Tectonic shifts in global science: US-China scientific competition and the Muslim-majority science systems in multipolarising science

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Introduction

- Global science is witnessing unprecedented transformations!
- After the establishment of the Internet in the 1990s, instantaneous collaborations and global networking among scientists have become possible (Wagner et al., 2015).
- The main competitor in global science at that time was the Soviet Union (Miao et al., 2022), but its dissolvement occurred concurrently with the advent of the Internet.
- Global science is going through yet another tectonic shift. China has globally built the world's most productive science system, surpassing the US since 2018 (Miao et al., 2022).
- The increasing multipolarity in science due to the rise of China is set to have implications not only for the science systems immediately surrounding China but also science systems around the world.

Purpose

- This study investigates **the competition between the US and China by analysing their collaboration patterns with six major Muslim-majority science systems**.
- The more the six selected Muslim-majority science systems collaborate with the two science giants, namely the US and China, the more they are influenced by and in interaction with them.
- The selected Muslim-majority science systems are a fast-growing group of science systems which differentiate themselves from other Muslim-majority science systems in multiple metrics, as identified in a previous paper (Oldac, 2022).
- In alphabetical order, they include Egypt, Iran, Malaysia, Pakistan, Saudi Arabia and Turkey.

Reference to the previous article:

Oldac, Y. I. (2022). Global science and the Muslim world: Overview of Muslim-majority country contributions to global science. *Scientometrics*, *127*, 6231–6255. https://doi.org/10.1007/s11192-022-04517-0

Positionality

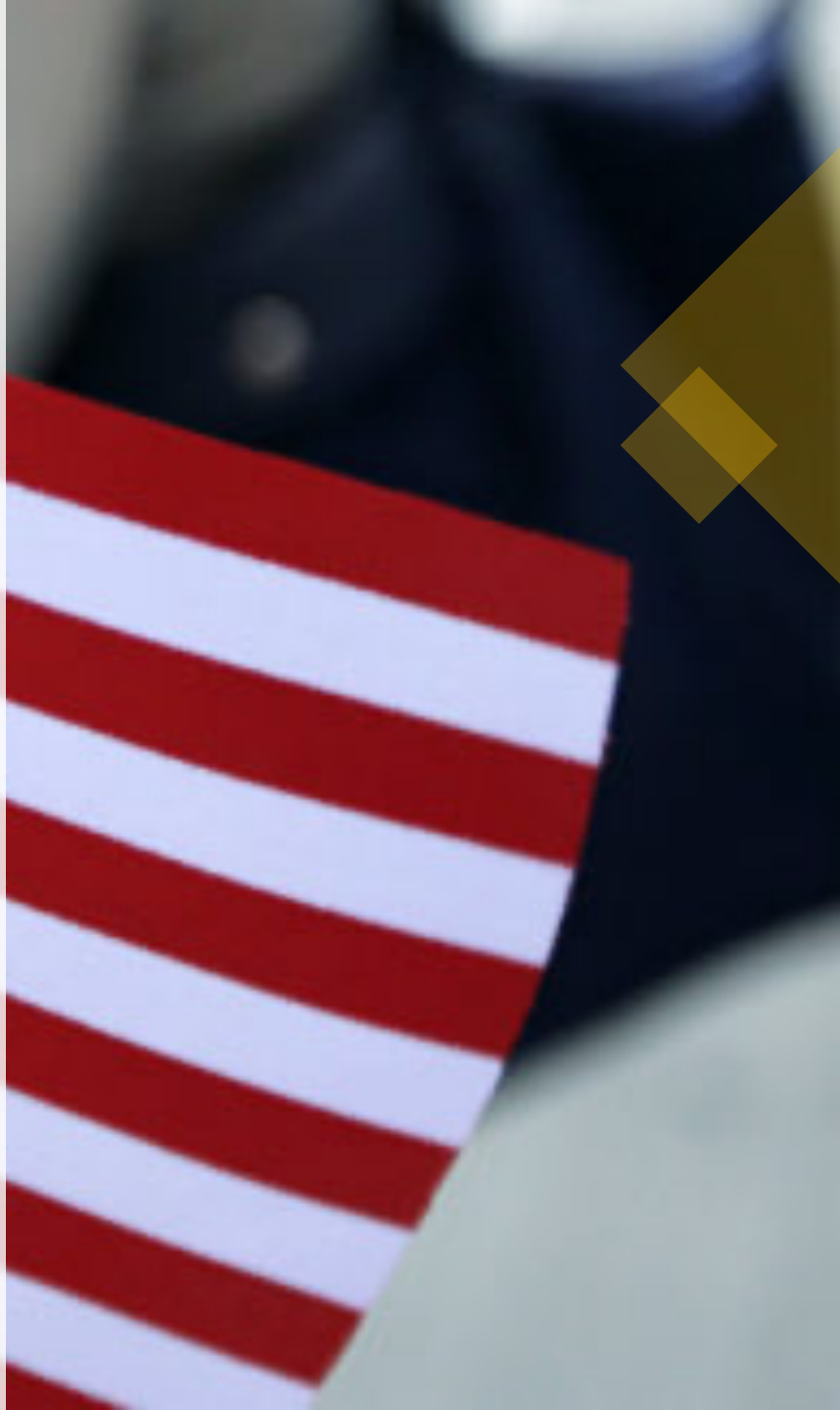
- My perspective derives from Amartya Sens' (2002) idea of **trans-positionality** in investigating the US, China and the six selected Muslim-majority science systems.
- As a researcher who has **lived in both the western and eastern parts of the world** and originally being from Turkey, **I do not take any perspective as given**, and my approach is grounded in **critical realism** (Sayer, 2000).
- This paper is developed within the field of higher education studies that interpret the science in the selected science systems in global social theory.

Theoretical background: Multiscalar Science Space

- **Global science is multi-scalar**. Various actors are involved in science at multiple scales, which include local, national and global scales, but are not limited to them (Marginson, 2022).
- The largest scale in the science space is **global scale**.
  - As these actors (e.g., scientists, national science systems, institutional actors) desire to augment themselves, they also contribute to global science.
  - There is a symbiotic relationship between actors in science space and global science and the relation is primarily a positive sum (Bornmann et al., 2018).
- The **national scale** also plays an important role in the multiscalar science space and is a relevant scale for this study.
- **Scientists almost always have two roles**: contributing to the national science, but at the same time contributing to the global science, especially if their work is published in outlets with international readership.

Theoretical background cont'd: Multipolarity in Global Science

- The symbiotic relationship in place between **national and global science** may or **may not** occur among **nation-to-nation scientific relationships**.
  - the nature of nation-to-nation scientific connectivity is affected by how national science systems are steered by policymakers and, to a certain extent, other actors within them, such as individual researchers and research institutions.
- Science can be a **positive-sum** phenomenon, but at the same time, it can also be a **zero-sum game**, depending on how it is positioned.
- The recent ongoing scientific decoupling between the US and Chinese science systems can be seen as an example of how once collaboratively positioned science systems can increasingly turn their collaboration into a competition (Lee & Haupt, 2020).
  - These two national science giants immensely contributed to global science, whilst their science systems were positioned in a collaborative spirit.
  - Scientific collaborations and the networks built over the years by scientists do not cease to exist overnight, but the trend is there (Wagner & Cai, 2022).



Muslim-majority countries

- Every one-in-four people on earth (24.7%) is estimated to be Muslim, totalling up to 1.94 billion (Countrymeters, 2021).
- The majority of Muslim population live in the Asia-Pacific region (62%), followed by the Middle East and North Africa (20%), Sub-Saharan Africa (16%) and Europe (3%).
- Muslim-majority science systems are rapidly increasing both the quantity and quality of their scientific publications, but they are understudied (Oldac, 2022). The scholarly literature would benefit from more data-informed scholarly discussions on them.
- This suggestion is not to necessarily treat them as a separate group but to better understand their contribution and role in global multiscalar science.
- The use of “Muslim-Majority” term is to acknowledge that these countries are not inhabited by Muslim people only. Most of them are diverse, with minorities from different backgrounds, all are valuable.

Istanbul, Türkiye

Kuala Lumpur, Malaysia

Selected Muslim-majority countries

Table 1. International co-authorship index among the selected systems

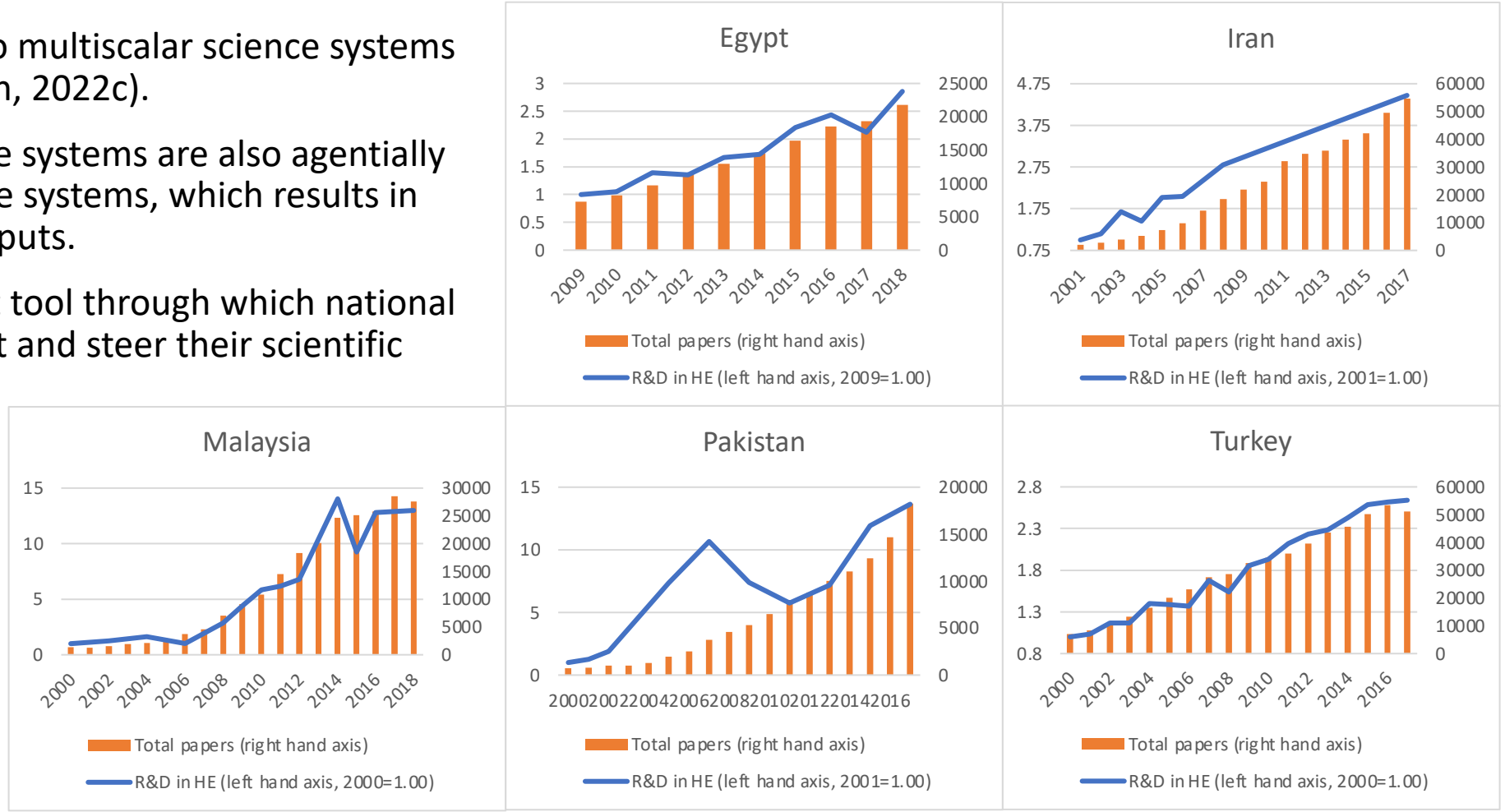
	Egypt	Iran	Malaysia	Pakistan	Saudi Arabia	Turkey
	2020	2020	2020	2020	2020	2020
Egypt	/					
Iran	0.76	/				
Malaysia	1.21	1.89	/			
Pakistan	1.86	1.03	4.34	/		
S. Arabia	11.96	0.56	2.91	5.80	/	
Turkey	1.84	3.03	1.42	3.11	2.06	/

Source: Author, drawing on data from NSB (2021), Table SPBS-39. NSB retrieves its data from journals and conference proceedings in Science & Engineering from Scopus

*any value above 1 indicates a higher-than-expected level of scientific collaboration between two science systems

Agency in national science systems

- I take an agential lens to multiscalar science systems in this paper (Marginson, 2022c).
- Muslim-majority science systems are also agentially investing in their science systems, which results in increasing scientific outputs.
- Funding is an important tool through which national science systems support and steer their scientific endeavours.



Figures. Relationship between national expenditure on R&D in higher education and total papers for five selected science systems

Cont'd: agency in national science systems

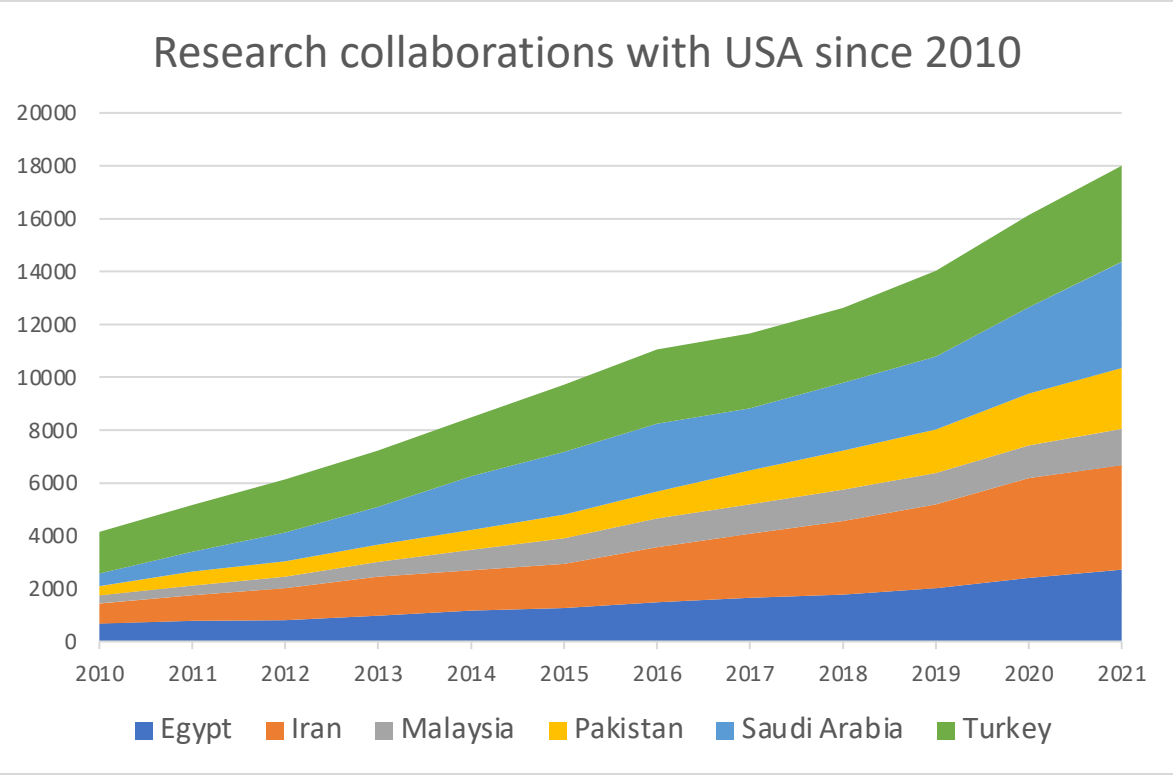
Science system	Total papers 2010	Total papers 2021	Multiplier all papers 2021 compared with 2010 (2010 = 1.00)	Multiplier internationally co-authored papers (2010 = 1.00)	Multiplier domestically co-authored papers (2010 = 1.00)
China	136,802	621,424	4.54	4.69	5.96
US	381,154	524,367	1.38	1.97	1.53
Egypt	6,411	30,440	4.75	7.05	5.49
Iran	18,586	59,702	3.21	5.61	2.99
Malaysia	7,334	23,702	3.23	4.91	3.45
Pakistan	5,227	31,173	5.96	11.17	3.77
Saudi Arabia	4,190	42,308	10.10	13.54	11.99
Turkey	26,229	59,092	2.25	3.71	2.75

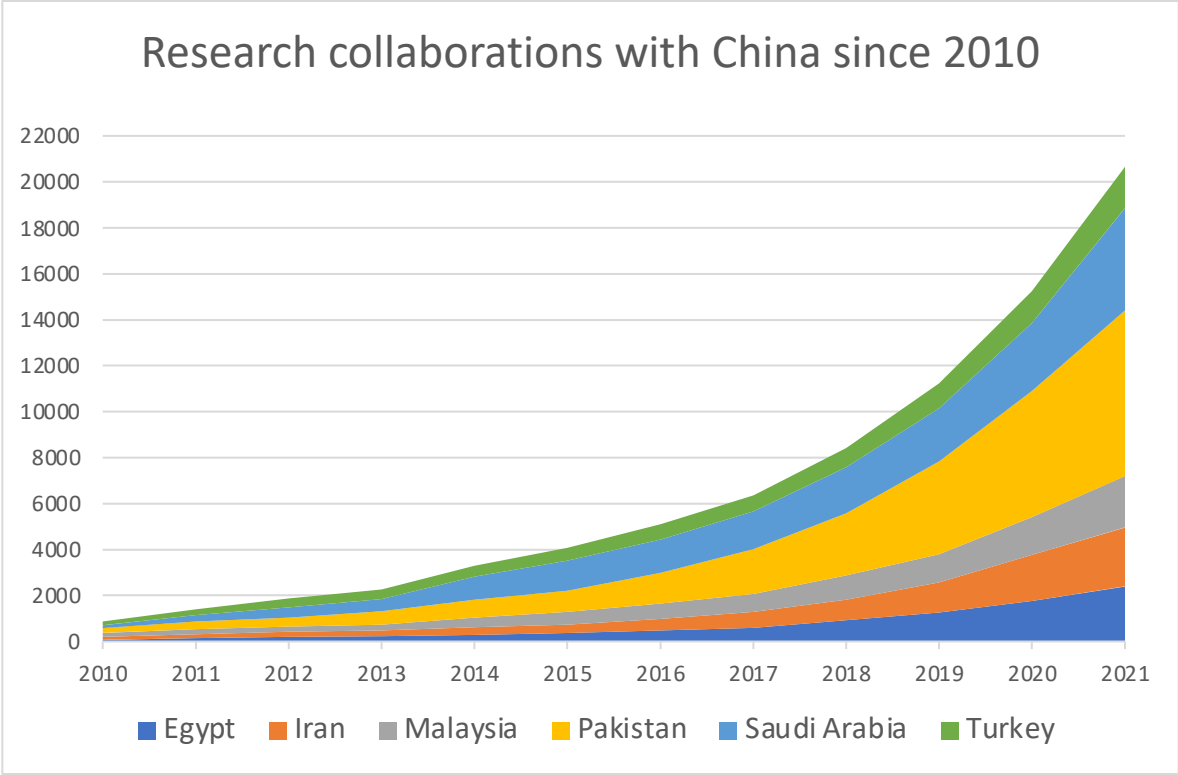
- All the selected science systems have **more than tripled their scientific publications** since 2010 in their total paper publications
- Regarding international collaborations, all the selected science systems have **more than quadrupled their collaboratively published papers**, except Turkey (published 3.71 times more papers since 2010) which was already a relatively larger system among the selected systems.

Methods

- The study used bibliometric data to address its research purpose.
- The study builds on more than one bibliometric data source and included data synthesised from the Web of Science database and National Science Board data (2021) which uses Scopus database.
- These databases are the most frequently used data sources for analysing scientific publications globally, but no data source is perfect.
- Discipline-based collaboration analyses rely on the Organisation for Economic Co-operation and Development (OECD) categorisation (2007).

Findings - Scientific collaborations are multipolarising!





Figures. Trend of scientific papers published collaboratively between the six selected countries and the US (left) China (right) since 2010

Findings - Scientific collaborations are multipolarising!

Table: Nation-to-nation research collaboration pairs, number of publications in 2021 and data on change with reference to 2010

Country pair	Papers 2021	2010 = 1.00
US-Egypt	2717	4.04
US-Iran	3959	5.16
US-Malaysia	1366	4.52
US-Pakistan	2310	6.58
US-Saudi Arabia	4008	8.40
US-Turkey	3641	2.32
Average	3000.17	5.17
US-all selected systems	18001	N/A

Country pair	Papers 2021	2010 = 1.00
China-Egypt	2389	32.73
China-Iran	2566	19.59
China-Malaysia	2246	12.98
China-Pakistan	7201	34.79
China-Saudi Arabia	4453	35.91
China-Turkey	1800	11.25
Average	3442.5	24.54
China-all selected systems	20655	N/A

Source: Author's own tabulation using Web of Science InCites data. Journal articles are included. Data retrieved on 24 May 2022.

Findings - Scientific collaborations are multipolarising!

- Moving from the trend data to the current situation of scientific collaborations in 2021, a three-to-three split occurs among the selected countries in their scientific collaborations with the US- versus China-based researchers.

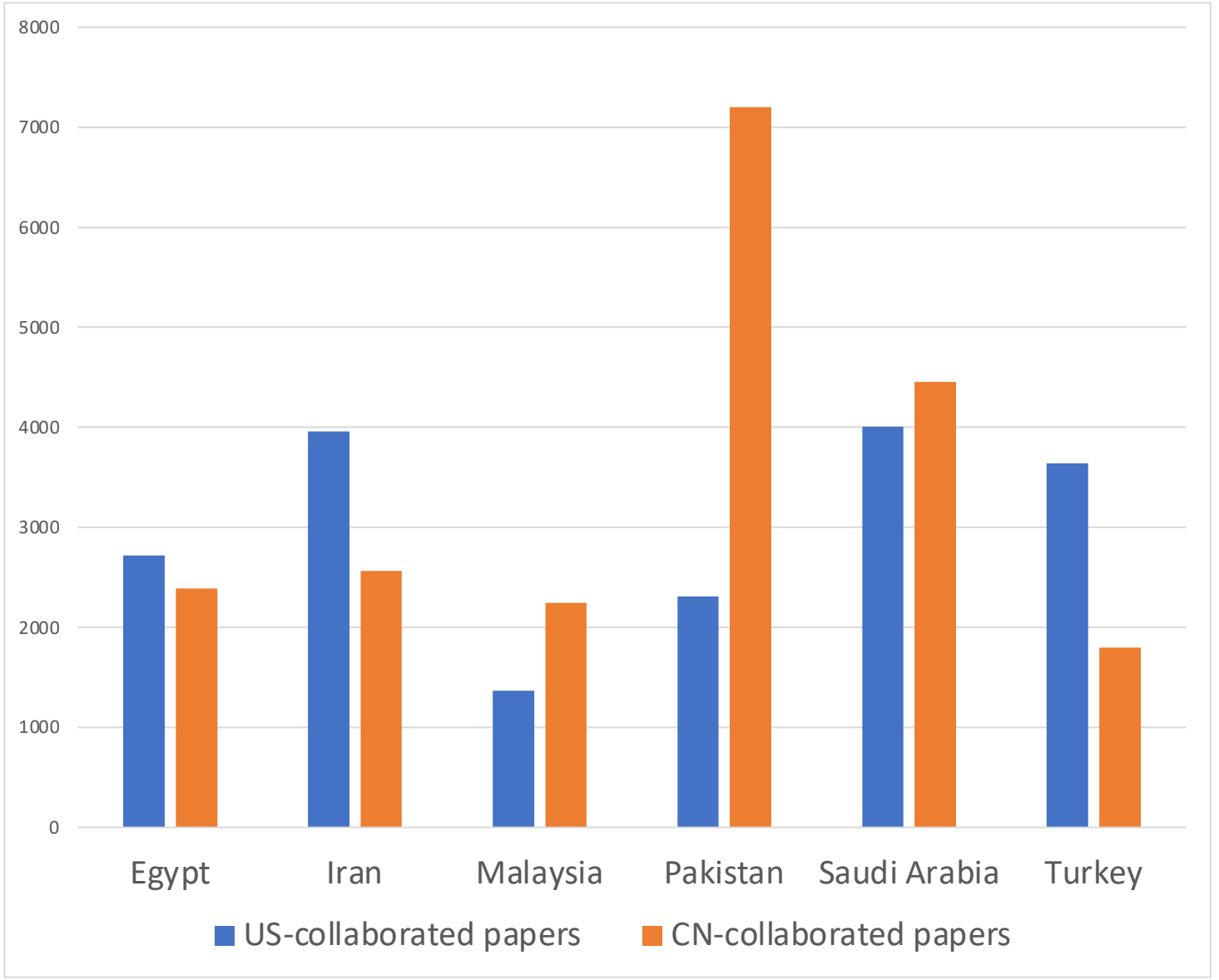


Figure. Nation-to-nation collaboratively published papers in 2021 with the selected countries

Findings – Discipline-based collaborations

- A 50-50 split occurs in discipline-based collaborations when viewed at research areas in total numbers.
  - More with China: natural sciences, engineering and technology and agricultural sciences
  - More with the US: Medical and Health Sciences, Social Sciences, Humanities

	NATURAL SCIENCES		ENGINEERING AND TECHNOLOGY		MEDICAL AND HEALTH SCIENCES		AGRICULTURAL SCIENCES		SOCIAL SCIENCES		HUMANITIES	
	US	CN	US	CN	US	CN	US	CN	US	CN	US	CN
Egypt	1269	1562	584	1057	1167	328	170	303	105	67	10	2
Iran	1823	1617	1409	1300	1281	255	180	104	324	102	33	11
Malaysia	636	1303	342	933	430	365	78	100	214	326	17	19
Pakistan	1197	4767	532	2734	814	659	102	568	218	858	5	9
Saudi A.	2088	3191	1206	2178	1377	369	93	153	246	193	21	5
Turkey	1690	1213	795	563	1227	279	145	79	525	157	42	1
Total	8703	13653	4868	8765	6296	2255	768	1307	1632	1703	128	47

Table. Discipline-based collaborative paper counts in 2021

Findings – Who bears the larger responsibility and initiative in the collaborations?

- In each collaborative research project, a party or person typically bears larger responsibilities than others.
- The main logic behind the analyses provided in this section is that first and/or corresponding authors are more likely to have a larger responsibility in research (cf. Lee & Haupt, 2020)
- The data synthesised in the table here indicates several interesting patterns!

	US – 2021		CN - 2021		US - 2010		CN - 2010	
Selected systems	% first author	% corres. author	% first author	% corres. author	% first author	% corres. author	% first author	% corres. author
Egypt	43.84	29.58	31.57	21.43	51.86	26.3	24.66	10.96
Iran	69.03	63.33	29.53	43.71	69.01	54.3	39.69	28.24
Malaysia	31.17	32.26	29.64	33.73	47.35	47.68	19.65	42.2
Pakistan	46.37	38.29	37.46	35.18	53.56	39.03	32.37	24.64
Saudi A.	36.83	33.65	11.27	21.19	38.16	27.67	16.94	12.9
Turkey	41.24	36.37	11.36	20.82	52.32	40.1	17.5	15
Average	44.75	38.91	25.14	29.34	52.04	39.18	25.14	22.32

Table. Percentage of corresponding and first authorship by the scientists based on the selected science systems in their collaborations with the US or China

Findings – Citation recognition

- Citation data do not necessarily indicate research quality but are a good indicator of epistemic recognition (Marginson, 2021).
- In this section, category normalised citation indicators (CNCIs) are used.
- Compared with the national average CNCI values, those of international collaborations are significantly higher and are all above the world average.
- Papers collaboratively published with China-based researchers had consistently higher citation premiums than papers collaboratively published with the US-based researchers!

System	Category Normalised Citation Impact
China	1.08
US	1.32
Egypt	0.97
Iran	0.86
Malaysia	0.89
Pakistan	0.96
Saudi A.	1.25
Turkey	0.73

Table. CNCI values of all papers published by the selected science systems

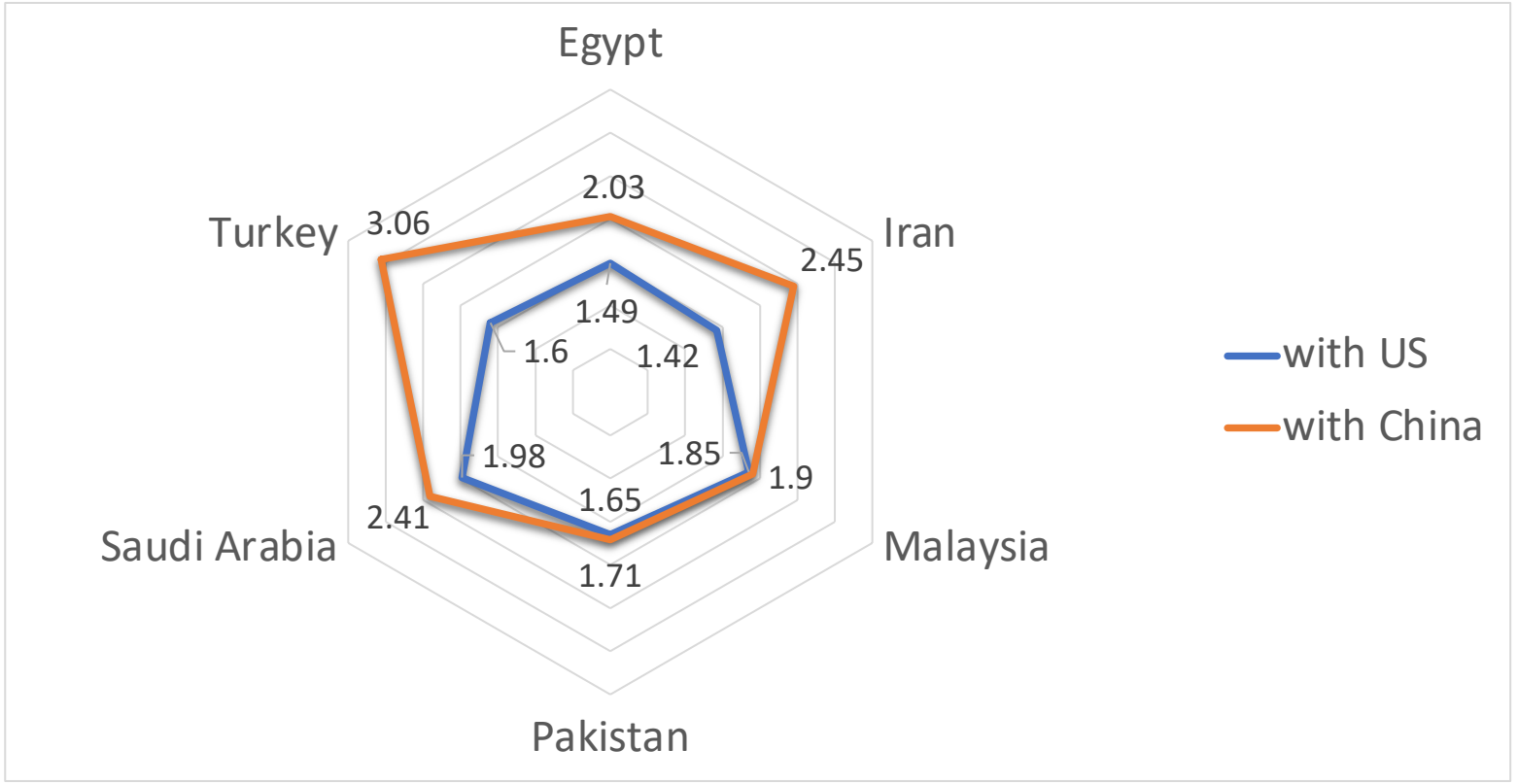


Figure. Category Normalised Citation Impact values of the collaborations between the six selected countries with the United States and China (2010-2021)

Universities from the selected science systems

Conclusions and discussion

- The analysis for all measures demonstrates **a clear pattern of moving away from having a single pole in global science**. The Chinese science system is moving up fast and gaining increasingly more space from the US science system.
- All the analyses consistently demonstrated that **the US is losing out its scientific influence with major Muslim-majority countries to China, as global science multi-polarises**.
- Agency in science space has a potent explanatory power.
- However, the future remains uncertain for a number of reasons:

1. Firstly, the US is losing its scientific influence on the selected Muslim-majority science systems, but this may not only be due to the meteoric rise of Chinese science. **The US has also, to some extent, quit its international connections due to anti-globalisation trends and domestic-focused agenda in foreign relations in recent years**.
2. Secondly, China has closed itself to the world due to COVID for over two years, and is only recently opening up, whereas the US science and most western systems are already back to their normal routines. Scientific collaboration networks establish after initial personal contact to build trust, **China's closing down of its borders can potentially put a blow to China's research connectivity with the world in the mid- to long-run**.

References 1/4

- Adams, J., & Gurney, K. A. (2018). Bilateral and Multilateral Coauthorship and Citation Impact: Patterns in UK and US International Collaboration. *Frontiers in Research Metrics and Analytics*, *3*. https://www.frontiersin.org/articles/10.3389/frma.2018.00012
- Bornmann, L., Adams, J., & Leydesdorff, L. (2018). The negative effects of citing with a national orientation in terms of recognition: National and international citations in natural-sciences papers from Germany, the Netherlands, and the UK. *Journal of Informetrics*, *12*(3), 931–949. https://doi.org/10.1016/j.joi.2018.07.009
- Castells, M. (2000). *The rise of the network society*. Blackwell Publishers.
- Chankseliani, M., Lovakov, A., & Pislyakov, V. (2021). A big picture: Bibliometric study of academic publications from post-Soviet countries. In *Scientometrics* (Issue 0123456789). Springer International Publishing. https://doi.org/10.1007/s11192-021-04124-5
- Chinchilla-Rodríguez, Z., Sugimoto, C. R., & Larivière, V. (2019). Follow the leader: On the relationship between leadership and scholarly impact in international collaborations. *PLOS ONE*, *14*(6), e0218309. https://doi.org/10.1371/journal.pone.0218309
- Gümüş, S., Bellibaş, M. Ş., Gümüş, E., & Hallinger, P. (2020). Science mapping research on educational leadership and management in Turkey: A bibliometric review of international publications. *School Leadership and Management*, *40*(1), 23–44. https://doi.org/10.1080/13632434.2019.1578737
- Hafezi, P. (2022, September 15). Iran to join Asian security body led by Russia, China. *Reuters*. https://www.reuters.com/world/middle-east/iran-signs-memorandum-joining-shanghai-cooperation-organisation-tass-2022-09-15/
- Hess, C., & Ostrom, E. (Eds.). (2007). *Understanding knowledge as a commons: From theory to practice*. MIT Press.
- Hoekman, J., Frenken, K., & Tijssen, R. J. W. (2010). Research collaboration at a distance: Changing spatial patterns of scientific collaboration within Europe. *Research Policy*, *39*(5), 662–673. https://doi.org/10.1016/j.respol.2010.01.012
- Ibrahim, R., Madon, H. D., Nazri, N. H. A. M., Saarani, N., & Mustapha, A. (2017). Paperless Transaction for Publication Incentive System. *IOP Conference Series: Materials Science and Engineering*, *226*, 012119. https://doi.org/10.1088/1757-899X/226/1/012119
- Kataria, J. R., & Naveed, A. (2014). Pakistan-China Social and Economic Relations. *South Asian Studies*, *29*(2), 395–410. https://doi.org/10.1088/1757-899X/226/1/012119

References 2/4

- Kerr, C. (2001). *The Uses of the University*. Harvard University Press.
- Krücken, G. (2021). Multiple competitions in higher education: A conceptual approach. *Innovation*, *23*(2), 163–181. https://doi.org/10.1080/14479338.2019.1684652
- Kwiek, M. (2020a). Internationalists and locals: International research collaboration in a resource-poor system. In *Scientometrics* (Vol. 124, Issue 1). Springer International Publishing. https://doi.org/10.1007/s11192-020-03460-2
- Kwiek, M. (2020b). What large-scale publication and citation data tell us about international research collaboration in Europe: Changing national patterns in global contexts. *Studies in Higher Education*. https://doi.org/10.1080/03075079.2020.1749254
- Larivière, V., Desrochers, N., Macaluso, B., Mongeon, P., Paul-Hus, A., & Sugimoto, C. R. (2016). Contributorship and division of labor in knowledge production. *Social Studies of Science*, *46*(3), 417–435.
- Lee, J. J. (2022). How China–US collaborations still happen, despite politics. *Nature*, *607*(7919), 423–423. https://doi.org/10.1038/d41586-022-01957-9
- Lee, J. J., & Haupt, J. P. (2020). Winners and losers in US-China scientific research collaborations. *Higher Education*, *80*(1), 57–74. https://doi.org/10.1007/s10734-019-00464-7
- Leydesdorff, L., & Wagner, C. S. (2008). International collaboration in science and the formation of a core group. *Journal of Informetrics*, *2*(4), 317–325. https://doi.org/10.1016/j.joi.2008.07.003
- Marginson, S. (2010). Higher education in the global knowledge economy. *Procedia - Social and Behavioral Sciences*, *2*(5), 6962–6980. https://doi.org/10.1016/j.sbspro.2010.05.049
- Marginson, S. (2020). The World Research System. In C. Callender, W. Locke, & S. Marginson (Eds.), *Changing Higher Education for a Changing World* (pp. 35–51). Bloomsbury Publishing Plc. https://doi.org/10.5040/9781350108448.0010
- Marginson, S. (2021). Global science and national comparisons: Beyond bibliometrics and scientometrics. *Comparative Education*, *0*(0), 1–22. https://doi.org/10.1080/03050068.2021.1981725

References 3/4

- Marginson, S. (2022a). 'All things are in flux': China in global science. *Higher Education*, *83*(4), 881–910. https://doi.org/10.1007/s10734-021-00712-9
- Marginson, S. (2022b). What is global higher education? *Oxford Review of Education*, 1–26. https://doi.org/10.1080/03054985.2022.2061438
- Marginson, S. (2022c). Space and scale in higher education: The glonacal agency heuristic revisited. *Higher Education*, *84*(6), 1365–1395. https://doi.org/10.1007/s10734-022-00955-0
- Marginson, S., & Rhoades, G. (2002). Beyond national states,markets, and systems of higher education: A glonacal agency heuristic. *Higher Education*, *43*(3), 281–309. https://doi.org/10.1023/A:1014699605875
- Marginson, S., & Xu, X. (2021). *Moving beyond centre-periphery science: Towards an ecology of knowledge* (Issue April). Centre for Global Higher Education.
- Mattsson, P., Sundberg, C. J., & Laget, P. (2010). Is correspondence reflected in the author position? A bibliometric study of the relation between corresponding author and byline position. *Scientometrics*, *87*(1), 99–105. https://doi.org/10.1007/s11192-010-0310-9
- Miao, L., Murray, D., Jung, W.-S., Larivière, V., Sugimoto, C. R., & Ahn, Y.-Y. (2022). The latent structure of global scientific development. *Nature Human Behaviour*. https://doi.org/10.1038/s41562-022-01367-x
- Ibrahim, R., Madon, H. D., Nazri, N. H. A. M., Saarani, N., & Mustapha, A. (2017). Paperless Transaction for Publication Incentive System. *IOP Conference Series: Materials Science and Engineering*, *226*, 012119. https://doi.org/10.1088/1757-899X/226/1/012119
- Mok, K. H., Xiong, W., Ke, G., & Cheung, J. O. W. (2021). Impact of COVID-19 pandemic on international higher education and student mobility: Student perspectives from mainland China and Hong Kong. *International Journal of Educational Research*, *105*(October 2020), 101718. https://doi.org/10.1016/j.ijer.2020.101718
- Musselin, C. (2018). New forms of competition in higher education. *Socio-Economic Review*, *16*(3), 657–683. https://doi.org/10.1093/ser/mwy033
- National Science Board. (2021). *Publications Output: U.S. Trends and International Comparisons*. National Science Foundation. https://ncses.nsf.gov/pubs/nsb20214/executive-summary

References 4/4

- Powell, J. J. W. (2018). Higher Education and the Exponential Rise of Science: Competition and Collaboration. In R. A. Scott & S. M. Kosslyn (Eds.), *Emerging Trends in the Social and Behavioral Sciences* (1st ed., pp. 1–17). Wiley. https://doi.org/10.1002/9781118900772.etrds0464
- OECD. (2007). *Revised Field of science and technology (FOS) classification in the Frascati manual*. Organisation for Economic Co-operation and Development. https://www.oecd.org/science/inno/38235147.pdf
- Oldac, Y. I. (2022). Global science and the Muslim world: Overview of Muslim-majority country contributions to global science. *Scientometrics*. https://doi.org/10.1007/s11192-022-04517-0
- Oldac, Y. I., & Yang, L. (2022a). Regionalisation and agency in science space: A historical bibliometric analysis of ASEAN science. *Manuscript Submitted for Publication.*
- Oldac, Y. I., & Yang, L. (2022b). The connectivity between Chinese and Turkish science systems: An agential perspective. *Asia Pacific Education Review*. https://doi.org/10.1007/s12564-022-09799-w
- Olechnicka, A., Ploszaj, A., & Celińska-Janowicz, D. (2019). *The geography of scientific collaboration*. Routledge.
- Sayer, A. (2000). Realism and Social Science. In *Critical Realism: Essential Readings*. Sage Publications Ltd.
- Sen, A. (2002). *Rationality and Freedom*. Harvard University Press.
- Sengupta, J. (2018). *Anti-globalisation wave to affect all, including US and EU*. ORF. https://www.orfonline.org/expert-speak/anti-globalisation-wave-affect-including-us-eu/
- Wagner, C. S. (2018). *The Collaborative Era in Science: Governing the network*. Springer International Publishing. https://doi.org/10.1007/978-3-319-94986-4
- Wagner, C. S., & Cai, X. (2022). Changes in Co-Publication Patterns among China, the European Union (28) and the United States of America, 2016-2021. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4035897
- Wagner, C. S., Park, H. W., & Leydesdorff, L. (2015). The continuing growth of global cooperation networks in research: A conundrum for national governments. *PLoS ONE*, *10*(7), 1–15. https://doi.org/10.1371/journal.pone.0131816
- Wuestman, M. L., Hoekman, J., & Frenken, K. (2019). The geography of scientific citations. *Research Policy*, *48*(7), 1771–1780. https://doi.org/10.1016/j.respol.2019.04.004

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