Stumbling bear, soaring dragon: Russia, China and the geopolitics of global science

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Russia, China and the geopolitics of global science

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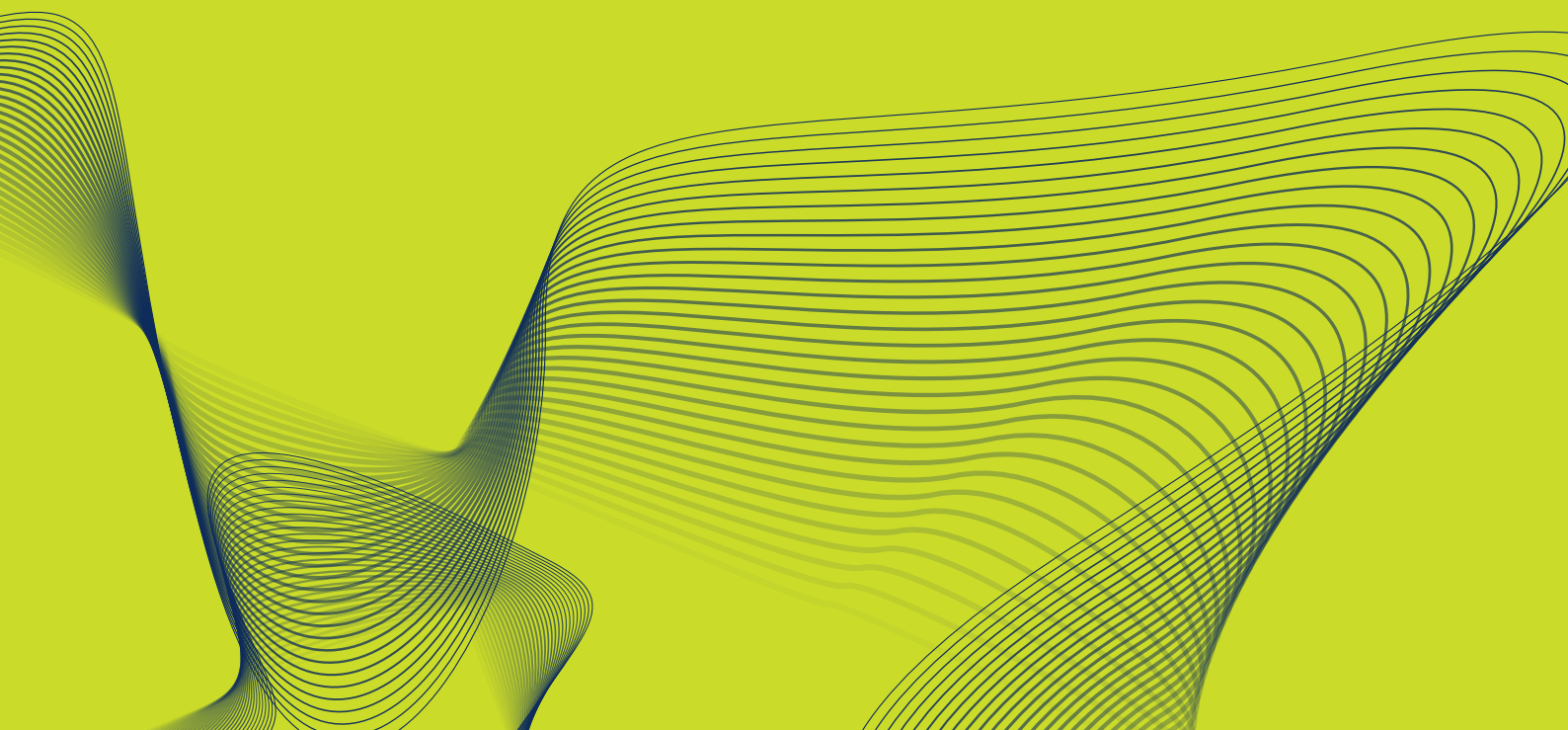


Executive summary

Knowledge, as Francis Bacon wrote, is itself power. Understanding how knowledge is generated, with whom and in which areas of enquiry, is critical in a world where two things are true: the best science is international and global connections are increasingly stressed by hardening geopolitics.

An open, collaborative research network has become the norm for western democracies. Those that do not also invest in international partnerships, or who are thrown out of them, lose access to leading research and related knowledge transfer opportunities.

This, the fourth paper in a series by the Policy Institute at King's College London and affiliates of the Mossavar-Rahmani Center for Business and Government at the Harvard Kennedy School, is an evaluation of international research partnerships that include China and Russia, the current and former leading research economies outside the G7.

> ... while Russia's science system is weak, deteriorating and increasingly marginalised, China is now the world's biggest spender on R&D

Data from 20,000 leading journals indexed by Clarivate™ in the Web of Science Core Collection™ are used to assess China and Russia's international research collaborations and their strengthening networks with other countries in Europe, the Middle East and Asia.

We consider these countries together because these two autocracies play critical roles in current geopolitics: China because of its economic reach, political clout, and fast-developing role on the global stage, and Russia because of its efforts to sustain its historical influence through regional power projection.

Both regimes present security, political and moral challenges for western democracies, but also very different scenarios for disengagement.

We find that while Russia's science system is weak, deteriorating and increasingly marginalised, China is now the world's biggest spender on R&D and, in stark contrast to just 20 years ago, is the first or second most frequent research partner with a wide range of countries.

Russia's ailing position in international science has made it easier for the west to deny it access to opportunities for research collaboration without weakening its own scientific endeavours. The UK government has suspended all publicly funded research collaborations with Russian universities. The EU has excluded Russia from Horizon Europe.

Russia is today 16th in the world for research output, accounting for less than 3 per cent of leading publications, a far cry from the USSR's historic position as the world's fifth most prolific publisher. It invests barely 1 per cent of GDP on R&D, its researcher workforce has fallen by 20 per cent since 2000, and half of its international collaboration is limited to astronomy and to nuclear and particle physics.

Russia is losing relevance in its own backyard, while China makes ever deeper relations with nations once squarely in Moscow's sphere of influence.

Today, of all the countries in Central and Eastern Europe, Russia is the lead (most frequent) collaborator only with Belarus. Even there, however, China is already second and likely to displace Russia soon if recent trends continue. Once again, China's tanks, Russia's lawn.

Russia ranks among the top 10 research co-authors of only Ukraine, Serbia, Bulgaria and Latvia. In Poland, it has dropped to 11th, overtaken by China. Among Arab countries, its share includes a four-fold growth of co-authored output with Saudi Arabia and the UAE; collaboration with Iran is rising and it has moved from 20th to 14th; but it has been displaced by China in Uzbekistan and by Turkey in Kyrgyzstan.

While marginalising Russian science, as many governments in the west have done, will have little effect on global science, taking a similar approach to China, should the geopolitics dictate such a step, would have dramatic outcomes for global knowledge production.

China is now the world's biggest spender on R&D and the first or second most frequent research partner for the G7, the Scandinavian and Baltic states, Australia, Singapore and South Korea. It has growing links with Iran (2nd), Egypt (3rd), Saudi Arabia (4th) and the UAE (4th), all of which have substantially increased their research output in the last five years, during which the increase in collaboration with China has often been three-fold or more.

Roughening geopolitics offers no guarantee that past patterns of scientific internationalisation will continue. Western policymakers need to learn lessons from the sequence of events that led them to isolate Russia. Recent events will have wider relevance for western collaboration with China and other authoritarian regimes that may be tempted to pursue expansionist foreign policies.

One scenario we explore is "DragonBear",[1] in which China and Russia voluntarily and proactively form a scientific collaborative axis and seek to expand it rapidly.

This is part of what would be a broader geopolitical deal between the two countries in which Russia as a junior partner of China could attempt to reshape the European security architecture while diverting the west's resources in such a way as to assist China in asserting its hegemony over the Indo-Pacific.

"Roughening geopolitics offers no guarantee that past patterns of scientific internationalisation will continue

Under DragonBear, both the west and China end up with a sub-optimal outcome in terms of science.

The data show that Beijing has more to lose from cutting western collaborative networks and far bigger gains by maximising global scientific collaboration than from entering a bipartite research engagement with Russia, China's 19th most significant partner. For the west, the costs of isolating China would be orders of magnitude greater than those it has incurred by banishing Russia.

At least for the time being, and for as long as the geopolitics allow, Russia and China must be treated as distinct science policy questions. Without nuanced understanding of the risks and benefits of international research collaboration, we risk passively slipping into ill-informed policy extremes.

At one extreme, in which we become increasingly embroiled in a global circling of the wagons, with nations prioritising economic sovereignty over mutual interdependence, we may blindly adopt a needlessly risk-averse set of policies that cripple global science. Under this scenario, today's highly globalised networks of knowledge creation, which include researchers seeking to mitigate climate change and to address public health crises, will wither as nations fall back on domestic priorities and on

1 The term "DragonBear" was coined by Velina Tchakarova in 2015 to describe a new mode of Sino-Russian bilateral relations aimed at shaping the global order in the 21st century.

research undertaken in the narrow confines of their own institutions and those of like-minded neighbours.

At the other extreme, we sleep-walk into engaging in scientific collaboration with countries whose interests are fundamentally inimical to our own. We naively provide scientific know-how, legitimacy and support to regimes that threaten the international system, engage in pervasive human rights abuses, and seek to harm us.

This report sheds light on data that will inform these critical policy decisions and point toward sensible policies that help steer a course between the extremes of blind trust and of intellectual disengagement and exclusion. We conclude with the following eight policy recommendations.

> .... we can strengthen the research environment by publicly and repeatedly committing to the core value of free and open inquiry

1. **Mapping.** This report sets out a history and current snapshot of a rapidly evolving international research landscape that must be extended by governments and academic institutions to underpin quality decision-making.

2. **Continue principled and robust collaboration with China.** Science and technology are international enterprises. We should confidently continue principled and robust international engagement that protects our values and also enables our academic institutions to remain at the forefront of global science.

3. **What we do at home matters.** Much in the realm of domestic and international politics is outside the control of our research institutions, but we can strengthen the research environment by publicly and repeatedly committing to the core value of free and open inquiry.

4. **Avoid knee-jerk discriminatory responses.** Academic institutions should work to counter trends within our own societies that weaken higher education.

5. **Diversify academic partners.** Universities should diversify their academic partners for both international students and research to avoid dependencies that can become vulnerabilities.

6. **Robust dialogue.** Western states should include higher education leaders and policymakers in a flexible and pragmatic whole-of-government approach, enabling a principled defence of interests and values.

7. **Clear policies.** Academic institutions should offer efficient and well-informed policies to vet research partnerships.

8. **Cultivate cultural expertise.** We should nurture a cadre of professionals with language skills, historical knowledge, and cultural competency relevant to the countries we seek to engage in academic collaboration.

Introduction

Prompted in part by events in Ukraine and the acceleration of de-globalisation that they have triggered, this is the fourth paper in a series of studies by the Policy Institute at King's College London and the Harvard Kennedy School to evaluate international relationships in higher education and research. The work has been an exercise in mapping relations, monitoring them for dependencies and recommending measures for mitigating risks and seizing opportunities where these are material.

The first three papers in this series looked respectively at changing patterns of international student flows,[2] at the risks and opportunities from the UK's booming ties with China,[3] and into the scope for the UK to partner more effectively with India as it becomes a more consequential player in the global knowledge economy over the course of the next few decades.[4] We bring China and Russia together in this latest paper because these two autocracies play critical roles in current geopolitics. We seek to assess the differing weights of and links between them in the global science system. The conclusion we shall reach is that while both these regimes pose security, political and moral challenges for open western democracies, they offer very different costs of disengagement and benefits from continued engagement. We therefore recommend careful and well-informed evaluation to underpin our strategic and research management planning and continuing engagement where that remains possible.

> "... while both these regimes pose security, political and moral challenges for open western democracies, they offer very different costs of disengagement

China is a critical global player because of its economic reach, political clout, and fast-developing role on the global stage as a competitor to the US and the EU; Russia because of its efforts to sustain its historical influence through regional power projection. Importantly, from the viewpoint of science policy, we examine them together because both countries have the latent potential to come into conflict, directly or indirectly, with western democracies.

The strengthening of ties between Moscow and Beijing predates the Ukraine crisis. The two countries have settled longstanding territorial disputes, deepened their energy nexus (with Russia overtaking Saudi Arabia as top oil supplier to China) and constructed trade and financial connections that can mitigate the impact of western sanctions. But the Ukraine crisis has revealed the strength of the bilateral relationship, raising the prospect of a major power bloc emerging and dominating Eurasia and providing a setback to any western hopes of maintaining a separation between the two.

Indeed, China and Russia, just days before the Ukraine invasion, declared the partnership between the two countries to be "without limits", raising serious questions about the nature of their relationship and the extent to which the alliance might harden into a more explicit anti-western bloc. Such concerns have grown in light of comments from Sergei Lavrov, Russia's foreign minister, that his country needed to "cease being dependent in any way on supplies of absolutely everything

2 Johnson, J. (2020) *Universities open to the world: how to put the bounce back in Global Britain*, Policy Institute at King's College London and Harvard Kennedy School. https://www.kcl.ac.uk/policy-institute/assets/universities-open-to-the-world.pdf

3 Johnson, J., et al. (2021) *The China question: managing risks and maximising benefits from partnership in higher education and research*, Policy Institute at King's College London and Harvard Kennedy School. https://www.kcl.ac.uk/policy-institute/assets/china-question.pdf

4 Johnson, J., et al. (2021) *Natural partners: building a comprehensive UK-India knowledge partnership*, Policy Institute at King's College London and Harvard Kennedy School. https://www.kcl.ac.uk/policy-institute/assets/natural-partners.pdf

from the west" and that Moscow's goal now was to develop ties with China at a faster rate "now that the west has taken a 'dictator's position'".[5]

The world of academic and commercial research is not immune to such developments. In this paper, we map not just China and Russia's research ties with each other but also their own respective research networks around the world. From a western securocrat perspective, these networks can penetrate and deeply influence institutions in other countries and make it harder for the west to engage fully and openly with historical and potential future partners in sensitive areas of technology such as communications and materials research.

In this report we move beyond anecdote through analysis of proprietary data from the 20,000 leading journals indexed by Clarivate in the Web of Science Core Collection to assess bibliometric patterns of international research collaboration. This route offers policymakers a guide to the globalisation of science over the last 40 years and highlights the challenges that de-globalisation would present to established collaborative networks in many countries.

The emergence of global science

Although scholars and ideas have always travelled the world, the development of pervasive networks of international collaboration is a relatively new phenomenon. In the early 1980s, most countries had as little as 5 per cent of their original research papers published in academic journals with co-authors from a second country. The volume of national and global research publishing grew slowly from year to year: a settled research world dominated by a transatlantic axis. The G7 group of large economies (US, Canada, UK, France, Germany, Italy, Japan) authored over 60 per cent of the papers indexed in the Web of Science; the USSR separately authored somewhat more than 5 per cent of papers; China, less than 1 per cent prior to 1990.

The growth of air travel promoted bilateral collaboration, leading to a general rise in scientific output led by research institutions with outstanding international reputations. After 2000, the arrival of the internet led to increasingly multilateral partnerships, and now more than a third of the research output of every major economy in Europe and North America links to two or more co-authors. A point to note, to which we later refer, is that China's research collaboration is much more bilateral than that in the west (Figure 1, over page).

42%
of published global research is by G7 nations

25%
of global research is now produced by China

The five-fold growth of articles and reviews between 1980 and 2020 also saw a shift in this regional balance. The G7 collectively now produce less than half of published global research (just 42 per cent in 2020) while China grew its output to an astonishing 25 per cent share in 2020. Spurred by enormous growth in GDP and its focus on improving higher education, this surge in production mirrored China's rising share in global R&D spending, which has overtaken the US.

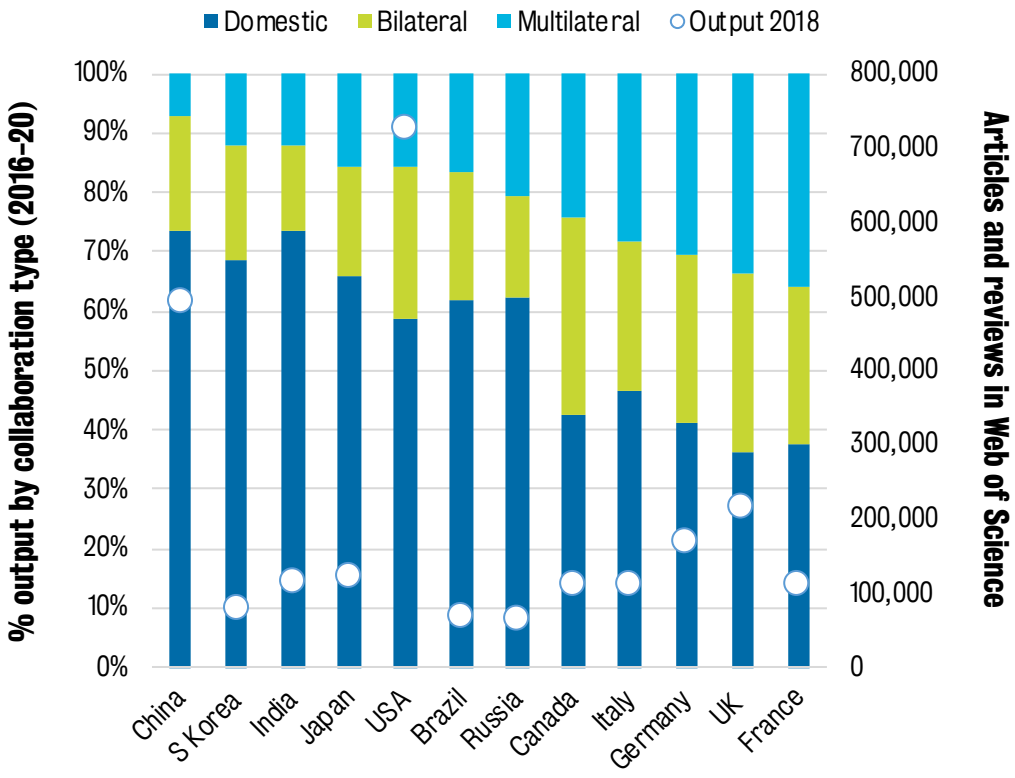
Data in our reports measures collaborations between scholars at *institutions* in various nations, not the *nationalities* or *educational backgrounds* of the scholars themselves. Still, it provides a helpful and broadly indicative map of the rapid recent growth of global science research collaborations, as well as an up-to-date and detailed picture of the speed with which China is expanding its reach around the world.

5 Reuters (2022) "Moscow not sure it needs resumed ties with West, will work on ties with China – Lavrov", 29 May 2022. https://www.reuters.com/world/moscow-not-sure-it-needs-resumed-ties-with-west-will-work-ties-with-china-lavrov-2022-05-23/

FIGURE 1: BALANCE OF COLLABORATION TYPES AMONG RESEARCH PAPERS

The balance of collaboration types among the research papers (articles and reviews) published in academic journals indexed in Web of Science that were authored or co-authored by research economies in the G7 and BRICK groups. Domestic papers are those that have no second country among author addresses.

Collaboration shares are shown as the average for the five-year window from 2016 to 2020 and each country's total output for the mid-year (2018) is also shown as a white disc in each column.



Cross-border science in times of geopolitical stress

There is a consensus that nations need to invest in research for their competitiveness, wealth creation and public benefit, and that those nations that do not fund collaborative partnerships as part of that investment will not have access to either the discourse between the leading research groups or the associated knowledge transfer opportunities.

Countries want their researchers to have a seat at the international table

Countries want their researchers to have a seat at the international table, to be in the labs that are melting pots of global talent and to know what is going on at the cutting edge in other systems. When the geopolitics are conducive to such international collaboration, countries are generally comfortable that their institutions can manage the competitive tensions in these relations between their researchers. The scientific endeavour generally comes first, the distribution of benefits from knowledge transfer and innovation a distant second.

In such times, the advantage in collaborative research comes primarily through priority over those not collaborating: a detailed knowledge of the work as it progresses, the learning opportunity provided to the research team and its organisation, and the training environment created for new researchers.

Subject to equitable sharing, partners to a project are in a better position to move in agile fashion to exploit an emerging opportunity than third parties unsighted on

the research and how it has evolved behind the scenes. A prerequisite is a research environment that recognises and rewards mutual contributions, equitably harvests the knowledge, and then enables that agile knowledge transfer response. This requires trust and transparency between the collaborating partners.

Enter the securocrats

During periods of geopolitical stress, the ability of the funders of R&D to secure economic advantage when the rewards are being shared with a competing nation is no longer just a narrow matter of research policy. It becomes a question of national security. And national security, crucially, then tends to be defined more broadly than in times of relative tranquillity, when it is limited primarily to areas of research into technologies with potential dual use in military applications.

When the geopolitics harden up, other questions arise: how have the boundaries between pure scientific pursuit and national security shifted? Is there still a *mutually* beneficial environment for scientific collaboration? In considering such questions, accurate mapping of the trajectories and distribution of collaboration, such as that provided in our series of papers, is essential.

That we now fight wars with economic and soft power, as well as cutting edge technology, means that geopolitical stress may potentially place a broader area of research out of bounds for collaboration with countries that do not share the same values and may in fact become hostile states. This reality has already led some western governments, science institutions and agencies to cut links with Russian institutions.

> EU academics are declining to review Russian papers when invited to do so by journal editors

Partial isolation of Russia

In the UK, for example, the government has announced a decision to suspend all publicly funded research and innovation collaborations with Russian universities and to work with partners to diminish Russia's role in multilateral science organisations.[6] Meanwhile, the European Union has excluded Russian entities from Horizon Europe, its main €95 billion ($105 billion) fund for research and ruled out the prospect of new grants or contracts.[7] At the same time, EU academics are declining to review Russian papers when invited to do so by journal editors.[8]

While such decisions will create challenges for climate science in the Arctic, for example, the need to be seen to stand up for western values has trumped such considerations.

While some Russian academics have signed petitions against the war, the statement from the Russian Union of Rectors, a group purporting to represent more than 700 rectors and university presidents, strongly supported the Kremlin line on the invasion.[9]

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6 Department for Business, Energy & Industrial Strategy (2022) "Research and innovation sanctions on Russia and support for Ukraine", 27 March 2022. https://www.gov.uk/government/news/research-and-innovation-sanctions-on-russia-and-support-for-ukraine

7 European Commission (2022) "Commission suspends cooperation with Russia on research and innovation", 4 March 2022. https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1544

8 Else, H. (2022) "Ukrainian researchers pressure journals to boycott Russian authors", *Nature*, 14 March 2022. https://www.nature.com/articles/d41586-022-00718-y

9 Lem, P. (2022) "Russian rectors' union echoes Kremlin propaganada on Ukraine", *Times Higher Education*, 7 March 2022. https://www.timeshighereducation.com/news/russian-rectors-union-echoes-kremlin-propaganda-ukraine

The sight of Russian forces destroying Karazin University in Kharkiv (and many other educational institutions) was too much for the staunchest advocates of science diplomacy in post-cold war bridge-building with Moscow.[10]

As Margrethe Vestager, the EU's Executive Vice-President for a Europe fit for the Digital Age, put it: "EU research cooperation is based on the respect for the freedoms and rights that underpin excellence and innovation. Russia's heinous military aggression against Ukraine is an attack against those same values. It is therefore time to put an end to our research cooperation with Russia."

The US and Canada have also ratcheted up their efforts to end collaborations. Most official US-Russian scientific ties had already been suspended following Russia's 2014 annexation of the Crimean Peninsula. In a statement on 11 March this year, the Canadian government said it was asking its federal funding agencies and several major grant recipients to refrain from entering into any new agreements with Russian research institutions.[11] Meanwhile, RosCosmos has suspended collaboration with the US over the International Space Station.[12]

It is worth noting that some collaboration continues in areas where Russia, for various reasons, cannot be excluded from international consortia. One example is the 35-country experimental nuclear fusion programme, ITER, in southern France. Russia was one of the seven founding members of the programme in 1985, with RosAtom responsible for the manufacture and supply some of the most complex and expensive components, including energy-absorbing resistors for power supply and protection of the ITER reactor's superconducting magnetic system.[13]

> Global research networks ... have yet to digest the implications of potential further de-globalisation

Academia has been one of the most internationally collaborative fields of human activity for the past 40 years. The west's partial boycott of the Russian knowledge economy is not the first example of a clash with geopolitics, but it is perhaps the clearest. The "hardening of geopolitics", particularly when it comes to China, predates the Ukraine invasion, but the steps to isolate Russia in global science promise to be a pivotal moment that marks the acceleration of a long-term trend.

Implications of potential further de-globalisation

Global research networks, along with the higher education systems with which they are closely connected, have yet to digest the implications of potential further de-globalisation. Without skilful management of the risks and benefits of internationalisation, global research will end up buffeted between ill-informed policy extremes driven by fear and ignorance.

At one extreme, in which global research becomes increasingly embroiled in a national circling of the wagons, with countries prioritising economic sovereignty over mutual interdependence, an excessively risk-averse set of policies will weaken global science. Under this scenario, today's highly globalised networks of knowledge creation will wither as nations fall back on domestic priorities and on research

10 BBC News (2022) "Ukraine: Kharkiv university ablaze after Russian missile hit", 2 March 2022. https://www.bbc.co.uk/news/av/world-europe-60585633

11 Government of Canada (2022) "Minister of Innovation, Science and Industry and Minister of Health statement on additional measures in response to Vladimir Putin's unjustifiable invasion of Ukraine", 11 March 2022. https://www.canada.ca/en/innovation-science-economic-development/news/2022/03/minister-of-innovation-science-and-industry-and-minister-of-health-statement-on-additional-measures-in-response-to-russias-unjustifiable-invasion-o.html

12 *The Guardian* (2022) "Russia to halt cooperation over International Space Station", 2 April 2022. https://www.theguardian.com/world/2022/apr/02/russia-to-end-cooperation-over-international-space-station

13 https://www.iter.org/proj/Countries

undertaken in the narrow confines of their own institutions and those of like-minded neighbours.

At the other extreme, we sleep-walk into engaging in scientific collaboration with countries whose interests are fundamentally inimical to our own. We provide scientific know-how, legitimacy, and support to regimes that threaten the international system, engage in pervasive human rights abuses, and seek to harm us. And, without informed management, we may provide that knowledge without even the reciprocity of shared understanding and outcomes.

An understanding of the data will inform these critical policy decisions and help steer a course between the extremes of naive embrace and abrupt intellectual decoupling and disengagement.

Stumbling bear...

For the past two decades, Russian President Vladimir Putin has been promising to reform his country's deteriorating science system. This has yet to bear fruit. Russia is an increasingly marginalised actor in global science, with few relationships of any material importance to other countries. It now represents less than 3 per cent of significant research publications in a rapidly expanding research world. The USSR, in its pomp in the 1980s was the world's fifth most prolific research publisher, even without accounting for its Russian language journals. Russia produces twice as many papers today as it did in 1981 but has fallen to 16th for research output among 30 leading nations because other well-established countries, like those in the G7, expanded four-fold.

Russia is in a position it will struggle to maintain. Russian science was weak before the invasion of Ukraine and will be even weaker as a result of it, with talent leaching out of the country as it did when tens of thousands of scientists emigrated or quit academia after the collapse of the Soviet Union.

> Russian science was weak before the invasion of Ukraine and will be even weaker as a result of it

Funding has been a major handicap in this respect. Russia is yet to recapture its former real-term levels of science funding and invests only a little under 1.1 per cent of its GDP on R&D, compared to an OECD average of around 2.7 per cent in 2020.[14] Although its researcher workforce remains the world's seventh largest in absolute terms, it has fallen in size by almost 20 per cent over the last 20 years, with many of the 80,000 lost researchers likely to include Russia's most productive and highly performing scientists.[15]

The decline in Russia's research capacity between the Soviet and current periods has necessarily led to substantial retrenchment not only in domestic activity but also in its international partnerships. It is still engaged in the larger international programmes in space science and in nuclear and particle physics and this has a marked effect on its portfolio. Russia's research collaboration is distributed thinly outside these highly multinational programmes. Of the roughly 20,000 academic papers published over the last five years with authors from both the UK and Russia, about 18 per cent are in particle physics, 15 per cent are in Astronomy and 6 per cent are in Nuclear Physics while only three other categories exceed 5 per cent.

Our analysis of four important geographical spheres of greatest Russian engagement confirms that its influence is much less marked than in the past. It is falling back in

14 OECD (2022) "Gross domestic spending on R&D". https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm
15 OECD (2022) "Researchers". https://data.oecd.org/rd/researchers.htm#indicator-chart

significance for partners across Europe, even before we account for the likely effects of the reported brain drain.

...Small pawprint

In Central and Eastern Europe, Russia is the lead collaborator (ie the most frequent international co-author) only with Belarus, while its historical relationship with Ukraine has waned (and of course recently imploded). Russia ranks among the top 10 partners by co-author frequency in only five countries: these two and Serbia, Bulgaria and Latvia. Here, in Russia's backyard, China has risen from 13th in 2011 to be Belarus' 2nd most frequent collaborator and is up from 14th to 9th in Ukraine. In Poland, Russia has dropped from 9th to 11th and has been overtaken by China, which has risen from 22nd to 8th (Table 1, Figure 2).

This trend is repeated widely. For 38 countries across Eurasia, Russia has fallen since 2011 from being among the top three most frequent collaborators in nine to just six in 2021. Even where it is still in the top set, its position is compromised (Table 2).

In the Near and Middle East, Russia is the lead partner for Armenia, but it is now second to Turkey in Azerbaijan and is ranked the fifth most important partner for Georgia, where the US has taken the lead. In no other country is Russia among the top 10. However, although it is only just among the top 20 collaborating nations for Arab countries, its share is expanding with a four-fold growth of co-authored output with Saudi Arabia and the UAE in the last five years.

> Russia ranks among the top 10 partners by co-author frequency in only five countries

In western Asia the pattern is more mixed. Collaboration with Iran is rising relatively quickly and Russia has moved from 20th to 14th most frequent co-author over 10 years, though this accounts for only 3 per cent of Iranian papers. By contrast, it has been displaced by China in Uzbekistan and by Turkey in Kyrgyzstan, on a very small research output in both cases. In Kazakhstan, however, Russia retains its lead role.

In South Asia, Russia is declining as a partner for Pakistan. It sustains a 4 per cent share of India's output (13th by frequency), compared to 25 per cent for the US. In Bangladesh, its share is increasing but it is only 19th by frequency.

This mixed picture indicates that Russia's role as a research power, and therefore scientific and technological partner, is generally both limited and relatively static, even in regions that might be regarded as its spheres of influence.

TABLE 1: RANKS OF CHINA AND OF RUSSIA BY FREQUENCY OF CO-AUTHORSHIP

The ranks of China and of Russia by frequency of co-authorship on the articles and reviews published in journals indexed in Clarivate Web of Science in 2011 and 2021. Countries are grouped by geographical regions and arranged in alphabetical order within groups. As an example, Russia was the 18th most frequent partner for China in 2011 while China was the third most frequent partner for Russia. Russia has so few co-authored papers with some countries in Asia (particularly in 2011) that no rank is given.

		Russia (rank)		China (rank)	
		2011	2021	2011	2021
	China	18	20		
	Russia			9	3
W Europe	Finland	9	15	15	5
	Germany	12	15	10	5
	Greece	14	20	16	9
	Sweden	19	20	12	11
Central & Eastern Europe	Belarus	1	1	13	2
	Bosnia & H	28	17	50	32
	Bulgaria	9	8	16	16
	Croatia	15	17	16	12
	Czech Rep	9	11	16	9
	Estonia	10	11	17	9
	Hungary	14	15	15	9
	Latvia	2	7	39	21
	Lithuania	9	10	23	12
	Poland	9	11	22	8
	Romania	13	13	19	10
	Serbia	13	8	17	15
	Slovakia	10	11	25	13
	Slovenia	20	23	17	15
	Ukraine	1	4	14	9
Central Asia	Armenia	4	1	9	11
	Azerbaijan	2	2	5	11
	Georgia	3	5	18	10
	Kazakhstan	1	1	18	2
	Kyrgyzstan	2	2	13	7
	Mongolia	2	4	6	2
	Uzbekistan	1	2	16	1

	Russia (rank)		China (rank)		
	2011	2021	2011	2021	
	30	14	13	3	Egypt
	22	14	15	2	Iran
	21	15	14	6	Iraq
	13	14	14	7	Israel
	53	20	9	9	Kuwait
	46	19	6	3	Qatar
	54	19	7	4	Saudi Arabia
	15	13	11	5	Turkey
	47	19	12	4	U A Emirates
	20	19	10	3	Bangladesh
			9	21	Bhutan
			11	13	Cambodia
	13	13	10	4	India
			14	9	Laos
	17	16	6	1	Malaysia
		36	7	2	Myanmar
		39	12	3	Nepal
	11	14	3	1	Pakistan
	17	14	7	2	Thailand
	10	13	8	2	Vietnam
	28	30	3	2	Australia
			3	2	Brunei
	43	31	10	7	Indonesia
	15	16	2	2	Japan
	11	12	7	4	New Zealand
	18	17	6	2	Philippines
	17	16	2	1	Singapore
	12	17	3	2	South Korea

Middle East

South & East Asia

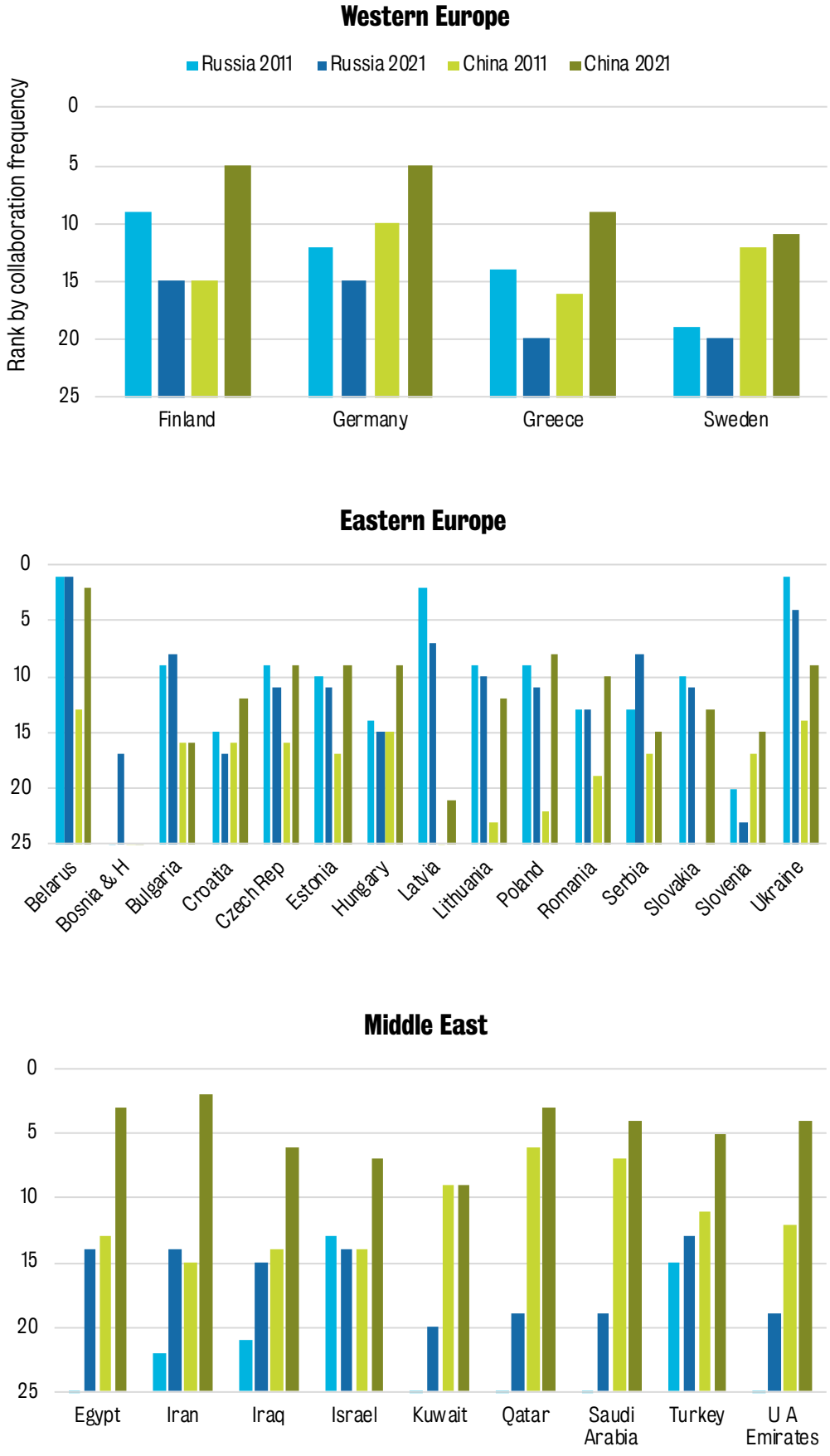
Asia-Pacific

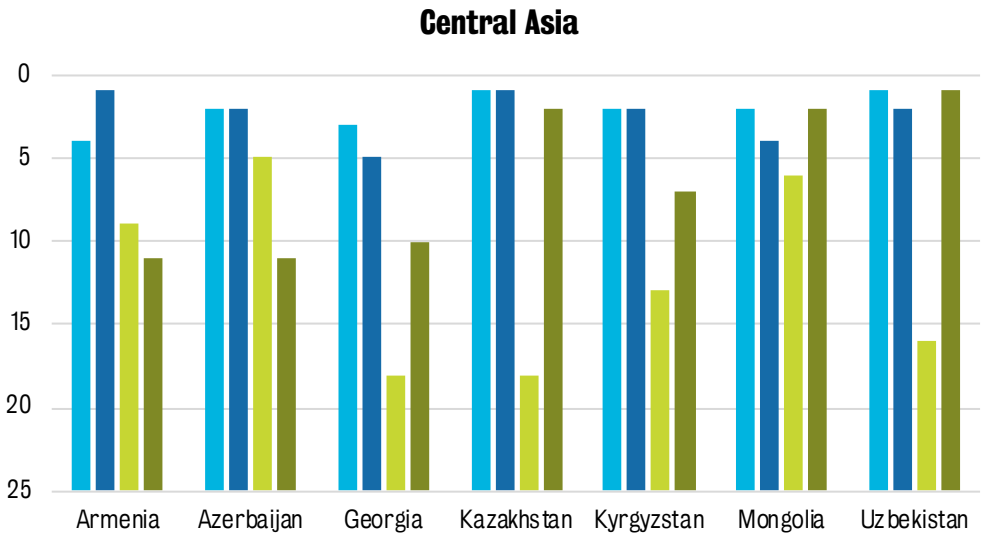
TABLE 2: FREQUENCY OF APPEARANCE AMONG THE TOP THREE MOST FREQUENT COLLABORATING PARTNERS FOR THE COUNTRIES LISTED IN TABLE 1

	2011	2021
Russia	9	6
China	8	21

FIGURE 2: FREQUENCY OF RUSSIA AND CHINA CO-AUTHORSHIP OF RESEARCH PUBLICATIONS

The frequency with which Russia and China co-author research publications with countries in six geopolitical regions, displayed as rank by frequency where 1 is the most frequent co-author. Data are shown for 2011 and 2021; a common legend is displayed for the first bar chart (western Europe) and the rank sequence (vertical axis) is limited to the 25 most frequent.




Central Asia
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Armenia
Azerbaijan
Georgia
Kazakhstan
Kyrgyzstan
Mongolia
Uzbekistan


South & East Asia
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5
10
15
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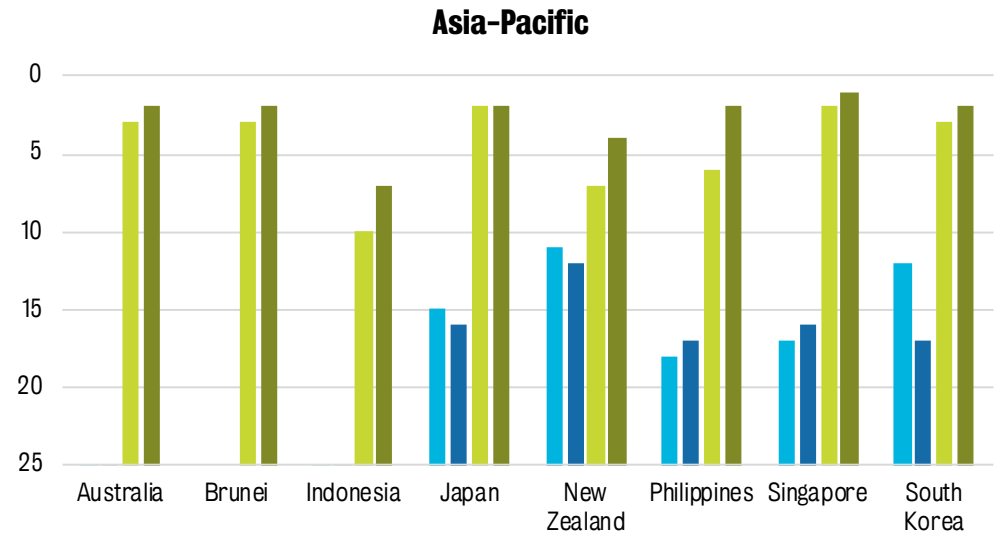
Bangladesh
Bhutan
Cambodia
India
Laos
Malaysia
Myanmar
Nepal
Pakistan
Thailand
Vietnam


Asia-Pacific
0
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10
15
20
25
Australia
Brunei
Indonesia
Japan
New Zealand
Philippines
Singapore
South Korea

Enter the DragonBear?

Looking at research collaborations in order of importance from Moscow's perspective, Germany and the US are Russia's key partners, at least for the time being. Although Russia's multilateral collaborations continue to rise, the numbers of focused bilateral papers between Russia and any country have not increased significantly in 30 years – with one exception. That exception is, of course, China, which is now Russia's third most important collaborator, having increased its co-authored count ten-fold since 2000.

Beijing's perspective, however, is another story. We find that Russia is merely China's 19th most significant partner, a position in which it has remained for the last 10 years. Russia has only occasionally been higher than 15th in the hierarchy of China's research partners. Put simply, China has over the past 20 years become much more important to Russia and will likely now overtake the US and Germany to become its single most important partner, while Russia remains no more important to Chinese science than many other Belt and Road initiative countries that participate in China's global network of science organizations (ANSO, Alliance of International Science Organizations). Russia needs China much more than the other way round.

> Russia remains no more important to Chinese science than many other Belt and Road initiative countries

The implications of this for China's strategic calculus are clear. When it comes to generating impactful research, Beijing has more to lose from cutting itself off from western collaborative networks than it has to gain from deepening ties with Moscow. The picture of the last 20 years suggests strongly that China makes far bigger gains by preserving the *status quo* and continuing its strategy of global collaboration than by forging a DragonBear bloc with Moscow. This *status quo* scenario, in which China maintains its steady growth and the west accommodates and welcomes China's rise while maintaining the core principles of free and open inquiry, is one that maximises the potential for global scientific collaboration from the perspective of both China and the west.

The DragonBear scenario is manifestly sub-optimal from a science perspective.

In such a scenario, China and Russia voluntarily and proactively form a scientific collaborative axis and seek to expand it rapidly. This might conceivably benefit Russian science, potentially reversing the trend of decline. But it is far from certain. Chinese scientists, like those in other countries, like to work with other talented scientists, not to waste their time. Even if the DragonBear nations' leaders wanted much more collaboration, it would be forcing scientists into sub-optimal relationships that are unlikely to be highly productive. Already China is giving little support to Russia in its war with Ukraine. It is a lot easier to ship equipment than it is to ship scientific capability. The scientific capability makes its own decisions.

Thus, even if the dragon's leader wanted to help its quasi-ally, he would have a hard time doing so in this context. What is much more likely is that the DragonBear scenario would see a weakening of China's own research base by causing it to miss out on vastly better and more interesting growth opportunities available from collaboration with western countries. In this DragonBear scenario, it is likely that China's collaboration with the west declines sharply as governments in the US, UK, EU and elsewhere clamp down in response, even if that unavoidably weakens western science in the process.

Science collaboration with China

Isolating Russia is one thing, but cancelling China, a superpower of global science, would be an altogether different proposition. We have discussed China's research profile, and the costs and benefits that require careful analysis, in our earlier reports.[16] China has overtaken the US to become the world's biggest spender on R&D and is an increasingly frequent research partner for all G7 countries. It has a powerful technology focus in predominantly bilateral projects. Few western researchers visit or work in Chinese institutions, compared to the numbers that engage with the US.

But excluding China from research partnerships would be a step of such significance for institutions in western knowledge economies that it could presumably only be contemplated in the context of some globally cataclysmic event, such as a Russian chemical, biological or nuclear escalation in Ukraine that China does not condemn, or, more directly, a conflict between China and the west over Taiwan.

China is emerging as an increasingly important, if not the leading, partner of many countries not only in Asia but also in other regions previously assumed to be in different networks of influence. As we explored in our earlier paper, it is now the most frequent bilateral collaborator for the US and Japan and second most frequent for the UK, Germany, France, the Scandinavian and the Baltic states.

Where Russia is falling in rank as a collaborator, China is rising. Among the same 38 Eurasia countries we analysed for Russia, China was among the top three most frequent collaborators for eight in 2011 and is now in that top group for 21 (Table 2).

> "... [China] is now the most frequent bilateral collaborator for the US and Japan

The difference noted between China's collaboration network and that of European countries (Figure 1) has implications for research management and research content. In the EU, there is a roughly equal balance across domestic, bilateral and multilateral research outputs. By contrast, most of China's extensive research output is domestic and only 5 per cent is multilateral. This means that collaboration with China is more likely to be about specific research topics rather than generic international programs, and the reasons for such selection need to be understood. At the same time, sharing, transparency and the mutual access may be affected: China's partners will need assurance on full and unfettered access to all immediate and wider aspects of any joint research projects, much of which could be opaque to them.

China's research network has become global. It is a frequent partner for many countries in South and East Asia. It is now investing in engagement across western Asia, where Russia had been influential. And, in the Middle East, its investment has expanded rapidly. It has a significant research relationship with many Asia-Pacific countries, including those with strong existing research portfolios such as Australia (2nd behind the US), India (4th), Japan (2nd), Singapore (1st) and South Korea (2nd). It is Pakistan's leading partner and is on a par with the UK in Malaysia. Its relative rate of increase in collaboration makes it likely to become the lead partner elsewhere (Table 1, Figure 2).

China has broad links across central Asia through the "belt" of the Belt-and-Road initiative. For example, Kazakhstan's research output doubled in the last five years and, while Russia remains the lead partner, collaboration with China increased ten-fold. China is now also the lead partner for Uzbekistan's research. Pakistan's research data indicate a ten-fold national increase in published output over 10 years, driven

16 Johnson, J., et al. (2021) *The China question*, op. cit.

in large part by a 200-fold increase in China collaboration since 2006 as part of the China-Pakistan Economic Corridor project.

Extending this overview into the Middle East, China has strong and growing links with Iran (2nd), Saudi Arabia (4th), the UAE (4th) and Egypt (3rd), all of which have substantially increased their research paper output in the last five years. Recent five-year (2017–2021) increases in collaboration with China have often been three-fold or more for these countries, while other leading partners have not doubled their collaboration in the same period. Given the nature of these regimes, and with Russian collaboration rising for Arab countries, this should be a region to monitor.

Maximising benefits, minimising risks

The crisis in Ukraine and the sanctions against Russia are just the latest manifestations of roughening geopolitics. They suggest that there is no guarantee that past patterns of internationalisation of scientific enquiry will continue in the future. Instead, a combination of hardening geopolitics and intellectual decoupling – at times initiated by China, at times by "the west" – will likely slow the cross-border collaboration of recent decades.

Hardening of geopolitics predates Ukraine but has been accelerated by it. As such, universities and governments around the world have some serious thinking to do. Given the international nature of the best science, enabling the world's leading universities to continue robust and principled academic engagement with China in which they both protect their interests and stand up for their values should be a public policy priority. A reversal of the globalisation of science and higher education would be a wrenching experience for knowledge economies worldwide. For the moment, this is watch-and-wait territory.

> "... there is no guarantee that past patterns of internationalisation of scientific enquiry will continue

Measures to isolate scientists in other autocratic countries, or those that supported or abstained on Russia's invasion of Ukraine, seem unlikely to be extended to China. But all bets would be off if there were any attack on NATO territory, any escalation of the conflict that involves chemical, biological or nuclear weapons, or if China offered Russia military assistance or blatantly ignored western sanctions.

We should also remain cognisant that China is not a passive observer of the changing research environment. The Chinese party-state is certainly using its own calculus to judge the international research environment as it relates to the development of science and national security. While we may not know the exact nature of this calculus, we should assume that China will make decisions, both pre-emptively and in response to decisions made by other countries, that it deems to be in its national interest.

Western knowledge economies, comfortable in a world of accessible global science, need to work out how to sustain international research collaboration in a complex geopolitical environment. Smart knowledge management means determining which areas are essential ground for more open science (such as climate science and public health) and which are not (such as strategic technologies). A relentlessly moving definitional challenge should be informed, at least in part, by the type of data-driven mapping of research relationships our work provides.

As we explored in *The China Question*, the cost of sub-optimal policy responses will be high for academic institutions at the heart of knowledge economies. To respond to this, they need to take a lead in helping governments and academic institutions

address the challenge of balancing the benefits of feasible future collaboration with what will inevitably become a more overtly managed system.

Conclusions and policy implications

This cautionary tale of two countries holds lessons for western knowledge economies as their leaders contemplate the potential of a further hardening of relations with China. Isolating Russia, a permanent member of the UN Security Council but a relatively small player in world science, has been a relatively low-cost exercise.

By contrast, China is a P5 member that has moved in the opposite direction. Since the turn of the millennium, it has gone from near obscurity to becoming a genuine superpower of global science and an indispensable partner for countries around the world. In just 20 years, as Russia moved ever further away from the discovery frontier, China became ever more deeply embedded in western higher education and research systems and a key science collaborator for every OECD country. If geopolitics demand disengagement, our mapping of the rich and growing web of research relationships underscores a new reality: the costs of isolating China – even if that were possible – will be many orders of magnitude more significant than those of banishing Russia. The significant costs of disorderly disengagement would rebound on tertiary education and research performance in western knowledge economies and globally.

> “ ... Russia and China must, at least for the time being, be treated as distinct questions

What follows is a series of policy recommendations intended to contribute towards the management of risks arising from western HE and research systems' relations with authoritarian regimes.

The starting point is that Russia and China must, at least for the time being, be treated as distinct questions. There is no one-size policy response that fits both the stumbling bear and the soaring dragon. Whereas the west has a clear and stated policy of isolating and weakening Russia, so that it desists from further expansionist aggression, there is no such objective with China.

Notwithstanding China's abstention in key UN votes on the Ukraine war, there has been no shift in policy in either the UK or US to isolate China as part of a formal strategy of containment and economic decoupling. Unless and until such a policy shift takes place, the following principles apply to research collaboration with China.

1. **Mapping.** This report sets out a history and a current snapshot of a rapidly evolving international research landscape that is essential for quality decision-making by governments and academic institutions. The Web of Science data can show, institutionally and by subject, how knowledge capital is influenced, how research trajectories are moving and how effective policy can be structured.

2. **Continue principled and robust collaboration with China.** Science and technology are international enterprises, characterised by global collaboration, as well as global competition. A tension will always exist between the benefits and risks of collaboration. The best science is global and many of the world's leading academic institutions are in the west. We should confidently continue principled and robust international engagement that preserves our values and enables our academic institutions to remain at the forefront of global science.

3. **What we do at home matters.** While the domestic policies of other countries and the vicissitudes of geopolitics are largely outside the control of our research

institutions, there is much that we can do at home to strengthen our research environment. We should unequivocally and publicly commit to the values that made our academic institutions strong in the first place: free and open inquiry. And we should ensure that such values are central to our international collaboration.

4. **Avoid knee-jerk discriminatory responses.** Academic institutions should work to counter trends within our own societies that weaken higher education. In terms of collaboration, the China Initiative of the US Department of Justice had a chilling effect on academic relations between the countries with little benefit to show before it was rapidly shuttered. This is particularly true because the initiative coincided with a rise in deeply repugnant anti-Asian sentiments and violence that are also own-goals when it comes to advancing education and science. Institutions should be clear about how these issues affect our work and express support for negatively affected groups in their own communities.

5. **Diversify academic partners.** Universities should diversify their academic partners for both international students and research, to avoid dependencies that can become vulnerabilities. Expanding the range and type of international partners helps protect against the inevitable ebb and flow of geopolitics. Both the US and UK should assist institutions in diversifying their international student intake, a crucial pipeline of talent for the research base, by continuing to monitor and improve on the competitiveness of their visa offer with respect to fees, processing times and post-study work rights.

> “Academic institutions should work to counter trends within our own societies that weaken higher education

6. **Robust dialogue.** Western states should include HE leaders and policymakers in a flexible and pragmatic whole-of-government approach, enabling a principled defence of interests and values. Governments and academic institutions in like-minded countries should create a forum for regular dialogue with scientists, area studies experts, and policymakers to ensure feedback loops that inform sound national policies.

7. **Clear policies.** Academic institutions should offer efficient and well-informed policies to vet research partnerships. No scientist or academician should be left wondering what types of research collaborations are above-board and which are not. Nor should they be scared away by excessive administrative requirements.

8. **Cultivate cultural expertise.** We should nurture a cadre of professionals with language skills, historical knowledge, and cultural competency relevant to the countries we seek to engage in academic collaboration. Doing so means interacting with the institutions in those countries from a place of nuance and understanding. Not doing so means going in blind and greater risk of falling prey to fear rather than reason. Training in Chinese language skills and cultural competency should be a national (security) priority. Specifically, governments should ensure funding for:

- Advanced Mandarin language study both at universities at home and in mainland China or Taiwan for students having completed at least two years of language study and who are willing to reside in the region for at a least one semester.

- Postgraduate study in mainland China and Taiwan at a select group of the highest quality programs.

Even as these policy suggestions are implemented, we identify the following areas for further research.

Quality vs. Quantity

We have mapped the total number of papers that are published by authors from a single country, two countries, or more than two countries in the global Web of Science citation index. This usefully illustrates the volume of research collaboration and to a significant extent, the quality, because only papers from 20,000 selected journals which demonstrate editorial rigor and best practices are selected for inclusion in the Web of Science Core Collection.

Further research should be more granular about the quality of scientific research produced. *The China Question* looked at citations, while noting some of the limitations of that approach. There are other problems with citation counting, particularly in the Chinese context, that should be explored and considered.[17]

Other methods should be considered for measuring the origins of the highest quality research. This might be by calculating the numbers of papers published in the very top crust of journals, interviewing scientists engaged in global research, and more.

Even more accurate mapping of our research relationships will allow us to make better-informed policy decisions.

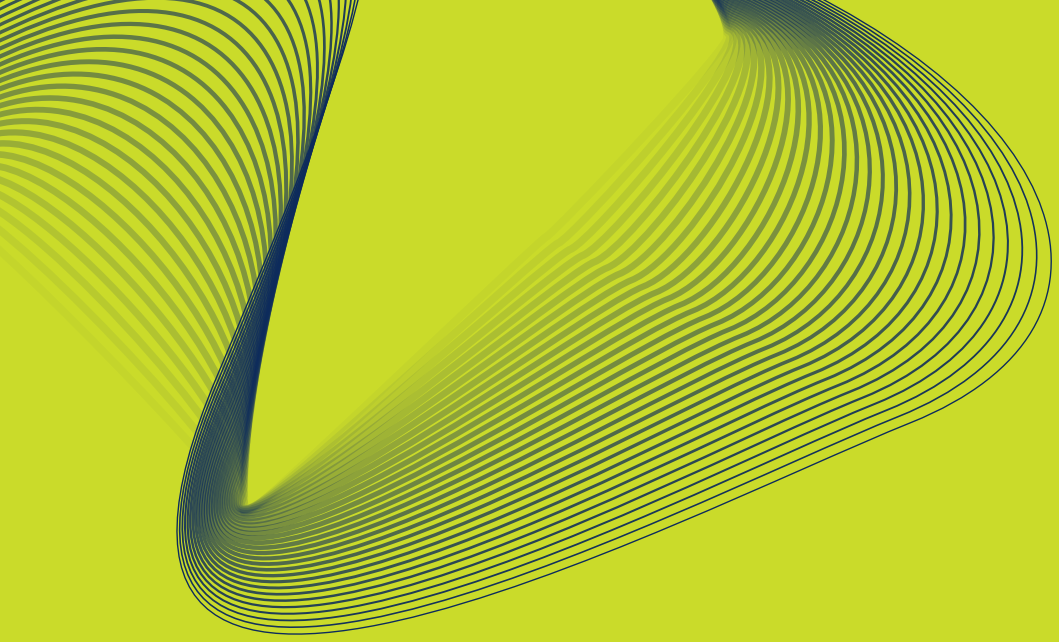
What is global science?

This paper usefully examines the institutional affiliations of researchers who published papers in the Web of Science. It does not, however, consider the nationality or international educational backgrounds of the researchers.

So, for example, when a team of scientists at a UK institution including citizens from the UK, India, and China co-author a paper we consider this as a wholly domestic effort. On the other hand, some work produced solely at a UK institution has apparent international collaboration from a Chinese student's original institution.

Further work should look beyond institutional affiliation to inform governments on the educational background and nationalities of researchers in key technology areas to add depth and colour to our mapping of trends in international science.

17 Yarrow, R. (2022) "Measuring and Mis-measuring China's Scientific Rise", The Wire China, 24 April 2022. https://www.thewirechina.com/2022/04/24/measuring-and-mis-measuring-chinas-scientific-rise/



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