINGAPORE	290	861	12.85%
Harbin IT	CHINA	180	790	17.86%
Sun Yat-sen U	CHINA	154	742	19.09%
Tokyo U	JAPAN	668	637	- 0.53%
Seoul National U	STH. KOREA	348	543	5.07%
U Hong Kong	HONG KONG	305	465	4.80%
National Taiwan U	TAIWAN	273	303	1.17%
MIT	USA	1221	1578	2.89%
ETH Zurich	SWITZERLAND	667	933	3.80%

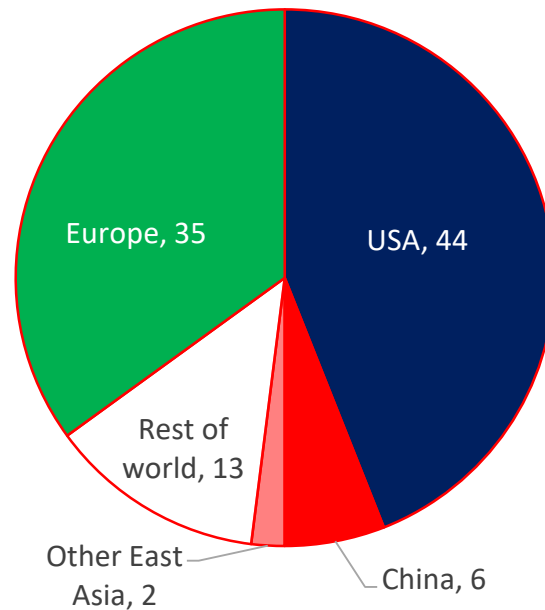
## Maths and Computing



## Physical Sci and Engineering



## Biomedical and Health Sci



Top 100 universities  
on basis of number  
of top 5% papers,  
2015-2018

Leiden ranking

# 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: 2015-2018

University	System	Physical sciences & engineering
Tsinghua U	CHINA	830
Massachusetts IT	USA	687
Zhejiang U	CHINA	569
Stanford U	USA	563
Nanyang TU	SINGAPORE	533
Harvard U	USA	532
U Calif., Berkeley	USA	531
U Science & T.	CHINA	500
Harbin IT	CHINA	455
Xi'an Jiaotong U	CHINA	455
Shanghai JT U	CHINA	439
U Cambridge	UK	424
Huazhong U S&T	CHINA	419
ETH Zurich	SWITZERLAND	417

University	System	Maths & computing
Tsinghua U	CHINA	300
Harbin IT	CHINA	252
U Electronic S&T	CHINA	217
Xidian U	CHINA	201
Beihang U	CHINA	197
Zhejiang U	CHINA	197
Huazhong U S&T	CHINA	195
Nanyang TU	SINGAPORE	181
Massachusetts IT	USA	180
Shanghai JT U	CHINA	153
Stanford U	USA	151
Northwestern P. U	CHINA	149
Southeastern U	CHINA	148
NU Singapore	SINGAPORE	140

Leiden ranking



# Top universities in other fields

(1) biomedical and health sciences, and (2) life and earth sciences, papers in top 5 per cent of their field by citation rate, World: 2015-2018

University	System	Biomedical & health sciences
Harvard U	USA	2983
U Toronto	CANADA	1103
Johns Hopkins U	USA	1074
UC, San Francisco	USA	976
Stanford U	USA	927
U Pennsylvania	USA	834
U College London	UK	831
U Michigan	USA	752
U Oxford	UK	742
UT, HSC Houston	USA	705
Yale U	USA	702
U Wash., Seattle	USA	694
Columbia U	USA	674
UC, San Diego	USA	635

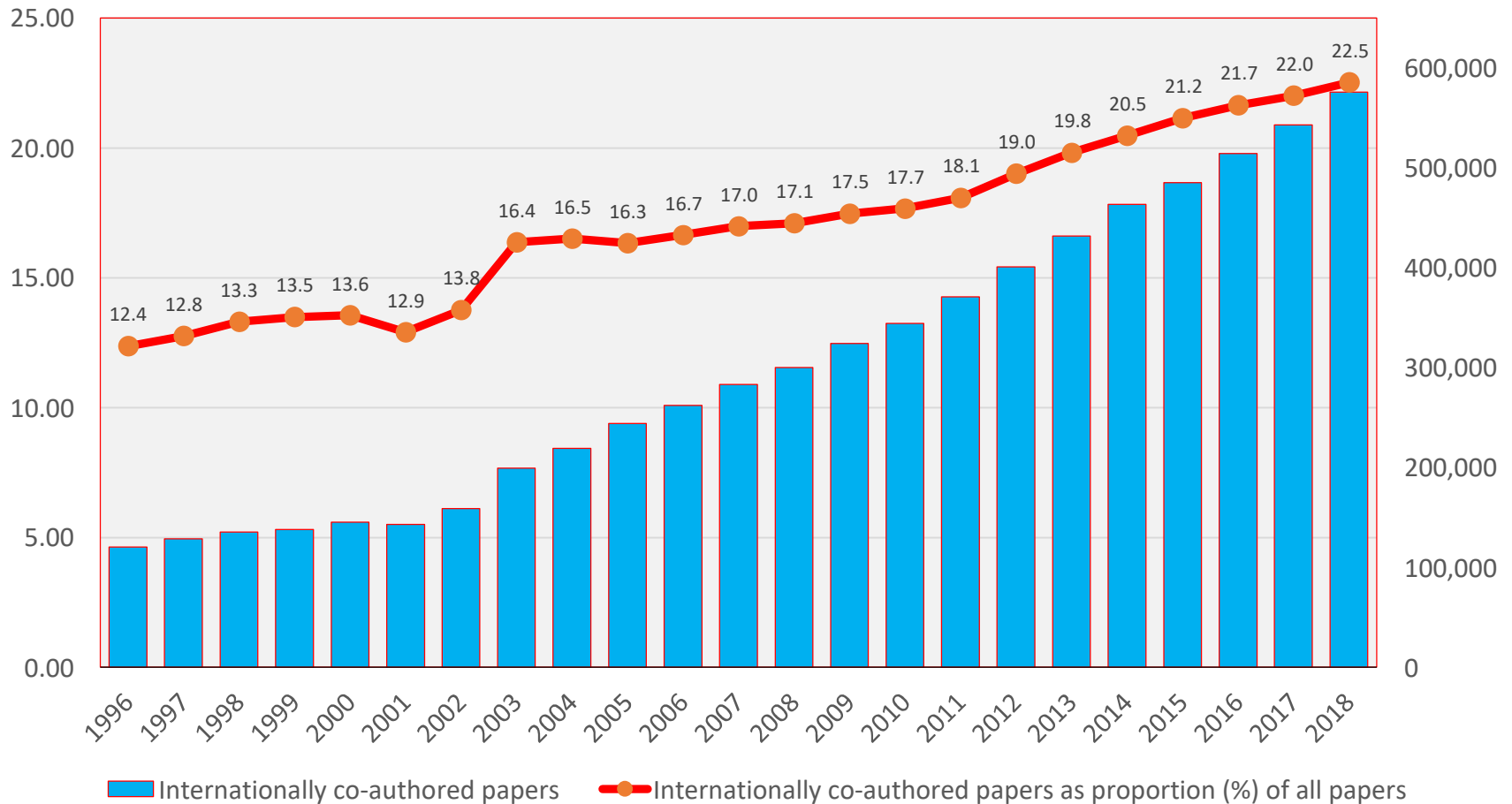
University	System	Life & earth sciences
Wageningen U	NETHERLANDS	252
ETH Zurich	SWITZERLAND	229
Harvard U	USA	227
U Wash, Seattle	USA	217
UC, Berkeley	USA	216
UC, Davis	USA	211
U Oxford	UK	205
Cornell U	USA	202
Stanford U	USA	199
Zhejiang U	CHINA	188
U Br. Columbia	CANADA	187
U Queensland	AUSTRALIA	182
U W-Madison	USA	177
Nanjing Ag U	CHINA	170

Leiden ranking

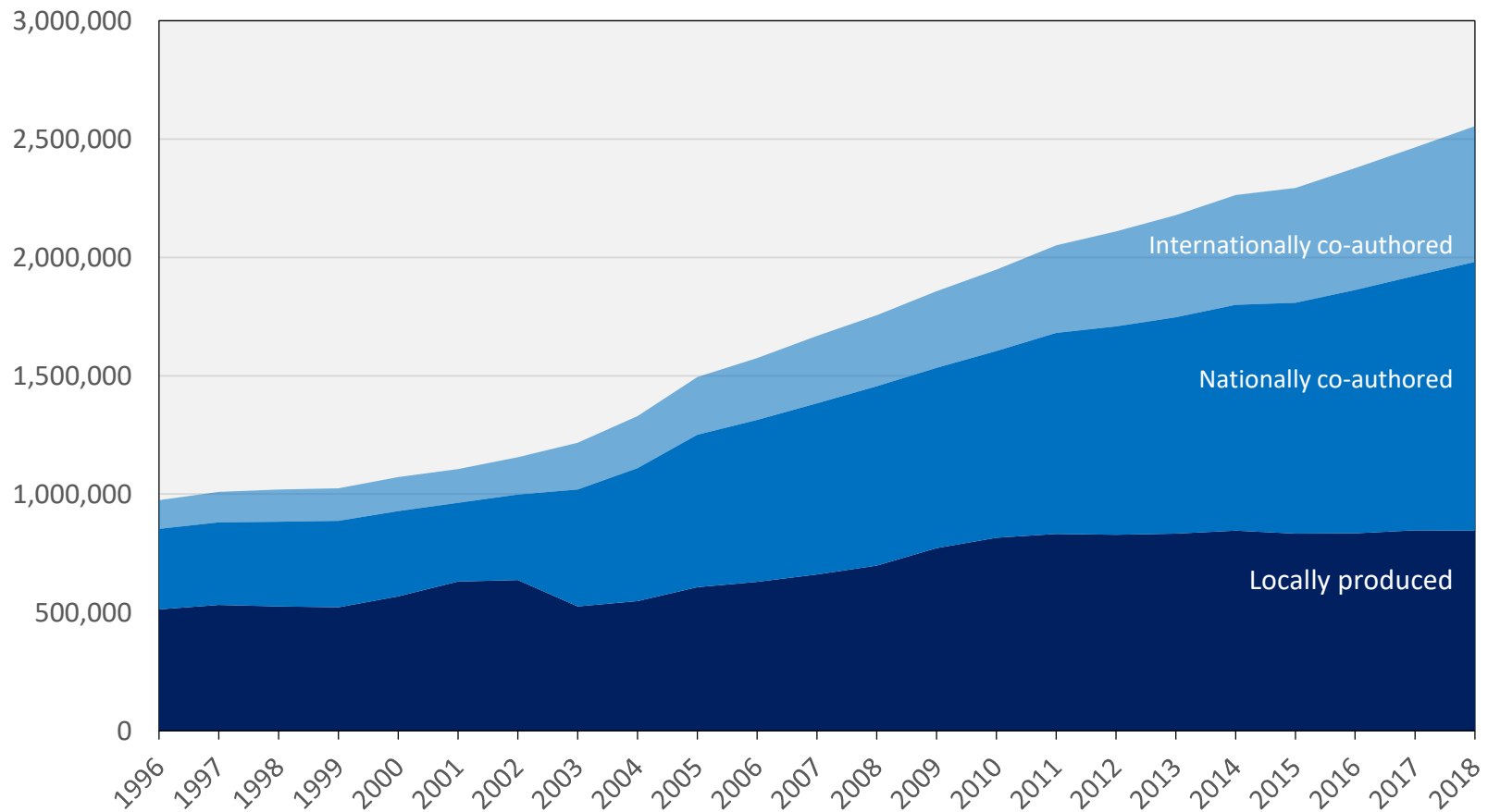
## Leading universities in top 5% papers 2015-18: Leiden ranking

university	country	Top 5% papers	all papers	% of all papers in top 5%
Harvard U	USA	4282	33,722	12.7
Stanford U	USA	2078	16,161	12.9
U Toronto	CANADA	1691	22,995	7.4
U Oxford	UK	1610	15,353	10.5
MIT	USA	1578	10,563	14.9
U Michigan	USA	1473	18,598	7.9
Tsinghua U	CHINA	1451	19,902	7.3
U College London	UK	1424	14,742	9.7
Johns Hopkins U	USA	1407	17,215	8.2
U Cambridge	UK	1370	13,485	10.2
U Washington Seattle	USA	1329	14,730	9.0
U California - Berkeley	USA	1313	10,671	12.3
U Pennsylvania	USA	1266	13,414	9.4
Zhejiang U	CHINA	1263	23,510	5.4

# Growth in internationally co-authored science papers, all countries: 1996-2018



# Number of science papers in Scopus, by type of collaboration, world: 1996-2018



Country pair	Joint papers	1996 = 1.00
China-USA	55,382	26.10
China-UK	14,763	21.74
China-Australia	13,138	46.42
China-Canada	9,449	18.75
China-Germany	8,206	14.03
China-Japan	8,024	9.47
China-Singapore	5,563	46.00
China-France	5,472	19.83

Country pair	Joint papers	1996 = 1.00
USA-China	55,382	26.10
USA-UK	28,616	4.06
USA-Germany	23,616	3.44
USA-Canada	21,968	3.29
USA-France	15,422	3.42
USA-Australia	13,939	6.03
USA-Italy	13,804	4.31
USA-Japan	11,533	2.00
USA-Spain	10,236	5.91
USA-Netherlands	9,984	4.64
USA-South Korea	9,761	5.73
USA-Switzerland	9,403	4.03
USA-Brazil	8,671	7.42
USA-India	8,058	5.81
USA-Sweden	7,034	4.07
USA-Belgium	5,171	5.03

## Country pairs of 5000 jointly-authored papers: 2018

US National Science Board data from Scopus

# China-US relations in science

- ‘China’s special relationship with the United States in science has helped to propel it to the scientific frontier’
  - Packalen, M. (2019). Edge factors: scientific frontier positions of nations. *Scientometrics*, 118, pp. 804-805
- The China-US relationship in science has also become a vital engine of knowledge in the open global system
- Since 1979 the US-China Agreement on Cooperation in Science and Technology has involved 50 interagency agreements with us federal agencies and supported thousands of cooperative programmes

‘... academic freedom, as a fundamental US higher education value, has allowed US researchers to partner, collaborate, and extend their scholarship beyond national borders as independent, “bottom-up” actors. This study demonstrates the successes of US research collaborations with China and the ways that the nation-state benefits. This study also challenges the overly simplified political rhetoric that China is dependent on or a threat to US scientific research. Our findings suggest the reverse: China is a major player in US-China research collaboration, via growth, via funding, and via intellectual leadership.’

- Lee, J. and Haupt, J., Winners and losers in US-China scientific research collaborations. *Higher Education*, 2019.  
DOI: 10.1007/s10734-019-00464-7, pp. 14-15.



# Everliving fire: China in global science



## Achievements

- Concentrated long-term investment in science
- Astonishing development of national science in thirty years
- Effective combination of central policy focus and autonomous discipline groups with initiative
- Open border internationalisation: universal English, connectivity
- Global disciplinary leadership in physical sciences STEM fields
- Many spinoffs for modernisation of China and Belt & Road regions
- Layer of top universities akin to Anglo-American leaders

## Limits

- Potential for central party-state to overbear science and universities
- Uneven disciplinary capacity, medicine/life sciences lagging
- Social sciences and humanities neglected, academic freedom in those disciplines more limited
- Western modernisation vs. partly defined indigenous modernisation agendas ('Chinese characteristics')
- Frenetic performance culture and academic corruption
- Highly stratified university system, quality issues in local universities
- Dependence on US relationship?



# Will China-US scientific collaboration survive?

[And will the same issues play out in UK?]

- Scientific globalism versus technological nationalism (Lee and Haupt 2020)
- In 2018 scientists from China and the United States collaborated on 55,382 jointly authored, *26 times* as many as in 1996. By far the largest nation-to-nation collaboration in world science (UK-China was 14,763, UK-US 28,616)
- In Covid-19 research 20% of papers with China authors and 43% with US authors have international co-authors, over two thirds are open access
- Measures taken by the US to retard exchange and cooperation in science (e.g. visa restrictions, border hostility to doctoral students, pressure to relinquish joint appointments and multiple projects) are strongly opposed by many scientists and university leaders in both countries
- China, regulating in defensive mode, may start to retard internationalisation
- *University autonomy and academic freedom are crucial*, if scientists are to maintain cooperation amid geo-strategic rivalry and securitisation agendas
- The situation is evolving rapidly ... watch this space



‘All things are in flux, like a river’, said Heraclitus. ‘Everything flows.’  
Everything is changing, everything is becoming.