HARVARD Kennedy School
MOSSAVAR-RAHMANI CENTER
for Business and Government

THE POLICY INSTITUTE

KING'S College LONDON

The China question

Managing risks and maximising benefits from partnership in higher education and research

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March 2021

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Acknowledgements

The authors are grateful to the Policy Institute at King's College London and the Mossavar-Rahmani Center for Business and Government (M-RCBG) at the Harvard Kennedy School for supporting this joint publication. They would like to thank Gavan Conlon from London Economics and Jazreel Goh and Matt Durnin from the British Council for their support on the data collection and analysis for this report. Analysis on research activity and performance, in chapters 1 and 3, was conducted using Web of Science™ data. The authors would like to particularly thank Professor Kerry Brown, Director of the Lau China Institute at King's College London, for lending his time and wealth of knowledge on this topic both during the inception meetings for the report, and in reviewing and providing comments during its finalisation. A number of others have provided advice and insights, including Professor Richard Zeckhauser, Frank P. Ramsey Professor of Political Economy at the Harvard Kennedy School; John Haigh, Co-Director of the M-RCBG; Edwin M. Truman, Senior Fellow at the M-RCBG; and Professor Bobby Duffy, Professor of Public Policy and Director of the Policy Institute, King's College London. The views expressed in this report, part of the M-RCBG Working Paper Series, are those of the authors and do not necessarily reflect those of the M-RCBG or of Harvard University. The papers in this series have not undergone formal review and approval; they are presented to elicit feedback and to encourage debate on important public policy challenges.

Contents

Executive summary

The UK urgently needs to put in place a robust framework for engaging China in research and higher education (HE). China is set to overtake the US to become both the world's biggest spender on R&D and the UK's most significant research partner, raising pressing questions for policymakers at a time of rising geopolitical tensions.

The extensive relationship with China across our university system, in both teaching and research, is inadequately mapped. The UK needs to do a better job of measuring, managing and mitigating risks that are at present poorly understood and monitored.

Our research shows that collaboration between China and the UK has increased from fewer than 100 co-authored papers before 1990, to around 750 per year in 2000 (about 1 per cent of UK output), and then to 16,267 papers in 2019 (about 11 per cent of UK output).

"The UK urgently needs to put in place a robust framework for engaging China in research and higher education"

There are now no fewer than 20 subject categories in which collaborations with China account for more than 20 per cent of the UK's high-impact research. In three key subjects – automation and control systems; telecommunications; and materials science, ceramics – collaborations with China represent more than 30 per cent of such output.

This heightened degree of integration makes any idea of decoupling from China both unviable and unlikely to be in the national interest but does signal the need for a clear and strategic approach to research collaboration, capable of mitigating real risks.

The research highlights the poor quality of data on international education and the need for greater awareness of its value to the UK economy. HE exports to China represent the UK's single largest services export to any country. The government should avoid caps on international students in aggregate or any form of discrimination by nationality.

But reliance on significant tuition fee income from Chinese students to cross-subsidise loss-making research creates a strategic dependency and potential vulnerability. The sector regulator, the Office for Students, should more actively monitor this risk and require institutions to have plans to mitigate it, including through recruitment diversification strategies.

This is a pressing need as the growth in capacity and institutional quality of China's own HE system is likely to place a significant downward pressure on student enrolments internationally over the medium term. China, over the next decade, is likely to consolidate its appeal as a global destination for HE.

Our research shows that Chinese students in the UK have very high overall satisfaction rates and a very low drop-out rate, indicating that UK universities are in a strong position to attract a significant proportion of those students who may still choose to study beyond China.

Introduction

How best to engage China is the first major foreign policy challenge for a post-Brexit UK and a critical question for the future of Britain's global and open knowledge economy. The Integrated Review of Security, Defence, Development and Foreign Policy,[1]charged with defining the government's vision for the UK's global role, has the challenge of steering a course between a combative US and a biddable Europe. While Washington has been levying new financial sanctions on Beijing,[2] that are likely to be maintained by the Biden administration, the EU has moved to reap the economic benefits of the newly-minted Comprehensive Agreement on Investment (CAI), the most ambitious bilateral deal China has ever concluded.[3] Pulling off a "have your cake and eat it" policy towards Beijing, so that the government satisfies China hawks within the Conservative party while at the same time ensuring that the UK doesn't accidentally follow Brexit with "Chexit", will require deft political skills.

> How best to engage China is the first major foreign policy challenge for a post-Brexit UK

While no one seriously advocates decoupling from China, given its size and interconnectedness and while the Prime Minister describes himself as "fervently Sinophile", the Integrated Review comes at a time of mounting anxiety over the UK's overt prioritisation of trade and investment ties during the so-called "golden era" under David Cameron and George Osborne.[4] Hailed at the time by China's President Xi Jinping as a "visionary and strategic choice that fully meets Britain's long-term interest",[5] the decision to become the western country most open to China is now seen as "naïve and cynical"[6] by influential Conservative party figures. The UK, according to historian Robert Tombs, "has allowed penetration by a potentially hostile state to a degree unparalleled since Charles II accepted money and mistresses from Louis XIV".[7] Defence intelligence chiefs are warning of the way China is investing heavily in collaborative research and overseas knowledge transfer activities in artificial intelligence, machine learning, cyber, space and other ground-breaking and disruptive technologies, capable of operating in the ambiguous and fast-growing grey-zone between civil and military applications.[8]

Such fears have been growing since 2017, when China's top legislature, the National People's Congress (NPC), passed the National Intelligence Law, allowing Chinese intelligence agencies to compel Chinese organisations and individuals to carry out work on their behalf and provide support, assistance and cooperation on request. This focused attention in Westminster on China's increasingly important role in the UK university system, a leading location of research into these sensitive areas, and on the role of its network of Confucius Institutes, which are embedded to date in at least 29 leading HE providers and are generally suspected of acting as propaganda arms of the Chinese Communist party (CCP).

Highlighted further by the Covid-19 pandemic, the UK's dependence on a neo-totalitarian technology power for the financial health and research output of its universities is now regarded as a particular point of vulnerability. The pandemic has sparked calls for greater national resilience across all critical areas of economic activity that have resonated far beyond traditional opponents of globalisation and openness between countries. Sir John Rose, former chief executive of Rolls-Royce, for example, recently became the latest senior industrialist to warn of the UK's dependence on Chinese post-doctoral science students and the related risk of intellectual property theft.[11] Further steps to tighten up the process of security clearance for Chinese academics are reportedly imminent,[12] at the same time as investigations are said to

be underway into British academics suspected of unwittingly helping the Chinese government build weapons of mass destruction.[13]

The ad hoc nature of official responses underscores a troubling reality that the extensive relationship with China across our university system in both teaching and research is only partially mapped. It remains poorly understood and monitored: policymakers are at present unable to assess the likely impact on a sector key to the UK knowledge economy. This is a worrying gap as the toughening of the UK's approach that began under the premiership of Theresa May, a hawkish former home secretary, has continued under her successor, Boris Johnson. What's more, it shows every sign of intensifying under pressure from Conservative backbenchers, such as former party leader Iain Duncan Smith and Foreign Affairs Committee chairman Tom Tugendhat. This intensification is evident in the Johnson government's decision to order Huawei off the UK's 5G networks by 2027,[14] to level formal accusations at Beijing of "gross and egregious" human rights abuses of China's Uighur population,[15] and to offer passports to British Nationals (Overseas) in Hong Kong[16] following the imposition of new national security laws.

> Academia and HE are key battlespaces for this intensifying geopolitical rivalry

Even if an economy weakened by the global pandemic would appear to leave the government little room for manoeuvre, the political pressures militating in favour of a further toughening up of the UK stance towards China are mounting. Pugnaciousness towards China has replaced Euroscepticism as the key test of virility on Tory benches. The cause of the Uighurs, championed in a number of reports by the Conservative Human Rights Commission, has created a powerful parliamentary coalition spanning both the left and right of the party, bringing together right-wing China hawks and those on the left taking a stance on human rights.[17] Indeed, if six others had joined the 33 Conservative rebels, who, in mid-January, defied the party whip to outlaw trade deals with countries committing genocide, the current government's substantial majority could have been erased. This is a pressure group that the government will struggle to ignore and hawkishness on China will no doubt be one of the issues that binds together the new Tory electoral coalition. "Every part of Boris Johnson's new Tory Party wants a tougher line on China," according to *The Spectator's* James Forsyth.[18]

Academia and HE are key battlespaces for this intensifying geopolitical rivalry. This is not a new phenomenon. There is always a tension between the benefits and risks of openness in research. The UK had similar concerns about the diffusion of British technology to France and Prussia during and after the industrial revolution. Japan and South Korea utilised predatory knowledge transfer practices, like those currently used by China, during their economic development in the decades following the second world war, to benefit from insouciance from western countries keen to bolster a cold war ally.[19] Academia is therefore both a natural and deeply familiar ground for "proxy war" between economic competitors. We should not be surprised that it is occurring again, nor that, given China's greater size, it is happening on a greater scale. That there are precedents for what is happening in no way diminishes the need to evaluate the relationship and fill the considerable gaps in our knowledge and understanding of it.

Thus far, as we show in this paper, the passing of the "golden era" has had little impact on Chinese student flows to the UK and to a burgeoning UK-China research relationship. This should be welcomed. This paper emphasises the value to the UK

of foreign students and overseas scientific talent. The UK has a long and illustrious history of foreign-born scientists and engineers training and working here, and making vital contributions to our standing in science, engineering and technology. Maintaining a leading position in the future will require the UK to collaborate with China, and to continue to attract and retain the best science talent globally from a country projected to be the pre-eminent spender on research and development for the foreseeable future.

> ...the UK needs to do a better job of measuring, managing and mitigating risks inherent in the current system

With pressure increasing for a further hardening of bilateral relations, however, this paper seeks to map key aspects of the existing relationship and examine some of the main concerns around, and threats to, deeper UK-China ties in HE and research. The paper argues that the UK needs to do a better job of measuring, managing and mitigating risks inherent in the current system. These risks include the extensive cross-subsidies of university research from fee-paying international students; the lack of financial resilience arising from a dependence on income flows from students from one country; the extent to which China has risen up the rankings of the UK's research partners to become one its most important science and technology collaborators, representing an exceptionally high share of the UK's research output in key scientific domains; and the associated threats to freedom of speech, academic freedom and institutional autonomy.

The research deliberately relies on data rather than anecdote to contribute to our understanding of the extraordinarily deep relationship with China, currently under threat, and to suggest policies that could form part of a framework for mitigating risks and maximising genuine opportunities for mutually beneficial and equitable partnership. Ultimately, it should help put in place the building blocks of a more sustainable internationalisation of the UK HE and research system, one which commands deeper and more durable political consent and can survive increased volatility in the geopolitical climate in the years to come. In this respect, it is intended to inform our response to the bigger strategic challenge of ensuring that the UK remains influential post-Brexit,[20] by deploying and leveraging its universities, science base and other knowledge economy assets to the greatest effect on the world stage.

Notwithstanding its importance, this is an under-researched subject in the UK context, certainly compared to the attention these issues have received in the US and Australia. This must change if the UK is to avoid HE policy being developed on the back of a weak evidence base. Recent reports from centre-right think tanks,[21] [22] backed by prominent Conservative members of parliament caucusing in the new China Research Group,[23] have raised fears of a return to "bureaucratic, impractical and damaging proposals for the sector". It is, for example, the same pundits who say "too many young people go to university"[24] who simultaneously (and erroneously) claim that Chinese students are crowding out British students and depriving them of places in HE.[25] The reality, of course, is that fee-paying international students bring nearly £8 billion in revenue to the system and make viable many courses that would otherwise not be offered at all.

If left unchallenged, these misconceptions will create greater unpredictability and inconsistency in the regulatory environment governing universities' plans for the recruitment of international students. It will likely also impact on the formation

of long-term research partnerships with Chinese institutions.[26] Indeed, there is a tendency in these reports to answer the China question in a binary way, as if there is no possible middle ground between naïve embrace and defiant disengagement. Neither extreme is likely to be in the UK national interest. China is, simultaneously, across various policy areas, a cooperation partner with which the UK has closely aligned objectives, a negotiating partner with which the UK needs to find a balance of interests, an economic competitor in the pursuit of technological leadership, and a systemic rival promoting alternative models of governance and violations of human rights on a massive scale. This requires a flexible and pragmatic whole-of-government approach, enabling a principled defence of interests and values.

> ...there is a tendency in these reports to answer the China question in a binary way

Managing the UK HE system's relationship with an authoritarian dictatorship that shows little desire to transform itself into a western-style liberal democracy requires a carefully calibrated policy mix. It should enable the sector to maintain strong people-to-people ties through student flows, and to capitalise on opportunities for cooperation with a superpower of global R&D in pursuit of shared objectives, such as the achievement of the Sustainable Development Goals and tackling climate change. At the same time, it must take a clear-headed approach to mitigating the real security risks that this entails and ensure that it upholds the core values of the academy. This is not an easy balancing act. Careful monitoring, transparency and openness will be essential to maintaining the fragile confidence of legislators.

A directive from outgoing President Donald Trump on stopping China and other US rivals from gaining inappropriate access to research funded by the federal government points to the future direction of policy in the US under President Biden. It also serves as a helpful template for the development of more robust UK safeguards.[27] Promulgated on 14 January 2021, National Security Presidential Memorandum (NSPM)-33 offers direction to federal agencies, universities, and individual scientists on how to safeguard national security without relinquishing the openness of US science. It explicitly and uniquely names China among the foreign governments who "have not demonstrated a reciprocal dedication to open scientific exchange and seek to exploit open US and international research environments to circumvent the costs and risks of conducting research, thereby increasing their economic and military competitiveness at the expense of the United States, its allies, and its partners".

In the UK, the university sector has begun to take steps to address the China question. Building on the Trusted Research guidance provided by the Centre for the Protection of National Infrastructure,[28] Universities UK (UUK) published detailed guidance in October 2020 for institutions on measures to guard against hostile interference and promote academic freedom.[29] These are a good start and represent a movement in the right direction. They are, however, coy about the cumulative and structural risk inherent in such deep and systemic engagement with China. This, as we will highlight, is now embedded in the UK research system to a degree that perhaps only a few realise and is not mentioned once explicitly in the 62-page document. For this reason, the limited and tactical safeguards proposed fall short of the action that will be required to protect UK interests.

The first chapter looks at the research relationship between the UK and China. This relationship is critical for the future of UK science as China overtakes the US in

terms of the absolute value of its R&D expenditure and its research output expands at an exponential rate, with no clear signs of plateauing. It is displacing the US as the principal partner in science and technology collaborations for many countries, including Britain. Collaboration between China and the UK has increased at a striking rate, from fewer than 100 co-authored papers before 1990, to around 750 per year in 2000 (about 1 per cent of UK output), 3,324 in 2010, and 16,267 papers in 2019 (about 11 per cent of UK output).[30] The UK is lagging the US in assessing the extent to which this is a balanced "win-win" relationship or one in which a strategic rival is instead systematically targeting cutting-edge research in the UK in order to transfer knowledge, secure the commanding heights of the technology battlespace and protect the core position of the CCP.

> [China] is displacing the US as the principal partner in science and technology collaborations for many countries

The second and third chapters address the question of international student flows from China to the UK. Chapter 2 examines the evidence on broader trends in the international student market, with a particular emphasis on Chinese international students and their importance to the UK university sector and our economy. It goes without saying that these flows are imbalanced and that there is an urgent need to increase understanding of China in the UK. The current single greatest failure of UK policy towards China is arguably to fail to admit that we lack basic levels of China, and Asia, literacy. Specialists in this field note that the UK produces a dismal 300 graduates in Chinese studies (not even Chinese language) every year. The UK is closing down capacity in this area, not increasing it, and its failure to educate itself is seen by leading figures in the field of China studies as perhaps its biggest vulnerability.[31]

Chapter 3 looks at trends in Chinese international student flows, seeking to understand how long China will remain a *net* exporter of students. In both cases, our aim is to articulate an evidenced account of the role of Chinese students in the UK, both today and in the future, to understand both the risks and benefits inherent in this relationship.

This is a question which receives too little attention in much of the UK debate, which assumes a growing outbound flow from China to the UK and has generated mistaken calls for the introduction of regulatory caps on Chinese student numbers in this country.[32] China cannot currently accommodate the totality of student demand for high quality HE within its own borders. Domestic Chinese demand for HE, however, will be negatively affected by demographic trends suggesting China's college age population will decline through to 2025. These chapters assess whether China will continue to export students as its own university system simultaneously expands, improves in quality and rises up global rankings, enabling many more students to satisfy their needs for high status qualifications that command a labour market premium without overseas study.

The fourth chapter examines a China that is on the verge of becoming a superpower in global HE in its own right. It finds that the western-led, English-speaking and Anglocentric paradigm for internationalisation has passed its peak and potentially faces a long-term structural decline. The world is witnessing the passing of an era of western-led dominance of international HE, which will be accelerated by the shock of coronavirus-related technological adaptations and shifts in student demand. The chapter looks at demand for international high school programmes in China – a common choice for students aiming to go abroad for college – which provides an

indicator of future Chinese overseas student numbers. It assesses trends pointing towards a more multi-polar internationalisation of global HE and research over the next decade. It will analyse the trend for China becoming a popular study destination for many students from Belt and Road Initiative (BRI) countries, the Global South and beyond.

The concluding chapter will offer policy recommendations intended to contribute towards the management of risks arising from the UK HE and research systems' relations with China. The UK, ideally in partnership with other liberal democracies, needs to prepare systems and structures that can handle internationalisation of global HE and research that is more multi-polar and potentially even Sino-centric than in recent decades. It makes a number of policy recommendations that aim to address: risks inherent in extensive and cross-subsidies of university research; the lack of financial resilience arising from an over-dependence on income flows from one country; threats to freedom of speech and research integrity; misperceptions relating to fears that overseas students are crowding domestic students out of university places; the need for greater attention to the diversity of the international student body; more effective integration of overseas students in the learning environment; and the overall quality of the international student experience.

In sum, this final chapter intends to offer a menu of policies intended to support a more sustainable model of international HE and research for an increasingly volatile time.

1. Research collaboration between the UK and China

Key messages:

- This chapter presents a novel analysis of the extent and depth of UK-China research collaboration where focus previously has been on Chinese student number flows.
- The UK's wholly domestic research volume has been static for over 25 years, while China's wholly domestic research output is expanding at an exponential rate. UK research volume has, however, been driven by increasing international research collaborations, while the proportion China's papers that are internationally collaborative has remained much lower than that of G7 economies.
- Collaboration between China and the UK has also increased, from fewer than 100 co-authored papers before 1990, to around 750 per year in 2000, and 16,267 papers in 2019 (about 11 per cent of UK output). This compares to around 19 per cent of UK papers with a US co-author and 10.5 per cent with a German co-author. This has led to a progressive rise for China in terms of ranked frequency among the UK's partners.
- These trends reflect a broader shift in R&D, according to which critical intellectual property is rarely now wholly owned by any one country or institution and is more likely to be shared.
- The China research portfolio is skewed to technology, with UK-China collaboration also focusing heavily on technology-based subjects. While China's output is rising steeply in all research areas, technology areas have recently seen a particular upsurge, in comparison to life sciences.

The global landscape in research collaboration

Analyses of the relationship between UK and Chinese higher education institutions (HEIs) have, justifiably, focused on the high numbers of Chinese international students in UK universities and the financial and policy implications of this trend. However, the emphasis on student numbers ignores the question of research and, in doing so, overlooks not only the emergence of China as an R&D superpower but also the extent of research collaboration between China and the UK in vital strategic areas.

> ...the emphasis on student numbers ignores the question of research

An analysis of UK-China research collaboration is best seen against an evolving background of international research structures and relationships. The global research base prior to 2000 was dominated by the G7 and appeared relatively stable from year to year in the balance of activity both between countries and subject areas. While gradual expansion and marginal shifts were seen, the international comparative research performance reports commissioned by the UK governments Chief Scientific Advisor were dropped from annual to biennial in 2005, illustrating the lack of significant change.

After 2000, the growth of new research economies became more evident. Much attention was given to the BRIC group (Brazil, Russia, India, China) and there was widespread change in the Asia-Pacific region. The factor most disruptive to the global landscape was the expansion of the publicly facing output of the China research base. This represented, at least in part, a shift away from the established, but industrially oriented, research base built on engineering and physical sciences. The unprecedented rapid and continued growth of China's identifiable investment, university researcher numbers and academic journal papers inevitably upset policy assumptions and planning founded on historical patterns of national research management.[33]

While older, established research economies seemingly continued to expand, later analysis showed that much of the "growth" at national level was due to greater international collaboration, while domestic research output hardly changed. Today, international co-authorship accounts for over half of, and sometimes as much as two-thirds of, the publication output of many G7 and western EU countries.[34]

This collaboration is relatively greater for leading research institutions and has created an international network of elite, innovative research activity. As a result, critical intellectual property is rarely now wholly owned by any one country or institution and is more likely to be shared. Technology competitiveness may therefore no longer come from intellectual property ownership but from the awareness and engagement that is established when researchers are involved actively and at an early stage in an innovative research area. This gives their institution and country both the competency and the preparedness to react in an agile fashion.[35]

Against the backdrop of an increasingly collaborative and integrated global research system, this chapter examines China's increasing strength in R&D and offers a fuller picture of the UK's engagement with Chinese research, to inform policy decisions about the UK's relationship with China, within and beyond the scope of HE.

Understanding growth in research activity

Data on "research activity" in terms of actual projects is not available on any internationally comparable basis and data on research expenditure provides only a gross overview that is insensitive to variable national research costs. The most useful data for acceptable international comparisons is that relevant to research publication. To compare the growth of the UK's and China's respective research output, our analysis collates the numbers of articles and reviews (substantive original academic research papers) published in the roughly 20,000 journals indexed in Web of Science™ (Clarivate). This includes only those journals that meet recognised thresholds of editorial good practice and that publish at least the article titles and abstracts in English, the global research *lingua americana* (at least in the natural and social sciences). A significant body of national and regional literature is therefore not accessed but it is generally acknowledged that researchers seek to gain recognition by publishing in the most internationally accessible media. Indeed, in the case of China, there are reports of institutional incentives being offered to researchers to publish in journals indexed by the Web of Science. Author addresses are used to assign papers to each country (and institution) that co-authors a paper. Each paper is assigned once to a country, irrespective of the number of co-authors.

Figure 1 shows how gross R&D input across China, the EU-28 and the US has grown over the last decade, with China's investment increasing by the greatest proportion during that time period. The following graph, Figure 2, shows the exponential growth in the overall publication output of China compared to the US, the EU-28 and the UK.

FIGURE 1:
INPUT AND OUTPUT: RECENT OECD DATA ON NATIONAL AND REGIONAL R&D BUDGETS

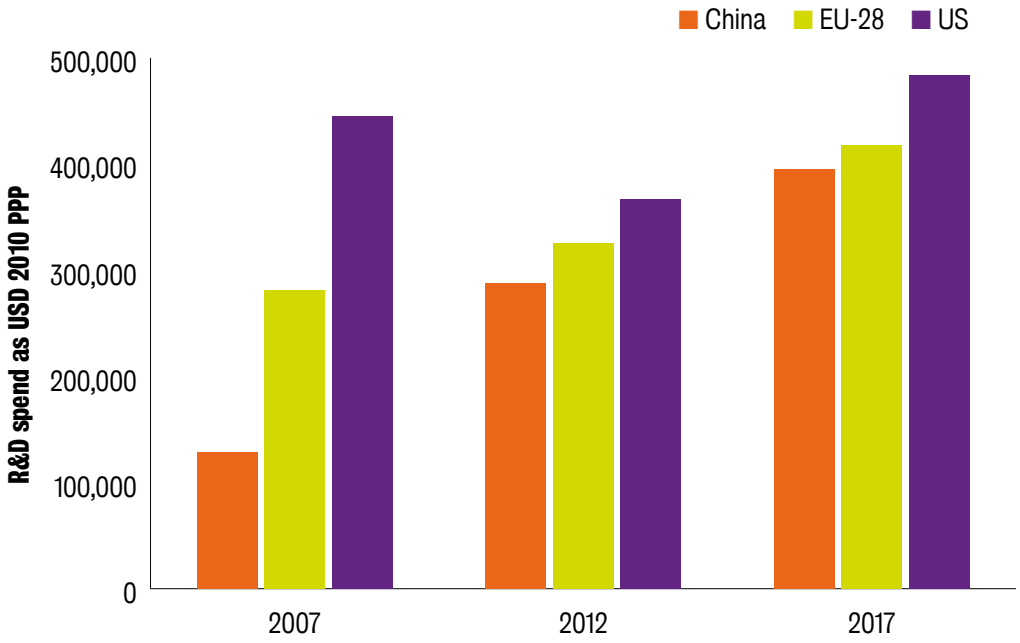
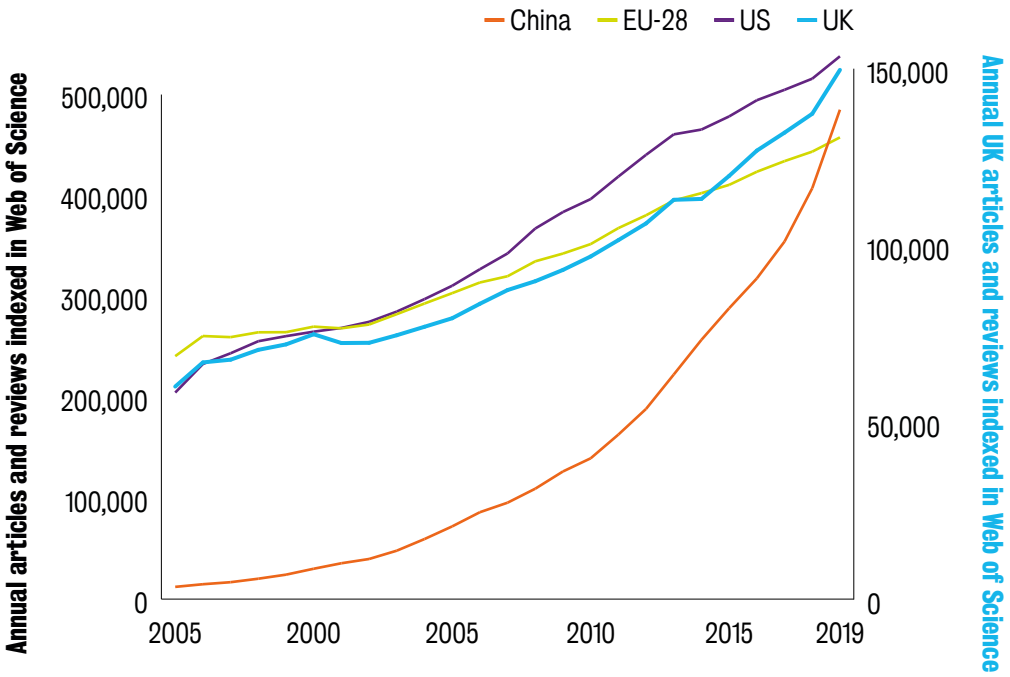


FIGURE 2:
ANNUAL PUBLICATIONS (ARTICLES AND REVIEWS) INDEXED IN THE WEB OF SCIENCE



In the graph of output, UK data is plotted against the right-hand axis; other regions are plotted against the left-hand axis.

The UK's output has grown at a similar rate to the rest of Europe and the US, although, recently, the US has begun to fall slightly behind. Note that, in the output graph, the scale of output for China, the EU-28 and the US is plotted on the left-hand axis, while the UK's is significantly smaller and thus plotted separately against the right-hand axis.

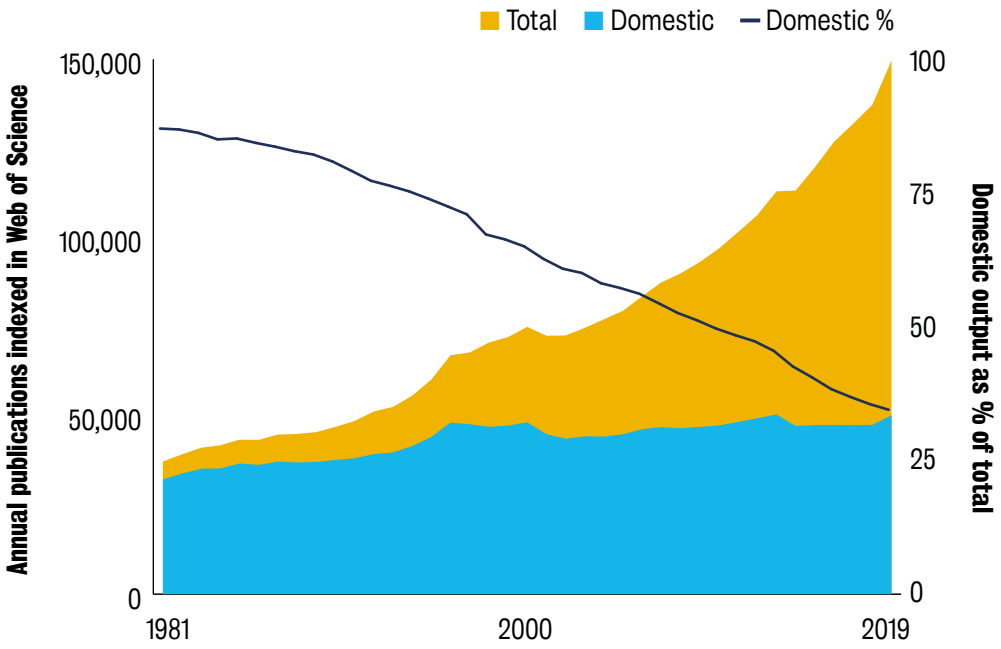
China's budget is overtaking other regions and its research expansion shows no signs of plateauing. It might be assumed that research output would be slowing in established areas, such as engineering and technology, while growing rapidly in other areas, such as life sciences, in which, historically, China has not been so heavily invested. This is not the case. Data (below) shows that output growth in all areas continues to rise steeply.

The growth of international research collaboration

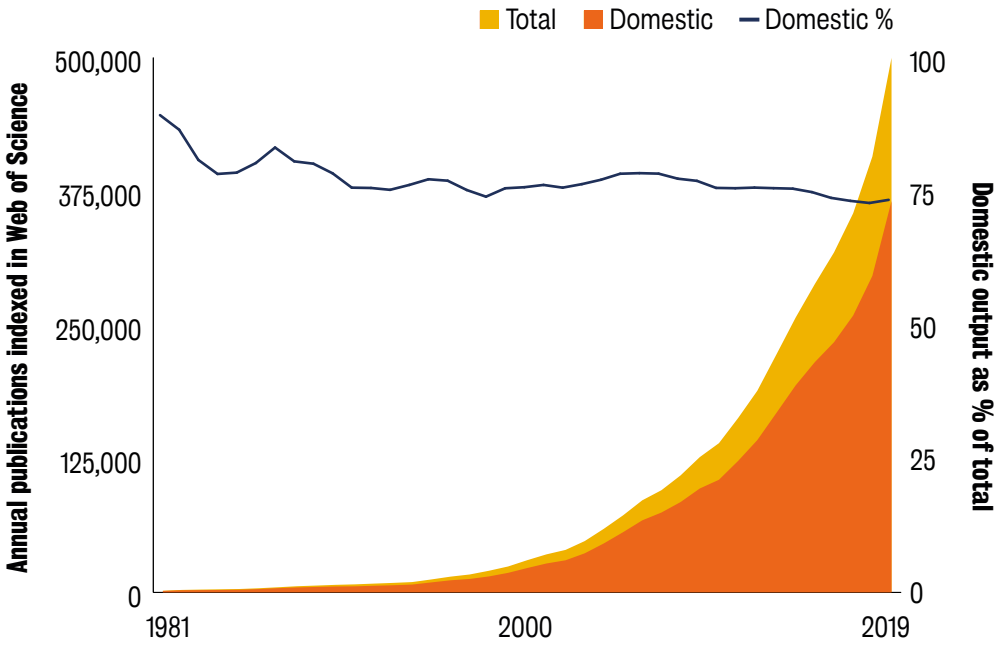
For the UK, as for most established research economies, research publication counts have increased annually over several decades. While this trajectory has been applauded, however, analysis shows that it is driven almost entirely by rising international collaboration and a consequent fall in the percentage of wholly domestic UK output. In fact, domestic research volume has been almost static for over 25 years (left-hand panel in Figure 3).

FIGURE 3:
ANNUAL COUNT OF TOTAL AND DOMESTIC (NO INTERNATIONAL CO-AUTHOR) RESEARCH PUBLICATIONS AND THE PERCENTAGE OF DOMESTIC OUTPUT

PUBLICATION TRAJECTORY FOR THE UK



PUBLICATION TRAJECTORY FOR CHINA



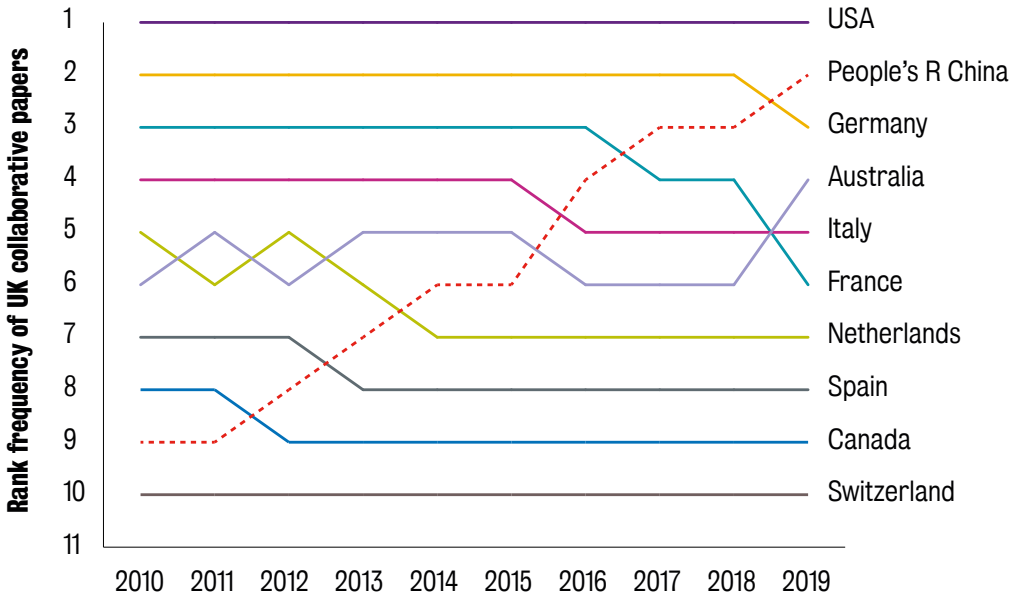
The trajectory for China is quite different to that of the UK. Its output volume is rising steeply, driven primarily by domestic growth. As it has expanded, the absolute volume of international collaborations has increased, but the steep overall growth in the percentage of China's internationally collaborative co-authored papers has remained much lower than that of G7 economies (bottom chart in Figure 3). Having said this, the absolute volume of China's collaborative research has still increased; China co-authored almost as many internationally collaborative papers in 2019 (135,000, up from 34,000 in 2010) as the total output produced by the UK (150,000).

The superficially slow growth of China's relative international collaboration is, in part, a consequence of its rapid absolute expansion. The existing networks of the large research economies necessarily absorb a great deal of their potential collaboration capacity since most research groups and institutions can only satisfactorily manage a modest number of partnerships. This makes it challenging for the rest of the world to absorb the novel opportunities that are provided to work with Chinese researchers. For example, if two-thirds of UK papers already have an international co-author, the residual volume of potentially worthwhile collaborative activity with China is limited.

The extent to which China has nonetheless increased its collaboration is reflected in its status as a frequent partner for other countries. In the 1980s, collaboration with China was extremely low for any G7 country. For the US, it still ranked behind all G7 countries in the early 2000s in terms of frequency of collaboration but, by 2019, China had almost twice as many US co-authored papers as any other country.

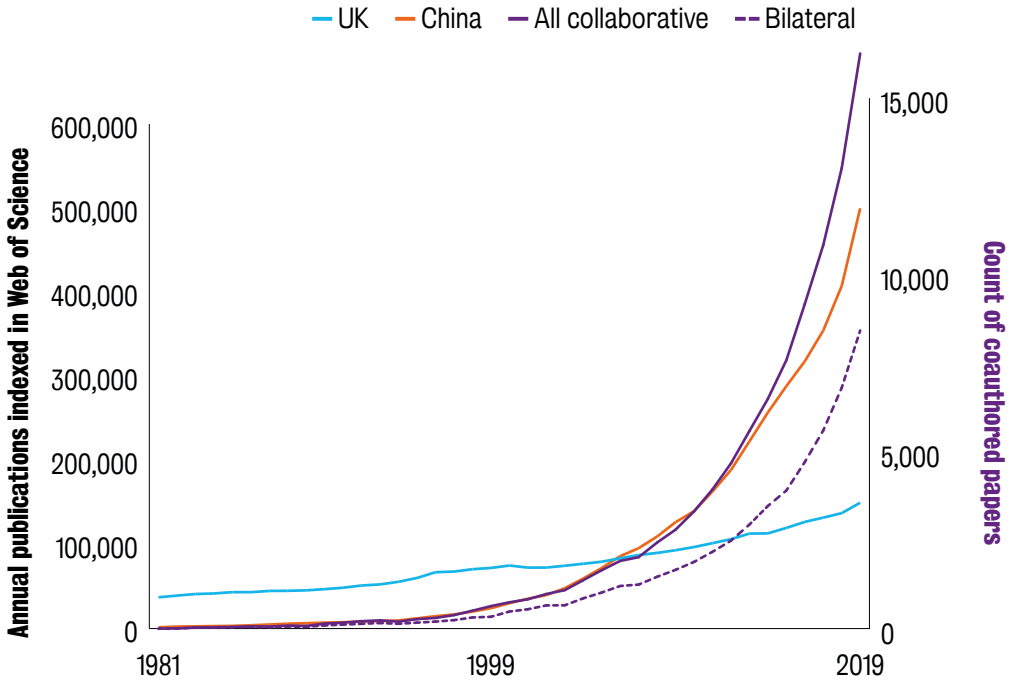
Collaboration between China and the UK has also increased, from fewer than 100 co-authored papers before 1990, to around 750 per year in 2000 (about 1 per cent of UK output), 3,324 in 2010 and 16,267 papers (about 11 per cent of UK output) in 2019. This compares to around 19 per cent of UK papers with a US co-author and 10.5 per cent with a German co-author. This growth has led to a progressive rise for China in terms of ranked frequency among the UK's partners (Figure 4).

FIGURE 4: RANKED FREQUENCY OF INTERNATIONAL CO-AUTHORSHIPS FOR UK RESEARCHERS (2010–2019)



Against general trends towards multilateralism, it is notable that a relatively high percentage of China's collaborative papers are bilateral (Figure 4). Co-authorship with China is clearly growing, accounting for about 11 per cent of UK output in 2019 (average 2015–2019 was 8.5 per cent) and the increase matches China's overall rate of growth.

FIGURE 5: ANNUAL COUNTS OF PUBLICATIONS FOR THE UK AND CHINA (LEFT-HAND AXIS) AND THE NUMBERS OF COLLABORATIVE PAPERS BETWEEN THE TWO COUNTRIES (RIGHT-HAND AXIS)



Plots are shown for all papers with a UK and a China author address and the bilateral papers that have no author from a third country.

Currently, 52 per cent of all UK-China papers are bilateral, compared with 27 per cent for UK-US co-authored papers, 28 per cent for UK-Australia papers, and less than 20 per cent for UK papers with major EU nations and other nations in Asia. Of the 48 per cent of papers co-authored between the UK and China that are *not* bilateral, the additional co-authors tend also to be from the UK's overall most frequent partners (Table 1).

TABLE 1: COLLABORATIVE PUBLICATIONS BETWEEN THE UK AND CHINA DURING THE FIVE-YEAR PERIOD FROM 2015 TO 2019 AND THE NUMBERS OF THESE PAPERS WITH THIRD COUNTRIES

Partner country	Count of papers	Percentage UK-China output
UK-China	**56,910**	**100.0**
Bilateral	29,593	52.0
USA	13,462	23.7
Germany	7,441	13.1
France	5,864	10.3
Australia	5,544	9.7
Italy	5,314	9.3
Spain	4,702	8.3

Some of these UK-China papers have multiple country addresses. For example, there are 5,363 that have both the US and Germany as co-authors. The greatest multilateral concentration is in Europe: there are 4,101 papers co-authored by both France and Germany, in addition to the UK and China. The number of such multilateral papers is growing relative to the overall database.

China is generally more bilateral in its international co-authorship than other large country, which may be a further reflection of its recent and rapid external research expansion. Around three-quarters of its recent papers co-authored with the US are bilateral, as are about 60 per cent of papers with Canada and Australia. However, this is less true of its collaborations elsewhere in Europe: less than 40 per cent of its collaborative papers with Germany and France are solely bilateral, which is line with the pattern for UK-EU publications and presumably reflects the success of integrated EU Framework Programmes.

The citation impact of UK and Chinese publications

Citations (references in more recent papers to prior literature) are informative as they illustrate intellectual relationships between more recent and earlier work, as well as the subsequent influence of earlier work. However, there are a number of caveats to any simple citation count.

Citations accumulate over time at a rate that is field dependent, meaning that recent papers have had little time to attract attention. The subject discipline of the paper must, as a result, also be taken into account. This "normalisation" of raw citation counts is done by comparing the observed citation count for each individual paper with the expected average for its subject category and year of publication. The ratio (observed/expected) is referred to as category normalised citation impact (CNCI) and analyses typically report the *average* CNCI for a sample.

Citation distributions are always highly skewed, with relatively high numbers of uncited or infrequently cited papers and relatively low numbers of very highly cited papers. The average CNCI is, therefore, not at the centre (the median) of a sample distribution but at a higher value, meaning that fewer than half the papers in any sample are "above average". This skew also makes the average CNCI for small samples uninformative because a small number of highly cited documents can distort the interpretation.

Taking these important caveats into account, extensive research on the relationship between citation counts and other assessments of research quality has shown that there is usually a general correlation between average CNCI and indicators such as the grades awarded in national research assessments. Small samples, however, are not a satisfactory guide to any aspect of academic performance, and such analyses are almost wholly uninformative in the humanities and may be weak in the social sciences. Elsewhere, and in addition to large samples, such as the portfolio for university departments, they can be valuable supplementary and supportive informative for well informed, experienced and expert peer review.[36] Citation impact analysis should, however, never be used as a substitute for peer review and any simple

metrics, such as the average, should be supported by deeper analysis into the overall distribution of citation impact.

FIGURE 6:
ANNUAL CATEGORY NORMALISED CITATION IMPACT OF PUBLICATIONS INDEXED IN THE WEB OF SCIENCE

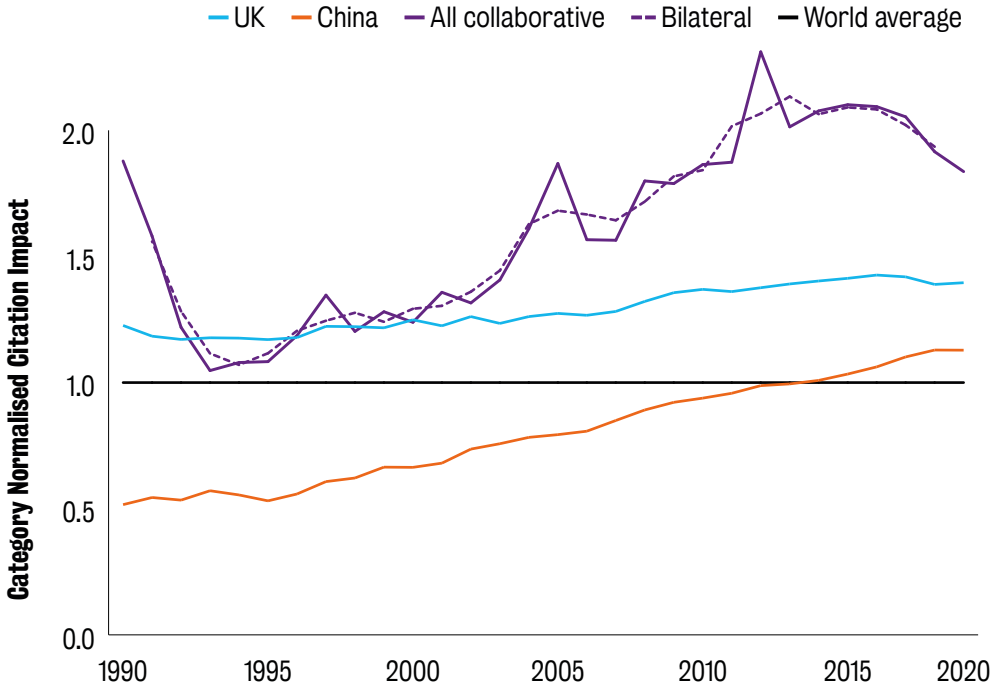


Figure 6 is based on citation counts for articles and reviews published in journals indexed in the Web of Science, with the data plotted for the year of publication using citations to date.

The UK has long "performed" above world average (which is always 1.0 since the relevant world average is used as the benchmark for normalising the individual counts) and its average CNCI has slightly risen over the period since 1992.

China's CNCI has risen over 30 years, from half the world average, to meet and now exceed that benchmark. The count of publications annually indexed in the Web of Science and with at least one Chinese author address has grown from 7,000 to almost 500,000 over the same period, a 70-fold increase.

UK-China collaboration grew 100-fold over these 30 years. Figure 6 shows that the average CNCI of collaborative papers in the first decade was little better than the UK average (other research has shown that the bilateral papers were cited less often than comparable UK research generally). By 2010, the CNCI of collaborative papers was well above the UK average. It appears to have fallen off in the last two years but this outcome must be interpreted with caution due to the cultural difference in citation behaviour that has been shown to produce a similar effect in data for China and, perhaps, Japan.[37]

The average CNCI is a useful reference point but a poor guide to the underlying distribution of performance. To address this deficiency, we visualise the data as an Impact Profile, which tallies the sample across a series of bins of successively higher impact indexed against world average,[38] rather than as a whole. Uncited papers are

assigned to a bin on the left and other papers are then grouped in eight bins, four above and four below world average. The boundary values for each successive bin is double that of the bin to the left. Thus, the bins on either side of the world average reflect the count of papers with CNCI for: "0.5 to 1.0" and "1.0 to 2.0".

FIGURE 7:
IMPACT PROFILES FOR PAPERS PUBLISHED BETWEEN 2010 AND 2019 AND INDEXED IN THE WEB OF SCIENCE THAT HAD AT LEAST ONE UK OR AT LEAST ONE CHINA AUTHOR

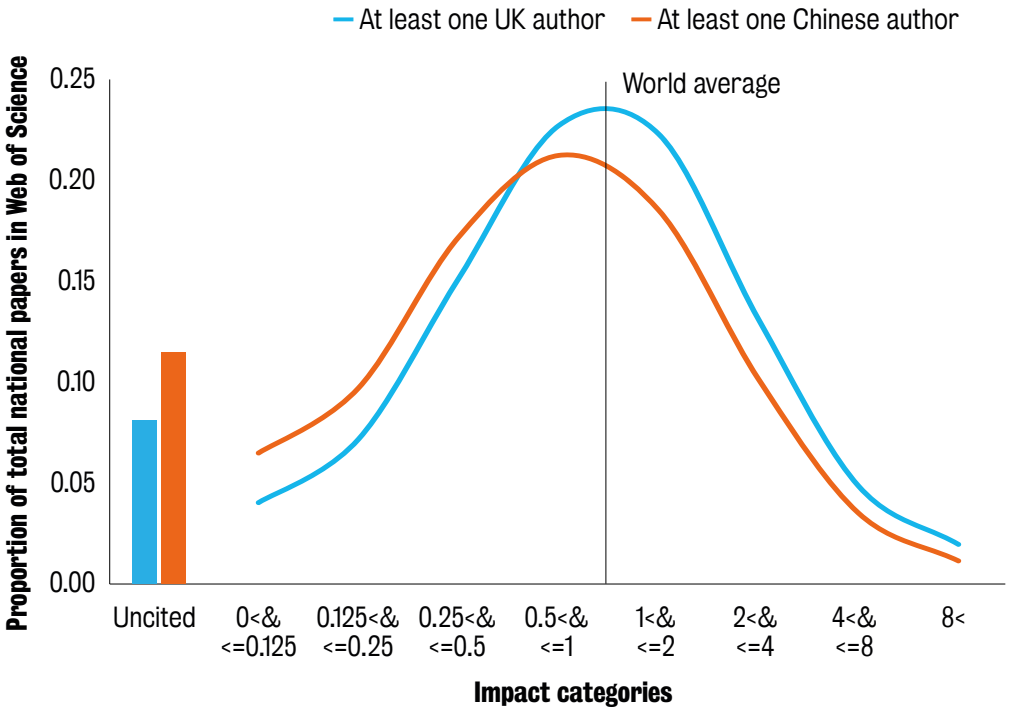


Figure 7 shows that:

- The UK has relatively fewer uncited papers than China (8 per cent of English papers, compared to 12 per cent of Chinese papers).
- The UK profile is to the right of China's, with a greater proportion of output in all the more highly cited categories around and above the world average (42 per cent of UK output compared to 34 per cent of Chinese output).
- Although China's average CNCI is below the UK's, it publishes a substantial volume of papers that are relatively well cited (15 per cent cited more than twice the world average).

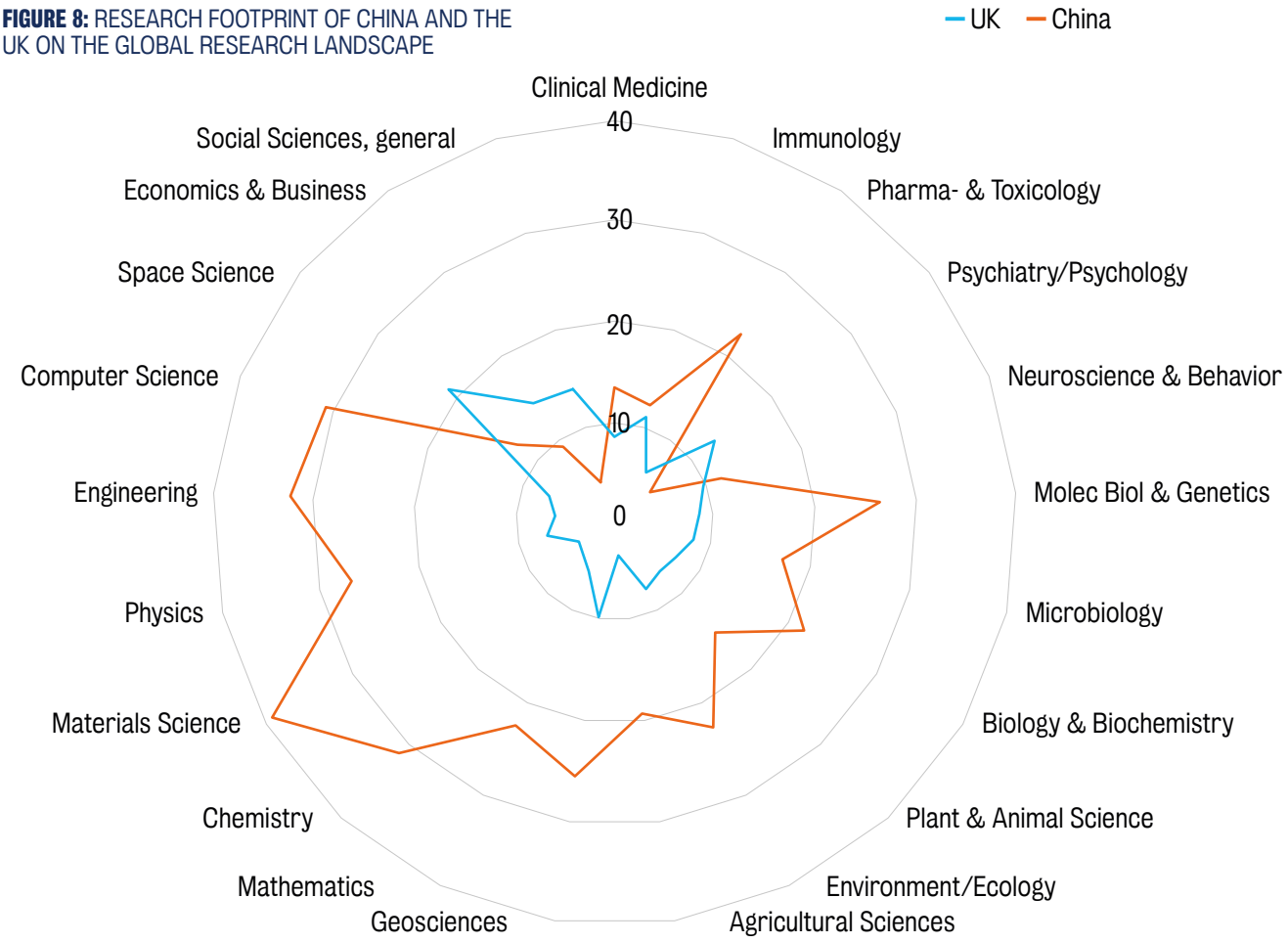
It should also be noted that, while the UK's average CNCI is invariably well above the world average, more than half of what the UK publishes (57 per cent in this decade) is cited less often than world average (the UK median CNCI is around 0.85). This apparently startling result would also be true for an analysis of the US, Germany, France and others; it is not an anomaly but a property of the skewed distribution.

Analysis at the level of research disciplines

The national pattern of research output and collaboration can be deconstructed at the level of research disciplines to further interpret the nature of the interaction between the UK and China.

Two systems of subject-level categorisation are used in this analysis. The broad level, to acquire an initial overview, employs the coarser subject categories of Essential Science Indicators (ESI, Clarivate). There are 22 non-overlapping ESI categories and they do not include the arts and humanities. The more detailed level, to explore specific activity, uses the finer 254 journal-based categories in the Web of Science system which includes the Science Citation Index, the Social Science Citation Index and the Arts & Humanities Citation Index. Some journals carry papers from more than one definable discipline and may therefore be represented in more than one of these categories but a deduplicated total is always applied when the data is aggregated.

FIGURE 8: RESEARCH FOOTPRINT OF CHINA AND THE UK ON THE GLOBAL RESEARCH LANDSCAPE



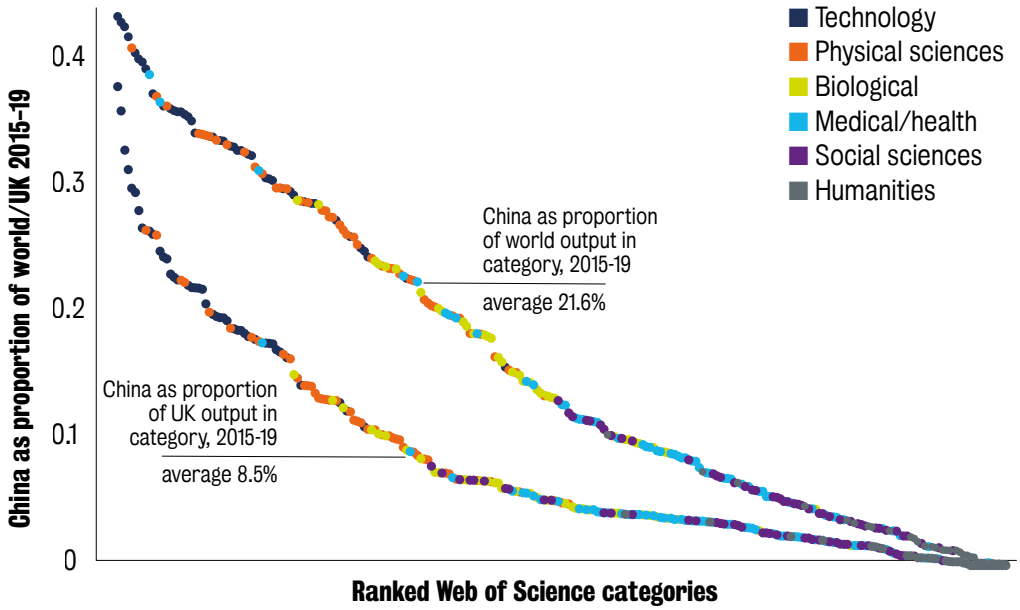
The percentage of global papers (2015–2019) for each country are shown, analysed at the level of the 22 Essential Science Indicators subject categories.

Figure 8 (at the broad ESI level) summarises the subject-level papers (articles and reviews) for China and for the UK over the five-year period from 2015 to 2019. ESI categories vary considerably in their publication activity, reflecting field diversity and culture. For example, publication output of the field of economics is only one-tenth of that of Clinical Medicine. In order to consider both the volume and categorical balance of research publications, the data is shown as a national "Research Footprint" in the global landscape and indicates the percentage of the world total in each ESI category for each country, thus standardising the actual national output against a consistent and relevant global norm.

Our analysis shows that UK researchers were authors or co-authors on about 8 per cent of world papers in the five-year period and China contributed to 23 per cent. The UK portfolio appears balanced when compared to the global baseline, ie its footprint is relatively rounded while the China portfolio is less balanced, reflecting the historical origins of the Chinese research base in engineering and technology. China now produces 40 per cent of the world's papers in materials science and around 30 per cent in computer science, engineering, chemistry and physics. It is less well represented in biosciences although its output in pharmacology and in molecular biology has evidently become substantial.

To look at the detailed pattern of collaboration we shift to the 254 Web of Science categories, focusing here on the spread of UK-China co-authorship. Figure 5 showed that collaboration had grown at about the same rate as China's overall expansion, but growth may not be even across subject categories.

FIGURE 9:
RANKED SERIES OF WEB OF SCIENCE SUBJECT CATEGORIES, ORDERED BY FREQUENCY OF CHINA CO-AUTHORSHIP ON ARTICLES AND REVIEWS (2015–19)



Subject categories are colour coded by six broad faculty-level areas. Two series are shown: China total authorship as a proportion of world output and China co-authorship as a proportion of UK output.

UK-China collaboration is far from uniform across the UK research base and is in fact concentrated in the technology-based subject categories (Figure 9). While this reflects the subject skew in the Chinese research base noted earlier, China's relative engagement with the UK research base is, in practice, more concentrated in the broad areas of technology and the physical sciences. China is collaborating at a lower rate across UK biomedicine than would be expected from the proportion of its own research in the life sciences. Having said this, China has substantial publication output in some of these areas and would potentially benefit from the UK's outstanding biomedical research.

Having compared the distribution of China's global and UK-collaborative research, we now turn to a more detailed view of the areas of particular concentration. The next three tables show the research areas in which there is a significant volume of UK-China collaborative output (Table 2), and where this collaboration constitutes a considerable percentage of the overall research base for each country (Table 3 and Table 4) (nb the threshold differs for the UK and for China).

Several areas (highlighted in green in Table 2 and Table 3) see both high UK-China volume and a high proportion of total UK output. The most obvious are electrical and electronic engineering and telecommunications, which 5,000 and 2,500 co-authored papers that cover around 30 per cent of the UK's total publication output. Computer science (information systems) and automation and control systems cover a similar share of UK output, though the volumes are smaller.

TABLE 2:
WEB OF SCIENCE SUBJECT CATEGORIES IN WHICH MORE THAN 1,000 PAPERS WERE CO-AUTHORED BY THE UK AND CHINA BETWEEN 2015 AND 2019 (TOTAL = 56,895)

	UK	China	Collab	% UK	% China
Engineering, electrical & electronic	19534	123777	**5815**	29.77	4.70
Materials science, multidisciplinary	26549	206991	**4726**	17.80	2.28
Physics, applied	15975	113202	**2853**	17.86	2.52
Environmental sciences	21441	81470	**2675**	12.48	3.28
Telecommunications	7505	47060	**2583**	34.42	5.49
Energy & fuels	12154	68608	**2512**	20.67	3.66
Chemistry, physical	16902	116325	**2425**	14.35	2.08
Chemistry, multidisciplinary	17802	126608	**2396**	13.46	1.89
Astronomy & astrophysics	20015	13940	**2301**	11.50	16.51
Computer science, information systems	6937	45486	**1949**	28.10	4.28
Nanoscience & nanotechnology	9260	78204	**1763**	19.04	2.25
Physics, particles & fields	7739	9699	**1698**	21.94	17.51
Engineering, mechanical	7088	41813	**1641**	23.15	3.92
Mechanics	8510	36567	**1551**	18.23	4.24
Engineering, chemical	8093	62170	**1516**	18.73	2.44
Geosciences, multidisciplinary	13174	29859	**1443**	10.95	4.83
Computer science, artificial intelligence	5854	28811	**1407**	24.03	4.88
Optics	8107	52513	**1381**	17.03	2.63

	UK	China	Collab	% UK	% China
Biochemistry & molecular biology	23418	73937	**1327**	5.67	1.79
Engineering, civil	6674	28569	**1291**	19.34	4.52
Instruments & instrumentation	5660	32571	**1230**	21.73	3.78
Automation & control systems	3143	24611	**1113**	35.41	4.52
Physics, multidisciplinary	7935	32061	**1008**	12.70	3.14

The table shows the annual number of papers with at least one author address for each country, the number of collaborative papers (some of which may have third party authors) and the percentage of national output that is collaborative. The green highlighting in Table 2 (high volume) identifies those subject categories that are also in Table 3 (high share of UK output). The blue highlight refers to the one category that is also a relatively high share of China output.

TABLE 3:
WEB OF SCIENCE SUBJECT CATEGORIES IN WHICH MORE THAN 20 PER CENT OF UK PAPERS WERE CO-AUTHORED WITH CHINA BETWEEN 2015 AND 2019 (CF AN AVERAGE OF 8.5 PER CENT)

	UK	China	Collab	% UK	% China
Automation & control systems	3143	24611	1113	**35.41**	4.52
Telecommunications	7505	47060	2583	**34.42**	5.49
Materials science, ceramics	898	13505	293	**32.63**	2.17
Engineering, electrical & electronic	19534	123777	5815	**29.77**	4.70
Computer science, information systems	6937	45486	1949	**28.10**	4.28
Engineering, ocean	1048	3098	289	**27.58**	9.33
Engineering, marine	818	2652	222	**27.14**	8.37
Transportation science & technology	2299	7626	602	**26.19**	7.89
Physics, nuclear	2338	6244	609	**26.05**	9.75
Thermodynamics	3512	25826	904	**25.74**	3.50
Computer science, artificial intelligence	5854	28811	1407	**24.03**	4.88
Engineering, mechanical	7088	41813	1641	**23.15**	3.92
Engineering, multidisciplinary	3825	25338	885	**23.14**	3.49
Remote sensing	1841	12722	421	**22.87**	3.31
Physics, particles & fields	7739	9699	1698	**21.94**	17.51
Instruments & instrumentation	5660	32571	1230	**21.73**	3.78
Metallurgy & metallurgical engineering	3140	40522	664	**21.15**	1.64
Imaging science & photographic technology	1371	9221	288	**21.01**	3.12
Engineering, manufacturing	2672	12320	554	**20.73**	4.50
Energy & fuels	12154	68608	2512	**20.67**	3.66

The table shows the annual number of papers with at least one author address for each country, the number of collaborative papers (some of which may have third party authors) and the percentage of national output that collaboration represents. The yellow highlighting in Table 3 identifies those subject categories that are also in Table 4 (relatively high share of China output).

The spread of categories that absorb a relatively high percentage of China's total output are diverse. Two (particle physics and astronomy) are characterised by multi-national teams, large-scale international facilities and papers with exceptionally high authorship lists. Apart from these two, only nuclear physics and management research exceed 500 papers in total (100 papers per year).

TABLE 4:
WEB OF SCIENCE SUBJECT CATEGORIES IN WHICH MORE THAN 9 PER CENT OF CHINA'S PAPERS WERE CO-AUTHORED WITH THE UK BETWEEN 2015 AND 2019 (CF AN AVERAGE OF 3 PER CENT)

	UK	China	Collab	% UK	% China
Physics, particles & fields	7739	9699	1698	21.94	**17.51**
Astronomy & astrophysics	20015	13940	2301	11.50	**16.51**
Medical ethics	829	37	6	0.72	**16.22**
Industrial relations & labour	1698	278	41	2.41	**14.75**
Palaeontology	2417	2343	344	14.23	**14.68**
Archaeology	3180	457	64	2.01	**14.00**
Anthropology	3991	610	77	1.93	**12.62**
Music	2163	70	8	0.37	**11.43**
Literature, British Isles	1527	9	1	0.07	**11.11**
Evolutionary biology	5548	3319	365	6.58	**11.00**
Geography	6626	1733	186	2.81	**10.73**
Ornithology	778	276	29	3.73	**10.51**
Social work	2539	324	34	1.34	**10.49**
Physics, nuclear	2338	6244	609	26.05	**9.75**
Psychology, applied	3098	1020	99	3.20	**9.71**
Psychology, experimental	7162	1963	188	2.62	**9.58**
Business	8304	4179	394	4.74	**9.43**
Management	10685	5925	555	5.19	**9.37**
Psychology, biological	1406	470	44	3.13	**9.36**
Engineering, ocean	1048	3098	289	27.58	**9.33**
Hospitality, leisure, sport & tourism	4345	1420	132	3.04	**9.30**
Development studies	2664	983	90	3.38	**9.16**

The table shows the annual number of papers with at least one author address for each country, the number of collaborative papers (some of which may have third party authors) and the percentage of national output that collaboration represents.

A concentration of research collaboration in technology areas is evident from the distribution in Figure 6 and from Table 2 and Table 3. This concentration accounts for a relatively high share of total UK output: over 25 per cent in 10 subject categories and over one-third of automation and control systems and of telecommunications.

The following analyses further unpack the details at subject category level for a spread of subjects in the life sciences and in technology and engineering.

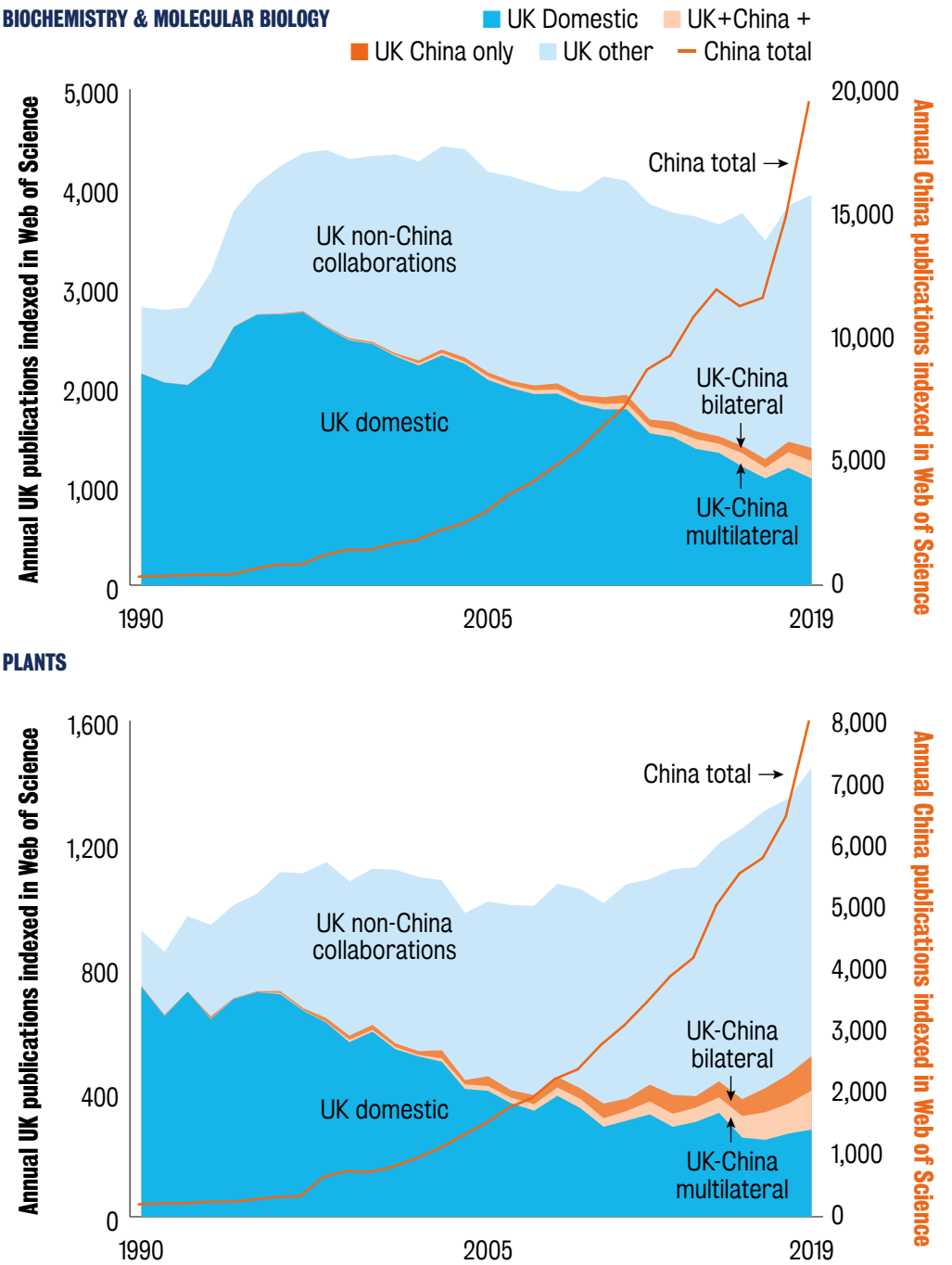
Six Web of Science subject categories were identified that were both relevant to the analysis and had a UK annual output volume that was sufficient to provide an

informative outcome. Even so, the size of the UK research base means there are some slightly volatile year-to-year fluctuations. We explore this in more detail in the following pages.

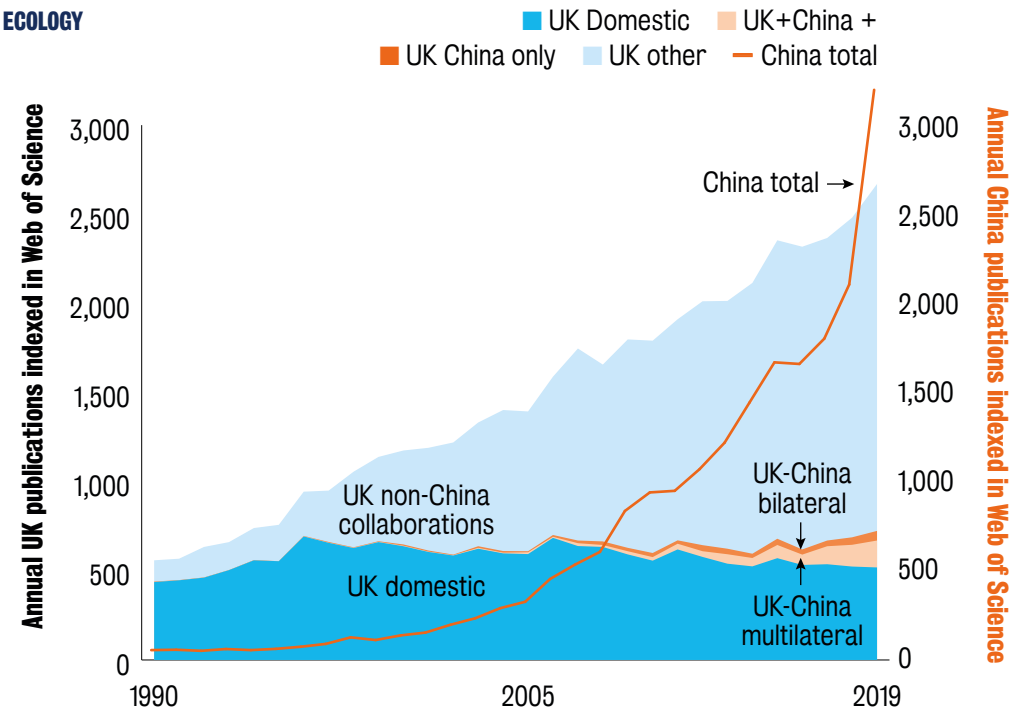
The data is summarised in Figure 9, which allows a rapid comparison of the three life science areas (biochemistry and molecular biology, plant sciences, and ecology) and the three technology areas (mechanical engineering, nanoscience and nanotechnology, and telecommunications). Note in these figures that China data is plotted on the right-hand axis which, with the exception of ecology, scales differently to the UK and collaborative data on the left-hand axis.

FIGURE 10:
UK ANNUAL RESEARCH OUTPUT (ARTICLES AND REVIEWS, 1990–2019) IN SIX WEB OF SCIENCE SUBJECT CATEGORIES DECONSTRUCTED BY DOMESTIC (ONLY UK AUTHOR ADDRESSES) AND INTERNATIONAL COLLABORATION

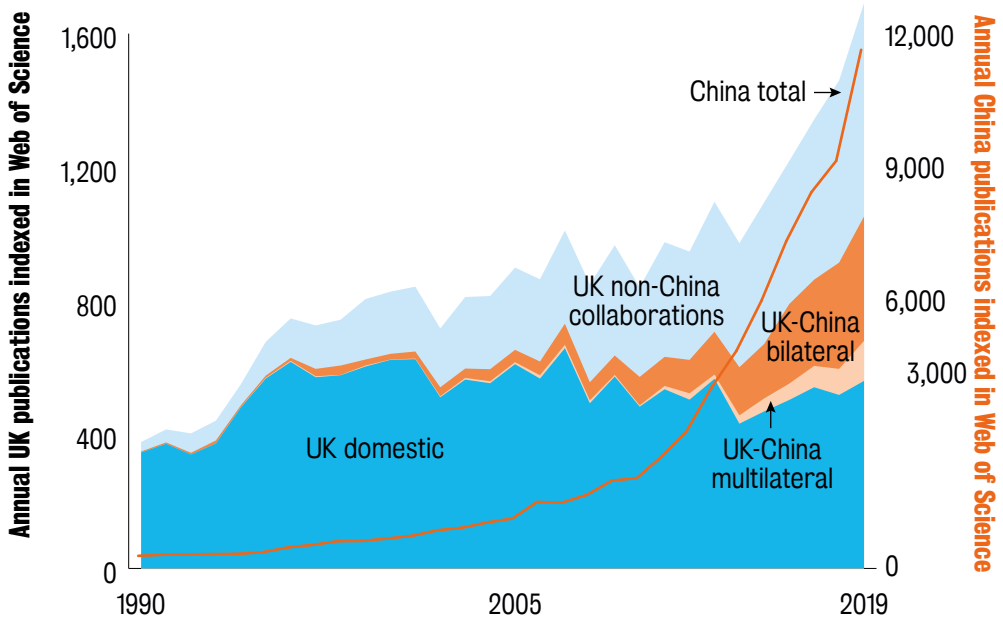
Each chart also shows the numbers of papers that are collaborative with China, either bilateral or with additional countries. The total output for China is shown on the right vertical axis of each chart and the scale may differ from that of the left vertical axis.

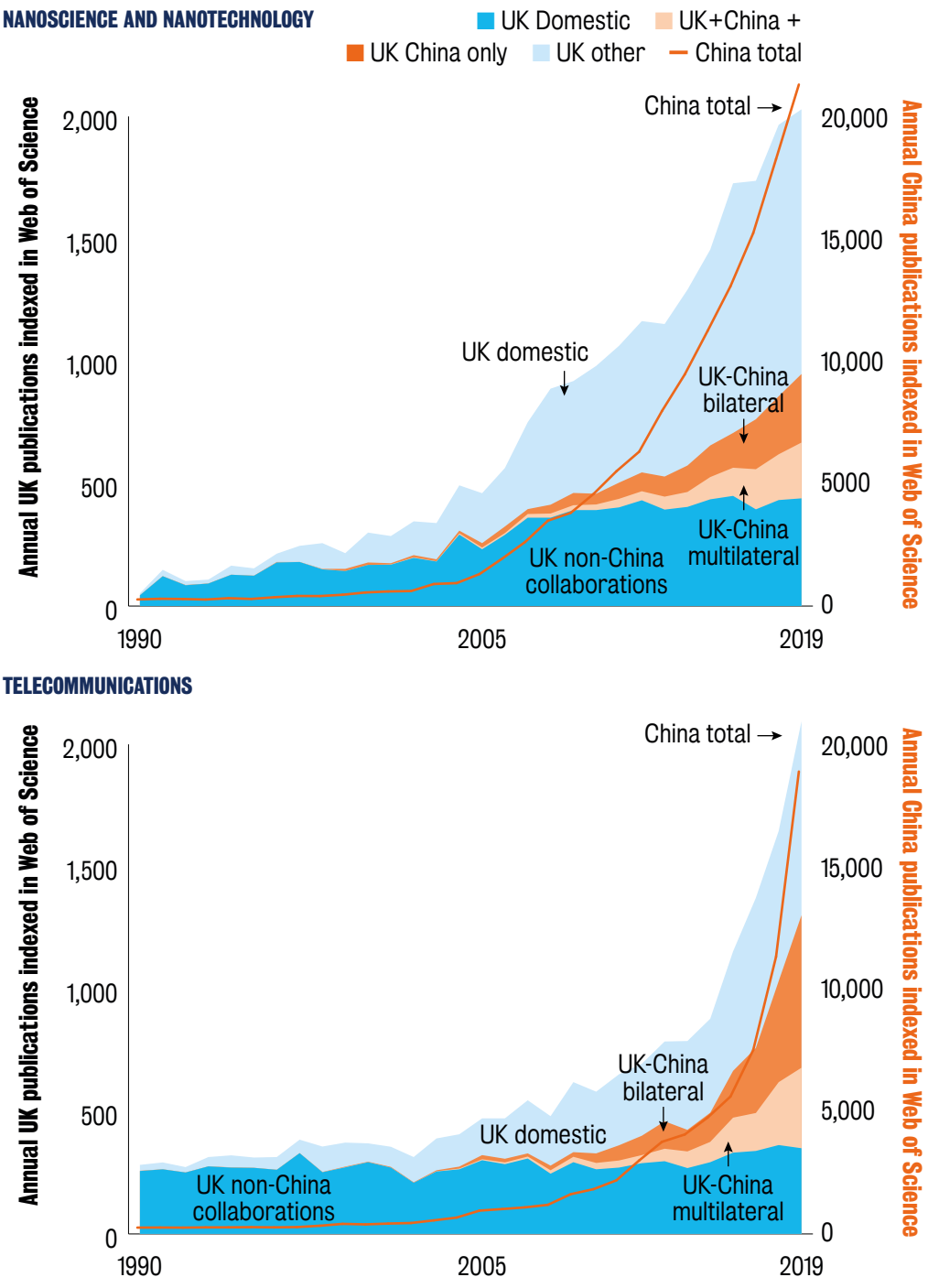


ECOLOGY



MECHANICAL ENGINEERING





These charts demonstrate that:

- China's output is rising steeply in all research areas and is recently steeper in technology areas than life science, while UK international collaboration is extensive in all research areas and accounts for overall national growth.

- UK-China collaboration is greater in technology research areas.

- UK-China bilateral collaboration is usually a relatively greater share of their collaboration in technology areas. UK output in some, but not all, technology areas is driven by collaboration with China.

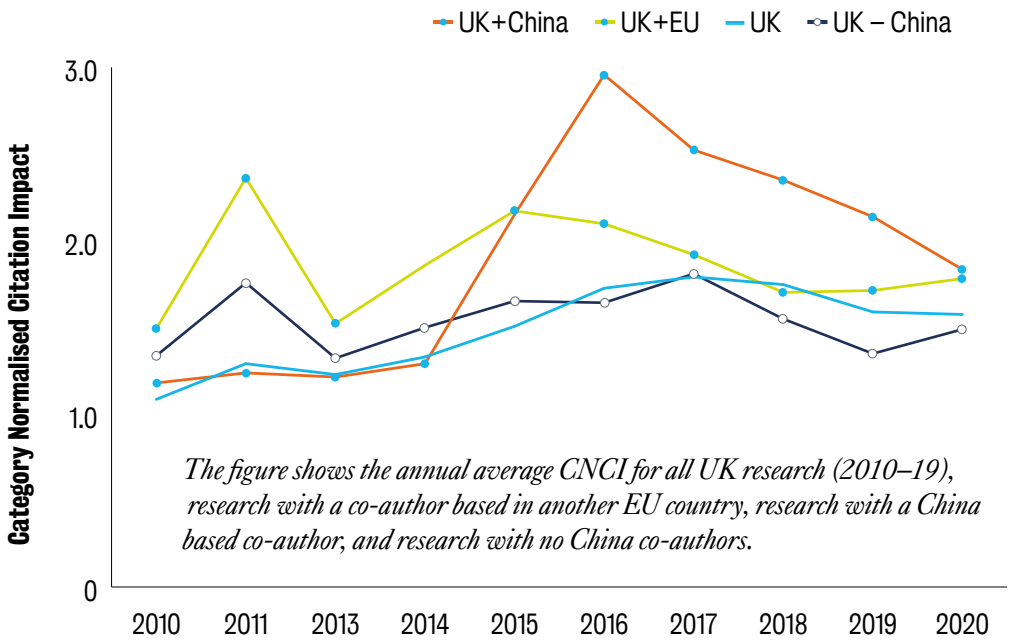
The CNCI of the UK, China and collaborative output in these six areas can also be calculated and compared. From 2015 to 2019, the UK achieved higher impact than China in all life science areas, while China has similar impact in mechanical engineering and much better impact in nanoscience and nanotechnology. However, collaborative research is of markedly greater impact than either national average in all areas, including those subjects where the UK is already strong. This is not surprising since international collaboration is strongly associated with higher citation impact, but it is a reminder of the beneficial returns.

TABLE 5:
CATEGORY NORMALISED CITATION IMPACT FOR ARTICLES AND REVIEWS PUBLISHED BY THE UK AND CHINA (2015–2019) IN SIX WEB OF SCIENCE JOURNAL CATEGORIES (WORLD AVERAGE = 1.0)

	UK	Collab	China
Biochemistry & molecular biology	1.59	1.92	0.95
Plant sciences	1.55	2.37	1.25
Ecology	1.52	2.32	1.04
Mechanical engineering	1.11	1.34	1.12
Nanoscience & nanotechnology	1.10	1.49	1.33
Telecommunications	1.61	2.10	1.14

The emergence of the citation benefit of the UK's research with China in telecommunications is seen in Figure 11, alongside data on UK research with the EU in the same field. In the last five years, the CNCI of research collaboration with China has risen to exceed that of UK research output co-authored with its EU partners. This now makes a significant contribution to the UK's research profile in telecommunications, in terms of academic impact and volume.

FIGURE 11:
CATEGORY NORMALISED CITATION IMPACT OF UK RESEARCH PUBLICATIONS (ARTICLES AND REVIEWS) IN TELECOMMUNICATIONS



The figure shows the annual average CNCI for all UK research (2010–19), research with a co-author based in another EU country, research with a China based co-author, and research with no China co-authors.

Below we briefly provide a commentary for each of the six disciplinary areas shown in Figure 10.

Biochemistry and molecular biology has been a historically strong area for the UK research base. The MRC's Laboratory of Molecular Biology at Cambridge has an outstanding record including an exceptional number of Nobel prizes. The UK's overall output in this area is now declining, primarily due to a decrease in purely domestic research (papers with no international collaborator) and a shift of attention to newly innovative areas. About three-quarters of UK output in 1990 was entirely domestic, whereas international collaboration now accounts for almost 73 per cent.

> Chinese research in this area has grown extremely rapidly

Chinese research in this area has grown extremely rapidly, surpassing the UK total output in 2007, and now reaching five times the UK level. Despite China's activity and the implicit benefit of working with a well-established research base, however, collaboration with the UK accounts for a relatively small part of China's output (309 of 3,936 UK papers in 2019, of which a relatively low 43 per cent were bilateral). This may result, in part, from the challenges, noted earlier, in facilitating new collaborative work with academics in an already-highly collaborative context. China is the UK's fifth most frequent partner, behind the US, Germany, France and Italy, and just ahead of Spain and Australia.

Plant sciences is recognised as an important research area for China, underpinning agricultural development to feed a huge population. It has long been a strong area for the UK and one in which overall output continues to grow through international partnerships. China's output is now five times greater than the UK's, but UK-China collaboration is nonetheless relatively small and was not growing particularly rapidly until the last five years, when it started to expand.

This may be a consequence, as with biochemistry generally, of the UK's existing high level of collaboration with other countries, which leaves less capacity for new partners. China is the UK's second most frequent partner, behind the US and slightly ahead of Germany. It is already well ahead of other EU partners.

Ecology has a long UK tradition and is a category in which the volumes of the UK's and China's output are comparable, although China's is evidently expanding more rapidly. The UK's output has consistently increased every year over a long period, driven primarily by international collaboration.

China accounts for only a small part of UK growth and is the UK's 10th most frequent partner accounting for less than half as many papers as Germany and Australia, and less than a quarter of the number of UK papers collaborative with the US. Most of the collaboration with China is multilateral and just 6 per cent of joint papers are bilateral.

The UK's research output in **mechanical engineering** has been relatively consistent since the late 1990s. It is important to note, when considering this field, that engineers also publish extensively in conference proceedings but the UK's Research Assessment Exercise (RAE) has prompted a shift towards journal publications as evidence of achievement.

Until 2012–13, UK research output growth was driven primarily by a gradual increase in general international collaboration. Since then, China has become the primary driver and most of this growth has been bilateral (80 per cent or more). It is reasonable to project that, within the next two years, about one-third each of the UK's mechanical engineering journal publications will be domestic, collaborative with China, and collaborative with other nations.

China's indexed publication output passed the UK's in 2003 and is now about seven times greater in volume and still rising

China's indexed publication output passed the UK's in 2003 and is now about seven times greater in volume and still rising. The similar upward trajectory seen in the UK's overall output will be sustained by continuing collaboration with this activity.

The UK had a strong domestic base in **nanotechnology** in the 1990s and this expanded over the decade to 2010 in collaborations with partners in EU Framework initiatives. A broad platform of international collaboration continues to be a feature in this area.

China's output volume was similar to the UK's in 2000 but has grown more rapidly since then and is now about10times greater. UK-China collaboration was rising from around 2010 and now exceeds UK domestic output. However, it is notable that this collaboration has become progressively multilateral.

UK domestic output in **telecommunications** research published in journals indexed in the Web of Science was substantial in 1990 but has remained consistent for 40 years. International collaboration has been the source of growth since and by 2009 this accounted for more than half of the UK output.

China's research output in telecommunications rose very steeply from 2010, at the same time that collaboration with the UK became more common. UK-China collaboration accounted for over one-third of UK output from 2015 to 2019 and constituted half of UK output by 2019. About two-thirds of this is bilateral, a share that is expanding. China now accounts for more UK research than collaboration with all other countries.

Conclusion

The data presented in this chapter makes clear the rapid rise in research engagement between the UK and China, as captured in the co-authorship of articles and reviews indexed in the Web of Science.

The scene is set by the extraordinarily rapid growth of China's visible, outward-facing research base. Its R&D budget, which stemmed from applied research in support of traditional heavy industries, now exceeds that of the EU-28 and is similar to that of the US (Figure 1). International research collaboration has become prevalent around the world, accounting for half to two-thirds of G7 publication activity (Figure 2), and is particularly strong among leading research institutions, thus underpinning critical areas of innovative research activity. China, with its exceptional investment and growth, must be a natural and important partner for any well-established research economy, including the UK. It is therefore no surprise that it has risen to be the UK's

second most frequent research partner (Figure 3) and the numbers of co-authored papers is rising steeply (Figure 4).

The citation impact of this research output is also rising. It is now well ahead of the average across the research base for both countries and continues to improve (Figure 5). Although the UK maintains a higher average impact than China, the impact profile of China's recent research demonstrates an increasing number of very well-cited papers which, in volume, exceeds that of the UK (Figure 6).

> ...research engagement between the UK and China is now substantial

The balance of China's research publication is still skewed towards its historical strengths in the technological and physical sciences (Figure 7), where China now produces a high proportion of global publications (over 30 per cent in many subject areas, see Figure 8). The research portfolio is diversifying and its output in some biomedical sciences has become a significant part of global output, though this remains small relative to its output in physical sciences.

China's collaboration with the UK is even more concentrated in technology and physical sciences than its already-skewed national portfolio (Figure 8), which may suggest a strong strategic focus. These subject areas account for a relatively high volume of total annual publications (Table 2) and for a relatively high proportion of UK output (Table 3). By contrast, those areas of collaboration that make up a relatively high proportion of China's output are mixed and tend to be in the humanities and social sciences (Table 4).

This pattern seems surprising given that the UK has a record of high-quality research in biomolecular sciences and that China's research in some of these areas is already substantial, making engagement mutually beneficial. It is possible, however, that research partnerships in the UK are closer to saturation in the life sciences than in the physical sciences. Certainly, however, China now collaborates in a substantial part of the UK's research in technology, an area likely to underpin new products and processes of economic and societal impact and, therefore, be of strategic significance.

A detailed analysis of three research areas in the life sciences and three technological research areas confirms that China's output, driven by growth in domestic capacity, is rising in all areas and steeply in technology areas. For the UK, extensive international collaboration, rather than domestic activity alone, accounts for research growth. UK-China collaboration is particularly concentrated in technology research areas where it is more likely to be bilateral and UK output in some of these is increasingly driven by that collaboration with China (Figure 9).

As with the average CNCI of the UK's collaboration with China, the average CNCI of collaborative publications in these six areas is very good and clearly above the UK average (Table 5). A focused analysis of Telecommunications research, an exceptional area of UK-China collaboration (Table 3 and Table 4), shows that the UK is benefitting markedly in this regard (Figure 10).

In summary, research engagement between the UK and China is now substantial, continues to increase and leads to joint publications of appreciable quality. This activity adds substantially to the UK's overall output because purely domestic

research is no longer growing and such collaboration enhances the attention given by other researchers, as reflected by citation impact. The UK's collaboration with China is concentrated particularly strongly in technology areas, to a degree that exceeds the already skewed distribution of China's overall activity across subjects. It accounts for a high proportion of recent UK output (20 per cent in many areas and over 30 per cent in some) but a much smaller part of China's activity.

What potential issues arise from these observations? These technology research areas are already important and are almost certainly going to underpin further important developments of economic and social significance. It would be easy to suggest that China's pattern of collaboration is strategically guided, rather than an open academic choice, since it is clearly and disproportionately focused on technology. On the other hand, the UK evidently benefits because the collaboration lifts its overall output and impact in just these research areas, which have not historically been as strong as in the life sciences.

"It would seem highly deleterious not to continue a partnership that gives explicit immediate and implicit long-term benefits

Collaboration defines the contemporary global pattern of innovative research meaning that both understanding and knowledge are shared. Intellectual property cannot be patented, corralled or stored, therefore, the benefits are reaped through rapid and informed use, and only by those engaged in the source activity. The UK's engagement with China may not be wholly driven by academic choice but it enables the UK to expand high quality activity in essential areas and links UK researchers to an enormous body of associated research. This should create an increase in the UK knowledge base, in active participation in discovery, and in research competency and capacity which are all prerequisites for agile, effective and successful exploitation of those research discoveries.

The key question is not, therefore, whether the UK should collaborate with China in research and particularly in areas sensitive to the UK's technological and economic competency. It would seem highly deleterious not to continue a partnership that gives explicit immediate and implicit long-term benefits. Put another way it would damage the UK's research base and curb the broader benefits that arise from that science, if there was an exit ("Chexit") from such collaborations, driven by political or other pressures. The key research policy question is, therefore, whether collaboration has proceeded with full and mutual awareness, a properly constituted contractual basis for knowledge management, agreements for full and mutual disclosure, and reciprocal participation and knowledge exchange on both sides. China is able to gain excellent insight into the UK research base: how it works, how priorities are chosen, how posteriorities are set aside and what is currently being done. Are the UK researchers getting an equally complete and candid view of their partners' facilities, activities and discoveries? Indeed, are they conscious that they should have such a view?

2. The international student market and the importance of Chinese students to the UK economy

Key messages:

- New evidence demonstrates that UK trade in education exports was the UK's largest service export in 2018, worth £23.3 billion in 2018, compared to £20 billion for financial services.

- We estimate that the net value of UK HE exports from the hosting of full-time Chinese students was approximately £3.7 billion in 2019. The overall export value of education to China, including part-time students from China in the UK, Chinese students at UK private schools and UK private schools operating in China, is likely to be far higher.

- UK national statistics do not, however, capture education exports. Adding education exports as a discrete category to Office for National Statistics (ONS) analyses of UK exports would act as an objective measure of the contribution that international students make to the UK economy and the importance of education exports to the UK's international trade.

As the world has become more globally interconnected, via advances in technology and communication, increasingly accessible travel and the emergence of a global, mobile middle-class, HE, too, has become increasingly international and globally integrated.

This chapter sets out the importance of international students to the economy of their host country, with a particular focus on the positive economic impact of Chinese students in the UK. It also sets out new evidence showing the value of education exports to the UK economy. Finally, it proposes that HE exports should be measured by the ONS as part of the UK's export statistics.

The economic value of international student mobility

International student mobility has risen steeply in the last two decades, with the number of globally mobile students more than doubling, growing from 2.2 million in 1998 to 5.6 million in 2018.[39] Until relatively recently, North America and Western Europe were the dominant players in providing international education, hosting almost two-thirds of the globally mobile students in 1998 (64 per cent).[40] However, by 2018 this share had reduced to just above half of the world's international students (52 per cent), with East Asia and the Pacific gaining 7 per cent and Central and Eastern Europe gaining 5 per cent of globally mobile students.[41] This suggests a shift away from an Anglo-American-dominated international student market, to a multi-polar one.

Despite this, the UK is one of the most popular international destinations for students worldwide, second only to the United States, with international students making up 21 per cent of the UK's total student population (485,645) in 2018/19, 343,000 of whom came from outside the EU.[42]

While international students make a considerable contribution to the academic and cultural life on campus and their locality, they also provide a significant economic boost to the host country. Estimates from the National Association of Foreign Student Advisers (NAFSA) show that international students in the US contributed US$38.7 billion to the US economy,[43] whereas those in Australia contributed A$37.6 billion (approximately US$28 billion).[44] UUK estimates show the contribution of international students to the UK economy is £25 billion.[45]

The importance of Chinese students to the UK university sector and economy

Data from the past two decades shows a significant increase in the number of Chinese students in the UK over that period. The number of first year students in the UK from China has increased from 25,000 in 2006/7 to 86,500 in 2018/19, the most recent year for which data is currently available.[46] This is almost five times that of India, the second biggest sending country for international students in the UK. Chinese students made up 35 per cent of the overall number of non-EU students, across all levels of study, in the U.K. in 2018/19.[47]

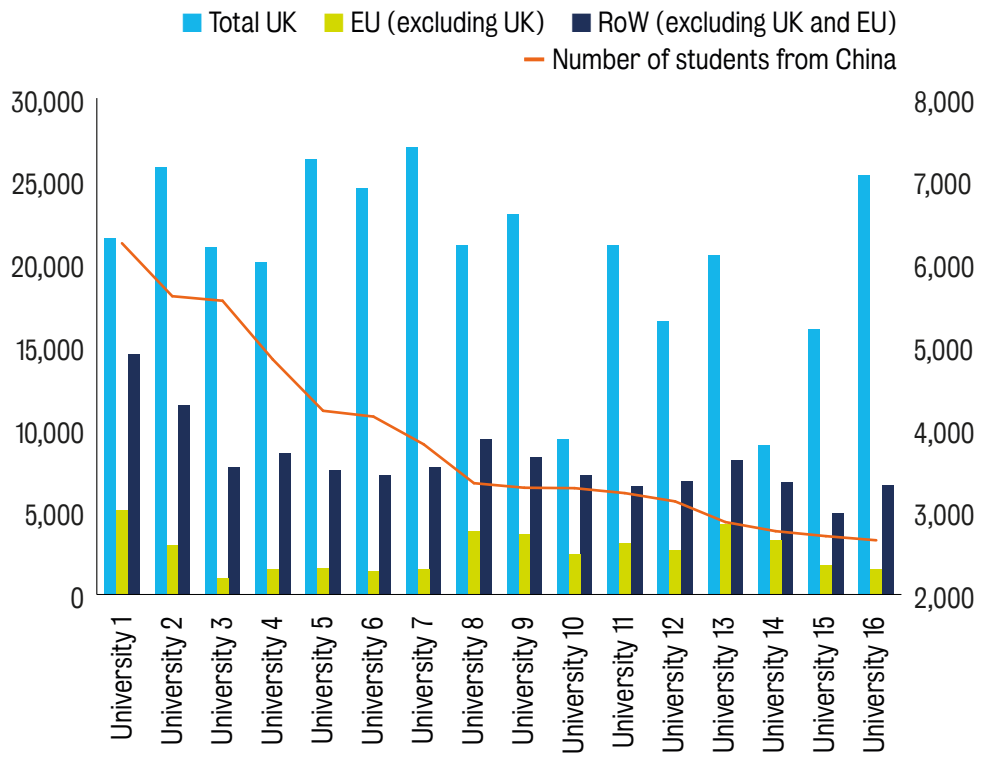
TABLE 6: TOP 10 NON-EU COUNTRIES OF DOMICILE IN 2018/19 FOR HE STUDENT ENROLMENTS, ACADEMIC YEARS 2014/15 AND 2018/19[48]

	2014/15	2018/19	% change
China	89540	120385	+34.45%
India	18325	26685	+45.62%
United States	16865	20120	+19.30%
Nigeria	17920	10645	-40.60%
Malaysia	17060	13835	-18.90%
Hong Kong	16215	16135	-0.49%

	UK	Collab	China
Saudi Arabia	8595	8125	-5.47%
Singapore	7295	6750	-7.47%
Thailand	6240	6305	+1.04%
Canada	6075	6490	+6.83%

Notably, Chinese students account for a significant proportion of students across many of the UK's leading universities, reaching 19 per cent of the overall full-time student population at some UK universities, as demonstrated in Figure 12.

FIGURE 12:
TOP UK UNIVERSITIES, BY NUMBER OF CHINESE STUDENTS 2018/19 (ANONYMISED)



The UK's Higher Education Policy Institute (HEPI) estimates that a typical non-EU student's overall contribution to the UK economy was £102,000, based on 2015/16 prices.[49]

Data also shows that UK tuition fee income in 2018/19 from EU and non-EU students accounted for 37 per cent of university's overall tuition fee income (£1.2 billion tuition fee income from EU students and £5.9 billion from international non-EU students).[50] International students account for 20.7 per cent of the UK's full-time students. The high proportion of tuition fee income from non-EU students is reflective of the higher fee levels for non-EU students. Income from international tuition fees can be used by HEIs to cross-subsidise areas of divestment such as research, a significant advantage of this income stream for UK HEIs.

Are education exports the UK's single largest service export?

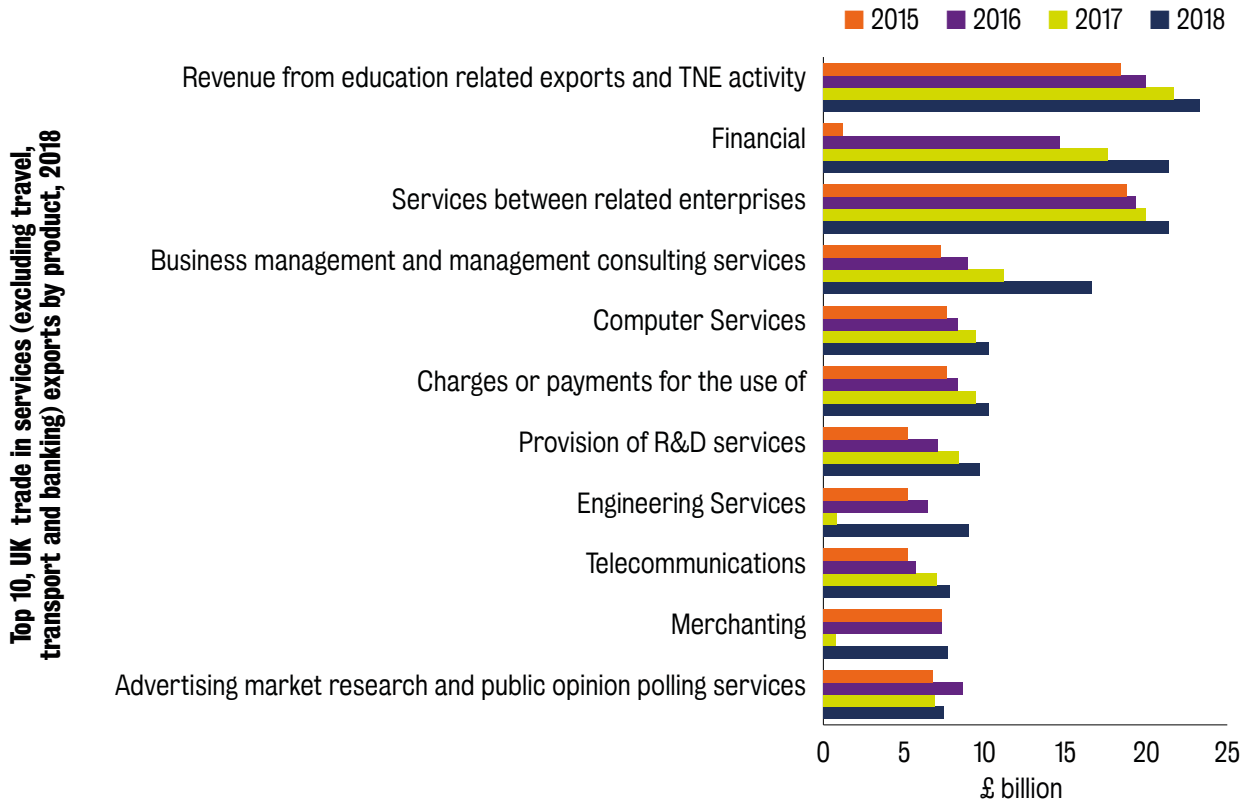
Education exports make a significant contribution to the UK economy. However, this remains uncaptured by our national statistics. Evaluation studies carried out by the Department for Education (DfE), UUK and HEPI are in broad agreement about the value of the UK's education exports.

A report from the DfE shows that UK revenues from education-related exports and transnational education (TNE) activity in 2019 were estimated to be £23.3 billion.[51]

Data from the ONS shows that exports of services (excluding travel, transport and banking) added up to £185.3 billion in 2017,[52] while in 2018, financial services continued to constitute the single-largest service product exported globally from the UK. It increased from £20 billion in 2017 to £21.7 billion in 2018. DfE estimates that education exports increased from £21.38 billion in 2017 to £23.28 billion in 2018. This comparison shows UK trade in education exports was the UK's largest service export in 2018 and is significantly higher than financial services.

The chart below uses the DfE estimates and plots them alongside the UK's 10 largest services exports reported by ONS.[53 54]

FIGURE 13: UK TRADE IN SERVICES (EXCLUDING TRAVEL, TRANSPORT AND BANKING) EXPORTS BY PRODUCT, 2018



HE export revenues from China were also calculated. Using the London Economics model for HEPI,[55] and adjusting for inflation, we estimate that the net value of UK HE exports from hosting full-time Chinese students was approximately £3.7 billion in 2019.

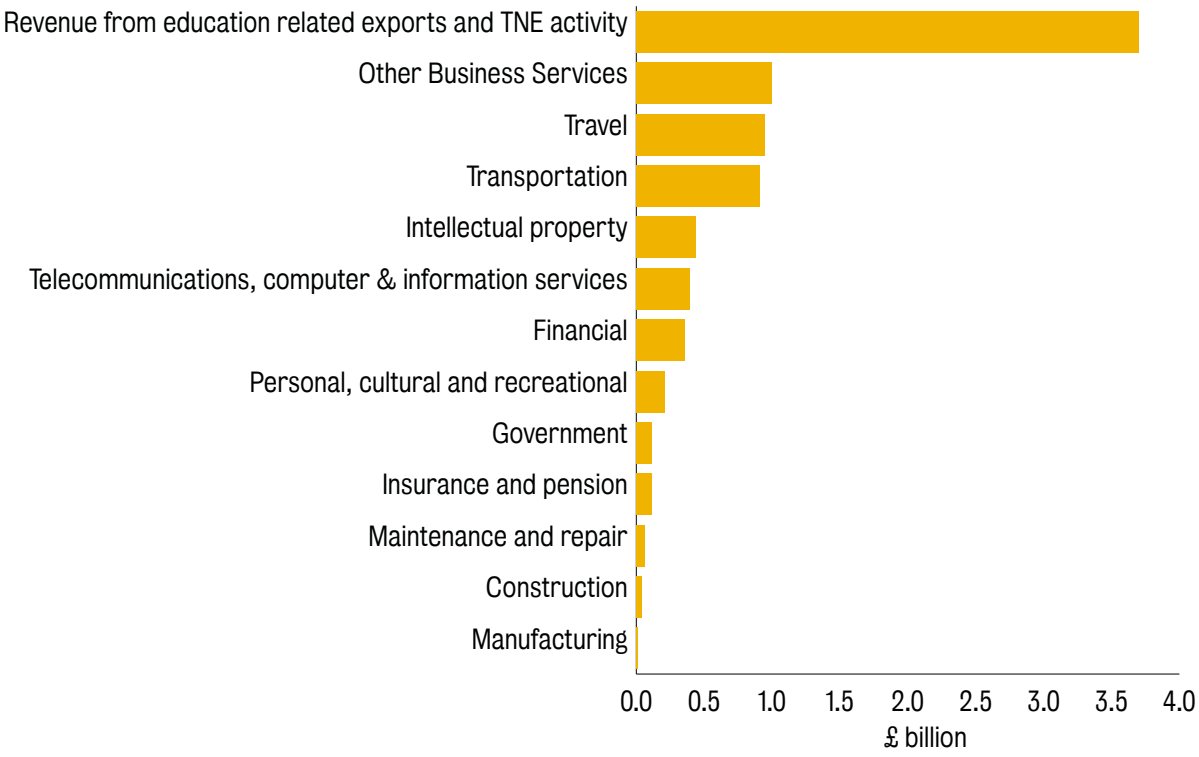
In a recent paper, Professor David Law estimated that HE exports to China in 2019 were the third largest export after non-monetary gold, valued at £6.4 billion and petroleum products (£5 billion).[56] Our estimates are similar to Law's findings, and they show education exports was the UK's largest service export in 2019.

The estimated £3.7 billion shows the *net value* of education exports to China. It is an underestimate of the export value of education and does not include revenues from:

- 1,950 part-time students from China.[57]
- 78,000 TNE students in China.[58]
- 10,865 Chinese students in UK private schools. [59]
- 29 UK private schools in China[60] (Independent School Council Annual Census).

The below graph shows how HE exports would compare to other export services to China, if the ONS recorded education exports.[61]

FIGURE 14: UK SERVICE EXPORTS TO CHINA BY TYPE OF SERVICE, 2019



At present, the DfE and education sector organisations and national agencies calculate the value of education exports. Detailed methodologies which estimate the contribution of international students are developed by the DfE[62] and London Economics.[63] The latter presents a more comprehensive account of students' expenditures, for example, living costs and family visits to the UK.

Our analysis shows that education is one of the UK's largest services exports. Its contribution, however, is not included the national statistics.

The International Education Strategy, announced by the DfE and the Department for International Trade (DIT), aims to "increase the value of our education exports to £35 billion per year, and to increase the number of international higher education students hosted in the UK to 600,000 per year, both by 2030".[64]

An accurate account for education exports, incorporated into the ONS export analysis, would act as an objective measure of the contribution of international students to the UK economy and of the importance of education exports to the UK's international trade. It would also enable the sector to accurately assess progress towards the DfE's International Education Strategy.

Conclusion

The evidence presented in this chapter demonstrates the importance of international students to the economic success of their host country. In the UK, tuition fee income from non-EU students – worth £5.9 billion in 2018/19 – plays an important role in cross-subsidising critical elements of HEI activity, including major research projects. Given the significant growth in the number of Chinese students in the UK over the past 20 years, the importance of Chinese students to UK HEIs cannot be overstated. The value of UK HE is not, however, included in national statistics. By including this in the ONS export data, policymakers and UK HEIs would have a consistent source from which to assess the contribution of education as a major services export, and to develop a more strategic response to attracting international students, including those from China.

3. The future of Chinese student enrolment in the UK

Key messages:

- Demand for HE in China is rapidly increasing; there was an eight-fold increase in the participation rate in tertiary education in China over the past two decades.
- Increased focus and investment by China on growing their own "world-class" HE capacity and institutional quality through the "Double First Class Initiative" is likely to reduce demand for international student placements outside of China.
- Chinese students in the UK have very high overall satisfaction rates and a very low drop-out rate, indicating that UK universities are in a strong position to attract students who still choose to study outside of China.

As outlined in chapter 2, over the past decade there has been a significant increase in the number of Chinese students studying in the UK, yet the evidence suggests that a complex mix of factors influences whether the UK should continue to look to China as a net exporter of students over the coming decade. This chapter will explore the factors influencing this trend, including the growth in capacity in the Chinese university system, institutional quality and international rankings, the value placed on international degrees by the CCP and, in turn, how these factors affect how Chinese students choose where to study. Finally, it sets out how China is on the verge of becoming a HE powerhouse and the implications of this for Chinese student enrolment overseas, including in the UK.

Structural trends impacting UK HE enrolments from China

Demography

Over 40 years after the introduction of the one child policy, China's student-age population is predicted to remain broadly static until 2030.[65] This "demographic time bomb" is expected to have a significant impact on global HE flows. The first children born after the introduction of China's two-child policy are now in early-years education. These children will enter tertiary education in the early 2030s but, until then, global universities will likely face increasingly sharp competition in attracting a stable number of Chinese students.

The international school system in China

While the number of total Chinese students will remain broadly static until 2030, it is unclear what will happen to the number of students studying overseas. Some indicators suggest that this number will continue to grow, given the significant increase in the number of international schools in China.

There are now 857 international schools located across the country, increasing from 629 five years ago, of which 563 are international Chinese-owned private schools.[66] The number of students enrolled in international Chinese private schools has also risen by 63.6 per cent in the last five years,[67] to 245,000.

Under the Chinese education system, international schools must follow the same national curriculum as state schools from grade 1 to 9 (for children aged ~6 to 15 years old). After this point, schools have the option to set an international curriculum, with students able to sit A-levels, the International Baccalaureate (IB) or the Advanced Placement (AP) to apply for university in Western countries.

Looking specifically at British independent schools, the latest figures, from 2019, show that 17 British independent schools run 36 campuses in mainland China. It is expected that a further 15 British independent schools will open their first campus in mainland China in the next few years.[68] Fees for the top British independent schools in China range from £26,500 to £36,000. As a result of the one-child policy, parents and grandparents in many middle-class families will pool resources to fund expensive education fees. Evidence suggests that 60 per cent of Chinese families invest one-third of their income in their child's education, second only to the expenditure on food each month.[69]

Those who participate in the mainstream Chinese system sit the Zhongkao at age 16, the intermediate exam which dictates whether a student will continue to high school or attend a vocational high school. It is estimated that around half of students in China obtain high school places following the Zhongkao,[70] and generally go on to sit the Gaokao, the Chinese university entrance exam, at age 18. The Gaokao is the deciding factor in university admissions decisions, with stringent cut off scores for admission to China's top tier, second tier and third tier universities. Approximately 10 per cent of students receive a tier 1 score and a further 20 per cent receive a tier 2 score.[71] A regional quota system is also in place for university admissions, effectively creating regional league tables for student admissions. The quota numbers are similar for major urban areas, which tend to have a comparatively small pool of students,

and large provinces. This gives students in Beijing, for example, a significantly higher chance of entry to elite universities than those living elsewhere in China.[72]

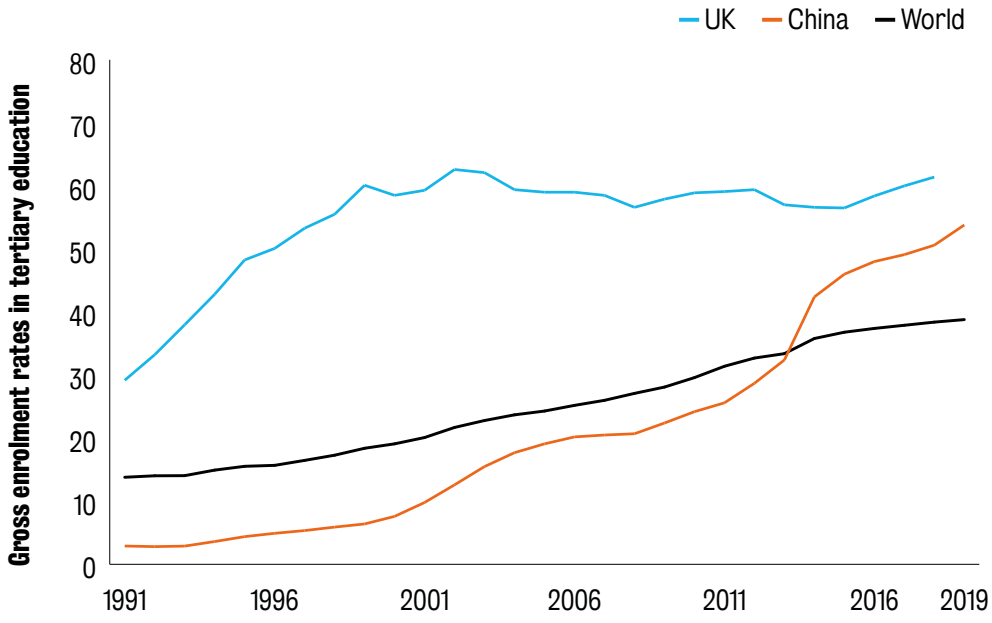
The Gaokao itself is held over two days, and students' final scores are based on performance in these exams alone. By contrast, the IB curriculum is based on longitudinal assessments, with assignments and projects contributing to the final grade, reducing the pressure on students during their final exams.

Admission to Chinese universities is heavily reliant on Gaokao scores, overlooking extracurricular activities and broader personal development. As a result, Chinese parents are increasingly turning to international schools as a route to Western universities, as a broader range of factors are generally considered in admission decisions.

Growth in capacity in the Chinese HE system

Over the past two decades, China has seen an eight-fold increase in participation in tertiary education, rising from 5.9 per cent in 1998 to 53.8 per cent in 2018. For comparison, Figure 15 shows China's growth presented alongside that of the UK and the world average gross enrolment rate in tertiary education.[73]

FIGURE 15:
GROSS ENROLMENT RATES IN TERTIARY EDUCATION: CHINA, THE UK AND THE WORLD AVERAGE[74]



Almost 47 million learners were in tertiary education in China in 2018, which represents a fifth of the world's tertiary education population that year. This is a significant increase from 1998, when 6 million learners were in tertiary education in China, estimated to represent 6.8 per cent of the global total.

A key contributor to this trend is the notable increase in the number of academic high school graduates choosing to remain in China and study at domestic institutions since 2014. This is the case across higher vocational diplomas, bachelor's degrees and postgraduate programmes.

TABLE 7:
CHINESE STUDENTS ENTERING HE PROGRAMMES IN CHINA, 2014–2019[75]

	Higher vocational diploma	Bachelor's degree	Postgraduate programmes
2014	3,380,000	3,834,000	621,323
2015	3,484,000	3,894,000	645,055
2016	3,432,000	4,054,000	667,064
2017	3,507,000	4,108,000	806,103
2018	3,688,000	4,222,000	857,966
2019	4,836,000	4,313,000	916,503
5-year CAGR	+7.4%	+2.4%	+8.1%

The proportion of candidates qualifying to study a bachelor's degree, having passed the Gaokao, also increased slightly, from 41 to 42 per cent, between 2014 and 2019, while the proportion qualifying to enter broader HE courses saw a much larger increase.[76]

Institutional quality in China

China has been focussing on increasing its national HE capacity and quality. In 2018 President Xi Jinping spoke at the National Education Conference, stating that China's focus in education should shift from capacity to quality, with education supporting the modernisation of China.[77] This was followed by the publication of two plans to reform the country's education sector: China's Education Modernisation 2035 Plan (2035 Plan) and the Implementation Plan for Accelerating Education Modernisation (2018–2022) (Implementation Plan).[78]

As part of this strategy, in 2017, three Chinese ministries released details of the country's "Double First Class initiative", a new programme to co-ordinate quality improvement across China's HE system. First announced in 2015, in line with the 13th Five Year Plan, the programme aimed to create a number of world-class universities and disciplines by 2020 and for China to become a HE power by 2050.[79] The overall goal of the project is to:

> Promote a batch of high-level universities and disciplines to enter the world's top ranks or the front ranks, speed up the higher education governance system and the modernization of governance capacity, and raise the level of innovation in personnel training, scientific research, social services and cultural inheritance in higher education institutions, making them…[an] important source of advanced ideas and excellent culture, and an important base for cultivating high-quality and talented people of all kinds.[80]

In total, 42 universities were marked for development into world-class institutions, of a total of more 2,000 universities and colleges in China.[81] The plan also includes a focus on improving Sino-foreign joint ventures in HE, with priority areas of natural science and engineering.[82]

This plan was underlined in the Implementation Plan for Accelerating Education Modernisation (2018–2022) which set out 10 key tasks to strengthen China's domestic HE industry. This included an aim to accelerate the Double First Class Initiative.

The 2017 Times Higher Education World University Rankings showed that four of the universities targeted under the Double First Class Initiative were in the top 200 universities globally and an additional 25 were listed in the top 1,000. The most recent 2021 data shows five universities listed in the top 200, and an additional 31 in the top 1000. The most elite institutions in China have also made significant gains, with Tsinghua University climbing 15 places and Fudan University gaining 85 places on its 2017 ranking.

TABLE 8:
CHINESE UNIVERSITIES IN THE TOP 100 THE WORLD RANKINGS IN 2021 AND 2016–2020 RANKINGS[83]

	2016	2017	2018	2019	2020	2021
Peking University	42	29	27	31	24	23
Tsinghua University	=47	35	30	22	23	20
Fudan University	200+	155	116	104	109	70
University of Science & Technology	600+		132	93	80	87
Nanjing University	250+		169	134	144	111
Zhejiang University	250+		177	101	107	94
Shanghai Jiao Tong Univ	300+		188	189	157	100

The Academic Ranking of World Universities presents a similar picture, with five Chinese universities in the global top 100 for 2020. Of these, Tsinghua University is ranked most highly at 29, while Fudan University is ranked at 100.

Ultimately, these university rankings illustrate the improving status of the top tier of HE in China, with an increasing capacity to attract domestic students and gain international prominence.

China's research capacity and capability

The number of highly cited researchers (HCRs) – academics with multiple, highly-cited papers in the last decade – is another useful metric by which to evaluate the quality of China's domestic HE market.

Two series of HCRs exist, the first focusing on 21 disciplinary fields across the sciences and social sciences, as defined by Clarivate's ESI, and the second focusing on those working across conventional disciplinary boundaries.

The 2020 list contains about 3,900 HCRs in the 21 ESI fields and about 2,500 HCRs with exceptional cross-field performance.

TABLE 9:
HIGHLY CITED RESEARCHERS, 2020, AS DEFINED BY ESI (CLARIVATE)

	Highly cited researchers	
	Number	Percentage of world total
United States	2,650	41.5
China	770	12.1
United Kingdom	514	8.0
Germany	345	5.4
Australia	305	4.8
Canada	195	3.1
Netherlands	181	2.8
France	160	2.5
Switzerland	154	2.4
Spain	103	1.6

The number of HCRs in Chinese universities has been increasing. This may result, in part, from the proliferation of literature published in China. However, the relatively fast rate at which the number of HCRs in Chinese universities is increasing, compared with rising publication levels, would suggest improvements in the presentation of research outcomes and greater global awareness of research achievements in China.

The number of cross-field HCRs has also grown over the three years for which data is available. Particularly high levels of interdisciplinary activity are seen in chemistry and materials research, both of which are areas of focus of Chinese research.

TABLE 10:
HIGHLY CITED RESEARCHERS IN CHINA, 2014–2020

	Highly cited researchers		
	ESI field specific	Cross field	China as % world
2014	113		3.5
2015	121		3.9
2016	154		4.7
2017	215		6.1
2018	276	206	7.9
2019	347	289	10.2
2020	408	362	12.1

Universities are also ordered based on the number of HCRs they employ. In 2020, two Chinese institutions ranked amongst the top 10 institutions globally (Table 10). While the presence of the extensive multi-campus Chinese Academy of Sciences might be unsurprising (akin to the US National Institutes of Health and the Max Planck Organisation in Germany), the arrival of Tsinghua University in 9th place (from 19th in 2019) is notable.

TABLE 11: INTERNATIONAL UNIVERSITIES BY NUMBER OF HCRS, 2020

Institution	Nation	Highly cited researchers
Harvard University	USA	188
Chinese Academy of Sciences	**China**	**124**
Stanford University	USA	106
National Institutes of Health	USA	103
Max Planck Society	Germany	70
University of California Berkeley	USA	62
Broad Institute	USA	61
University of California San Diego	USA	56
Tsinghua University	**China**	**55**
Washington University of St Louis	USA	54

In 2020, there were 44 universities in China that employed five or more HCRs, an increase from four institutions in 2014. When looking at the areas of computing and mathematics more specifically, several Chinese universities now top the international league tables. Tsinghua is ranked first in physical sciences and engineering, ahead of MIT.

The factors influencing Chinese student choice

The value of international degrees in China

While the CCP has focused resources on improving the capacity of China's top universities over the past five years, recent Chinese government policies have continued to make positive statements about overseas study. The Education Modernisation 2035 policy outline, for example, states that the government should "optimise services for studying abroad".

US-educated graduates have, however, been shown to be at a serious disadvantage in the Chinese labour market, compared with applicants who were educated in China. Over 27,000 fictitious online applications were submitted online, for the purposes of the study, to business and computer science jobs in China.[84] On average, US-educated applicants were 18 per cent less likely to receive a call back, with applicants from highly selective US institutions underperforming those from the least selective Chinese institutions.[85]

This study also involved a survey of 260 hiring managers in China who, when asked to choose between two otherwise identical candidates from the US and Chinese universities, expressed a preference for the Chinese-educated graduate around 80 per cent of the time.[86] When prompted, 35 per cent of hiring managers said US candidates were overqualified or more likely to choose another job once hired.[87] Another 35 per cent said a Chinese-educated candidate would be a better fit for the company, while, only 7 per cent of respondents agreed that Chinese universities offered a better education.[88]

Interestingly, the call-back gap was smaller at foreign-owned firms. This is consistent with the finding that a lack of knowledge about American HE in Chinese firms limits their employment of those educated outside of China.89 While comparable data is not currently available for UK-educated graduates, we expect that the findings would likely be replicated in a UK context.

> ...global rankings of individual institutions are one of the top factors that Chinese students consider

This analysis comes alongside broader research showing that internationally educated graduates earned on average only US$71 more per month than domestic graduates, as a result of high competition from other candidates with international degrees and weak domestic social networks.[90]

It is also worth noting that employability data for international students does not factor into global rankings, nor the UK Teaching Excellence Framework, despite this information being available for undergraduate home students.[91]

The Chinese government also continues to provide a substantial number of international scholarships each year. The number of new government-funded scholarships increased from 12,000 in 2012 to 30,000 in 2016 and has remained at that level since.[92] These grants are administered by the China Scholarship Council (CSC or, officially, the National Education Fund Management Committee), which offers scholarships to both Chinese students abroad, international students who wish to study in China and a broader range of international faculty exchanges.[93] As of 2018, about 65,000 Chinese students abroad (7 per cent) received public funding from the Chinese government.[94] The majority of scholarships for Chinese students abroad have been provided to senior researchers and post-docs (42 per cent), compared to 35 per cent for PhD students and 23 per cent for masters and undergraduate students.[95] The largest of the CSC schemes funding Chinese students overseas is known as the National Construction High-Level University Postgraduate Program (NCHUPP). The programme funds over 10,000 Chinese PhD students and postdocs each year, prioritising "urgently needed talents serving major national strategies, important industries, key fields, major projects, cutting-edge technologies, and basic research".[96] Students are required to return to China for at least two years upon completion of their degree and must provide details of guarantors to repay the grant, plus penalties, should the student not return to China after completing their studies.[97]

The relatively small proportion of Chinese students overseas who receive state support appear to be focused in critical industries that align with China's national priorities. This suggests that international qualifications have a greater perceived value when contributing to building China's domestic capabilities than in the general labour market, as underlined by the strict requirements for Chinese students overseas to return home after graduation.

University rankings

Analysis from the British Council suggests that the global rankings of individual institutions are one of the top factors that Chinese students consider when choosing where to study, with increasing attention being paid to subject area rankings. In addition, a survey for the Bright Futures project found that "quality of education" is

a key motivator in Chinese students choosing to study in the UK, with 93 per cent citing this as "very or extremely important'.[98]

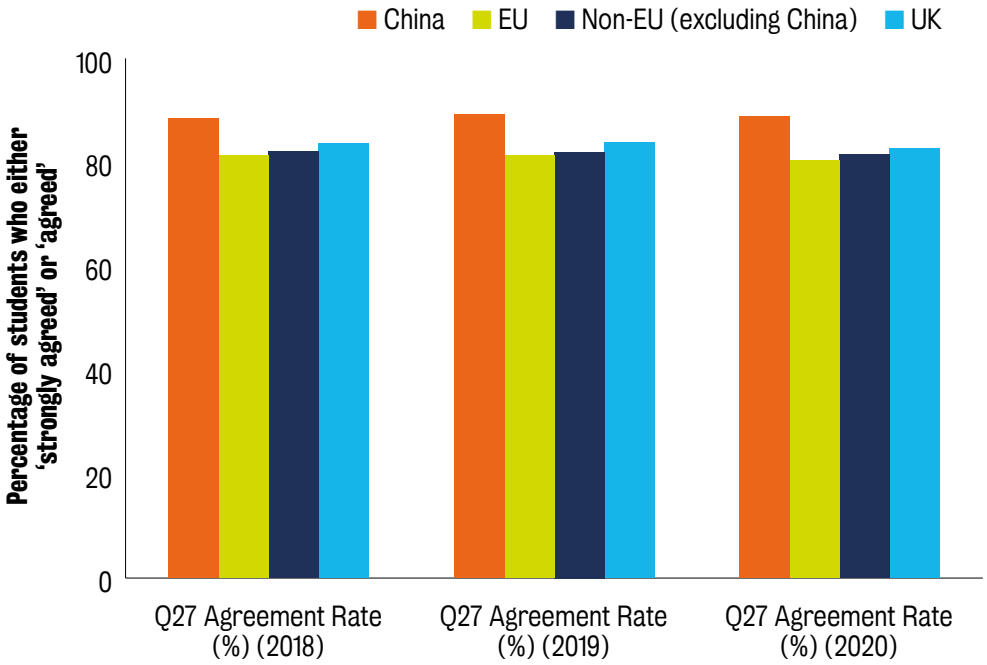
Institutional and subject rankings, however, are not the only factors driving Chinese students' decisions. "Gaining new experiences", for example, was "very or extremely important" for 89 per cent of respondents, while 83 per cent described wanting to meet people from different backgrounds.[99]

Student satisfaction and graduate outcomes

Recent analysis of the 2021 National Student Survey gives us a helpful perspective of students' overall satisfaction with their course of study at UK institutions. In the survey, students were invited to agree, neither agree nor disagree, or disagree with the proposition that "overall, [they] are satisfied with the quality of the course".

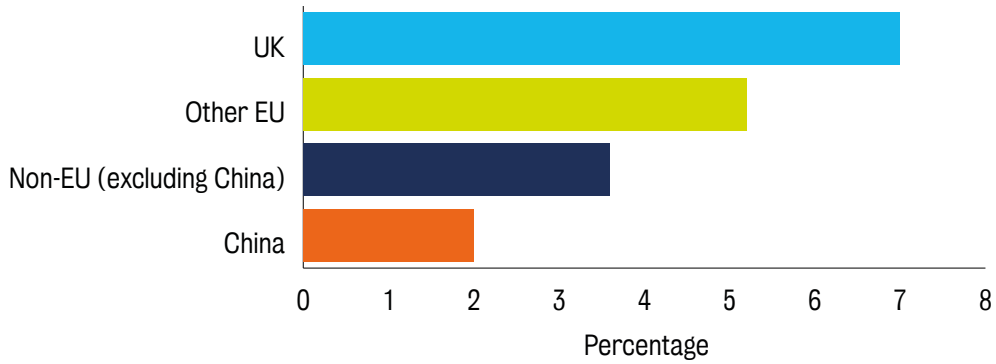
The data shows that while there was a slight decline in the overall satisfaction in 2020 compared to 2019 – likely resulting from the pandemic – Chinese students appear to have been less affected compared to students from the UK, EU and non-EU countries (excluding China).[100] Analysis also suggests that, except for a few countries with a very small number of students, those from China have the highest level of overall satisfaction with their course.

FIGURE 16: OVERALL SATISFACTION WITH QUALITY OF COURSE[101 102]



The evidence also shows the non-continuation (drop-out) rate for Chinese students is 2 per cent, significantly lower than that of UK students (7 per cent), EU students (5.2 per cent) and the rest of the non-EU students (3.6 per cent).[103]

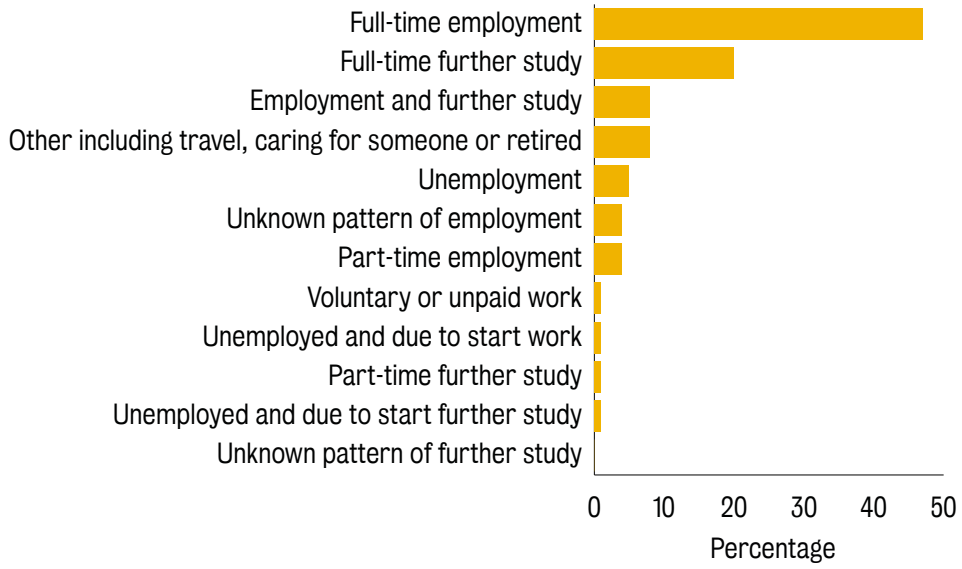
FIGURE 17:
NON-CONTINUATION (DROP-OUT) RATE[104]



This analysis paints a striking picture. Chinese students in the UK have a very high overall satisfaction rate and a very low drop-out rate. As noted earlier in this chapter, while the quality and capacity of Chinese universities will continue to increase over the coming decades, UK universities are in a strong position to attract those students who still choose to study beyond China.

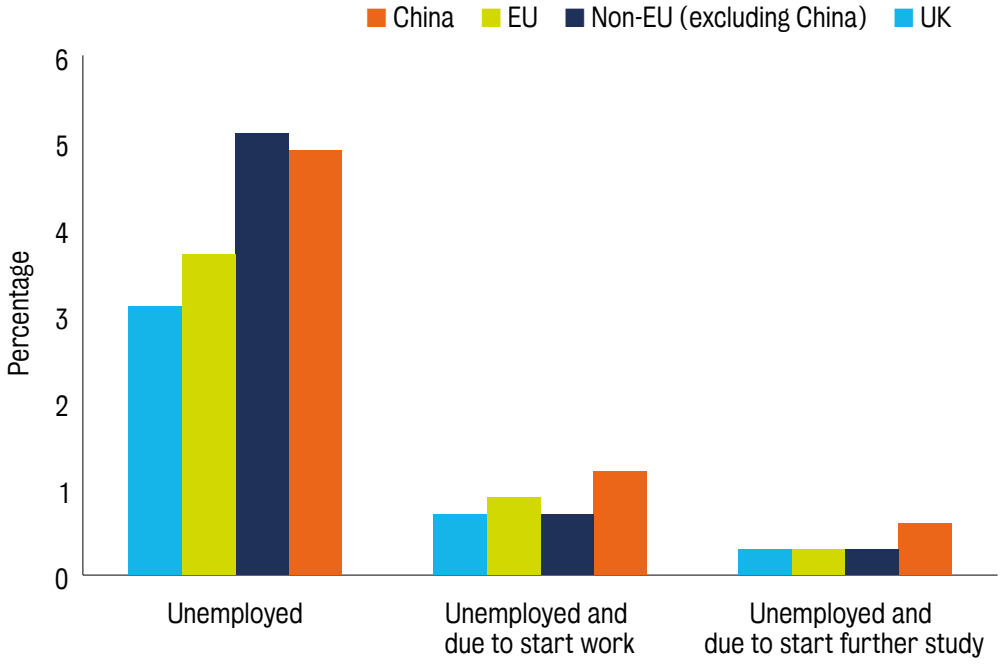
The Graduate Outcomes survey releases data relating to all UK HE providers, including alternative providers and further education colleges in England, Wales and Northern Ireland. The graduate outcome data is collected approximately fifteen months after students' completion of their HE courses.[105] The response rate for international non-EU graduates is 30 per cent[106] and, as such, these statistics need to be treated with caution.

FIGURE 18:
CHINESE DOMICILED GRADUATES BY ACTIVITY SINCE GRADUATION 2017/18[107]



Chinese graduates in employment or unpaid work, including those in further study (8 per cent), accounted for 61 per cent of the surveyed respondents. The unemployment level among Chinese survey respondents was 5 per cent, similar to that of other non-EU students (5 per cent) and above that of EU students (4 per cent) and UK students (3 per cent). Unemployed graduates from China due to start work or further study accounted for a further 2 per cent.

FIGURE 19: UNEMPLOYED GRADUATES AND THOSE DUE TO START WORK OR FURTHER STUDIES (EXCLUDING SIGNIFICANT INTERIM STUDY)[108]



Graduate outcomes by activity and domicile

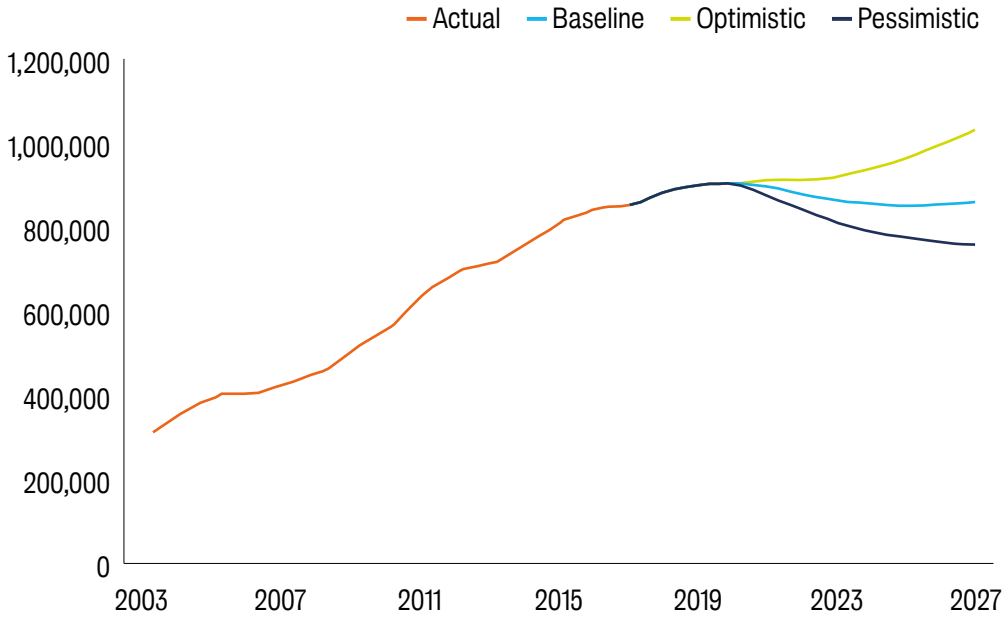
The future of Chinese student enrolment in the UK

Forecasts for Chinese student enrolments overseas

Each of the factors outlined here, including China's complex demographic trends, the increasing number of international schools in China, the growth in the capacity of the country's domestic HE system, and improved institutional quality at home, play an important role in current forecasts of Chinese students overseas.

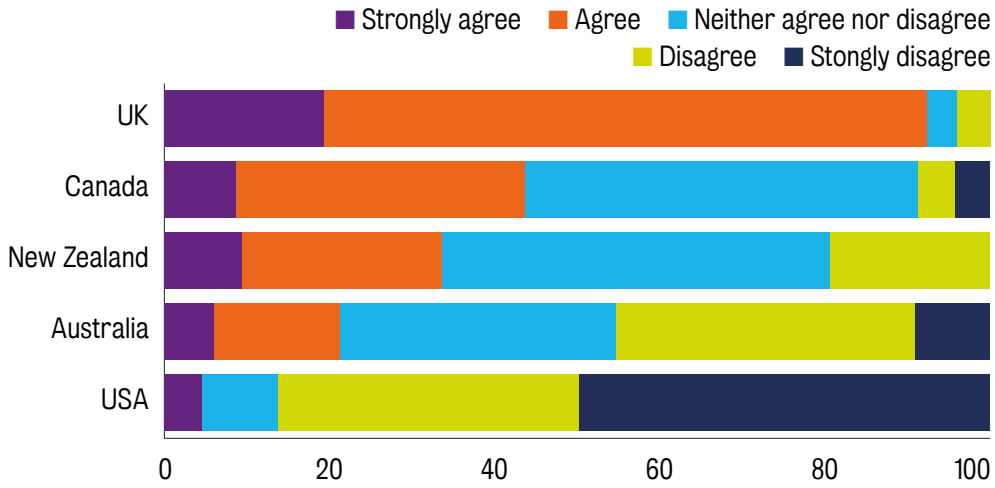
As demonstrated in Figure 20, the baseline projections suggest that the number of Chinese outbound students to all countries is likely to peak around 2020, before declining gradually over the next seven years.

FIGURE 20: CHINESE STUDENT ENROLMENTS IN OVERSEAS HEIS[109]



A recent survey with major education agents in China suggests the UK is enjoying a growing popularity with students and their parents, with over 90 per cent of the surveyed agents reporting a growing interest in the UK as a study destination. Having said this, the challenge for international HEIs in the coming decade will be in attracting those Chinese students who may now consider domestic HE over international study. The forecasts from the British Council suggest that international student mobility from China will plateau in the mid-term to 2027. The remainder of this chapter will explore the factors that influence Chinese students' choice of university destination.

FIGURE 21: RESPONSES FROM EDUCATION AGENTS IN CHINA, 2020, TO THE STATEMENT: "OVER THE PAST TWO MONTHS, THERE HAS BEEN MORE INTEREST IN THIS COUNTRY AS AN EDUCATION DESTINATION COMPARED TO OTHER COUNTRIES"[110]



The UK is less likely than other countries to be affected by the disruptions brought by the pandemic. The provision of TNE and international partnerships by UK HEIs have resulted in the development of strong infrastructure overseas, including overseas branch campuses, joint campuses and institutes, trusted networks of local partners delivering UK and joint degrees and research collaborations. Physical presence overseas and a trusted network of local partners has also allowed the UK HE sector greater flexibility in responding to changes in demand and the external environment. Overseas students are, as a result, able to study at a local education institution or with a partner, travel to the UK or study remotely online through newly established digital pathways.[111]

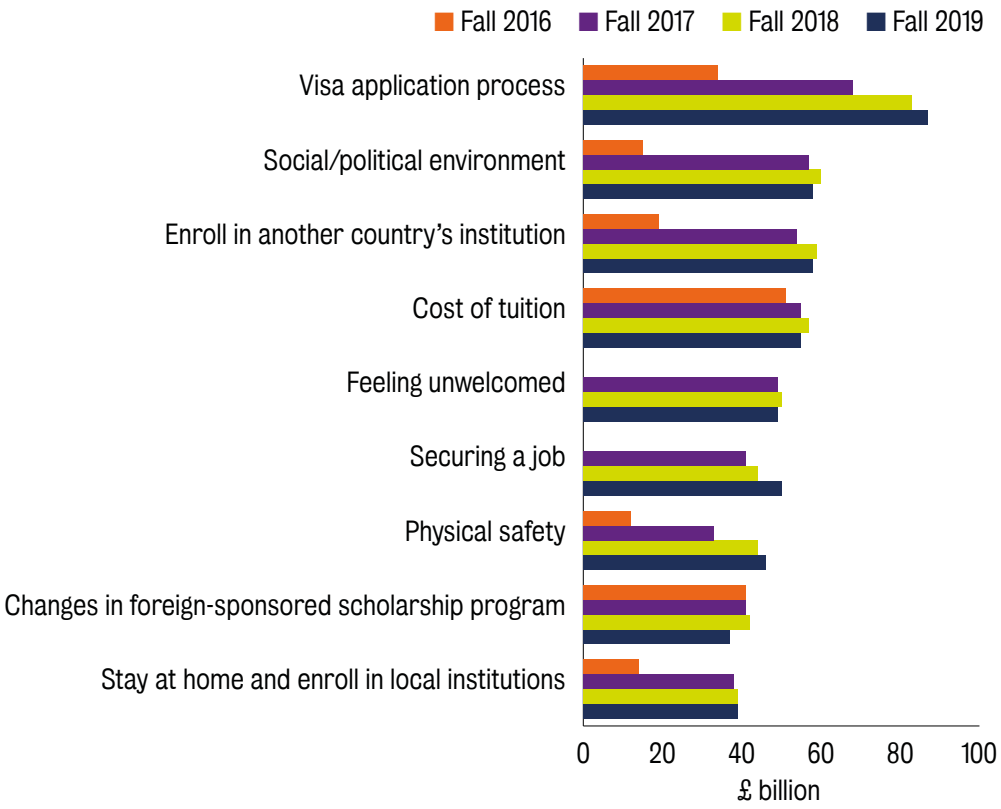
Transnational pathways fuelled growth in student enrolment in England between 2009 and 2013,[112] and a more recent report, from the British Council and UUK, showed that the number of students on bachelor programmes in the UK, who started their course in China, has continued to rise.

While this chapter has not focused explicitly on the impact of the Covid-19 pandemic, it is worth noting that the number of Tier 4 (sponsored study) visas granted to Chinese nationals declined in the year ending September 2020 (falling to 52,968, a reduction of 66,896, or 56 per cent).[113] There are various explanations for this – including travel disruptions, national lockdowns and the closure of visa centres. Visa numbers were also affected by those students who chose to study with UK universities online or who were granted a visa did not to travel to the UK and, therefore, did not use it.[114] Having said this, the UK has fared relatively well in comparison to other study destinations, including the US and Australia, where the decline in student visa numbers is more pronounced, and new applications may be increasing. The UK University and Colleges Admissions Service (UCAS) sector-level end-of-cycle report, for example, shows a 24 per cent increase in the number of applicants from China (26,710) and a 33 per cent increase in the accepted applicants (16,185) compared with the end of the 2020 application cycle.[115] A definitive assessment will, however, have to wait until January 2022, when the HESA data for the 2020/21 academic year is released.

Explaining the decline

In general, the same number of Chinese students are studying abroad, but many are choosing different countries. The US, UK and Australia are seeing a declining market share while Canada is experiencing a rapid growth in its share of international students. Aside from Covid-19, a number of factors, which are within an institution's and country's control, should be considered.

FIGURE 22:
TOP REASONS FOR DECLINING INTERNATIONAL ENROLMENT IN THE US[116]



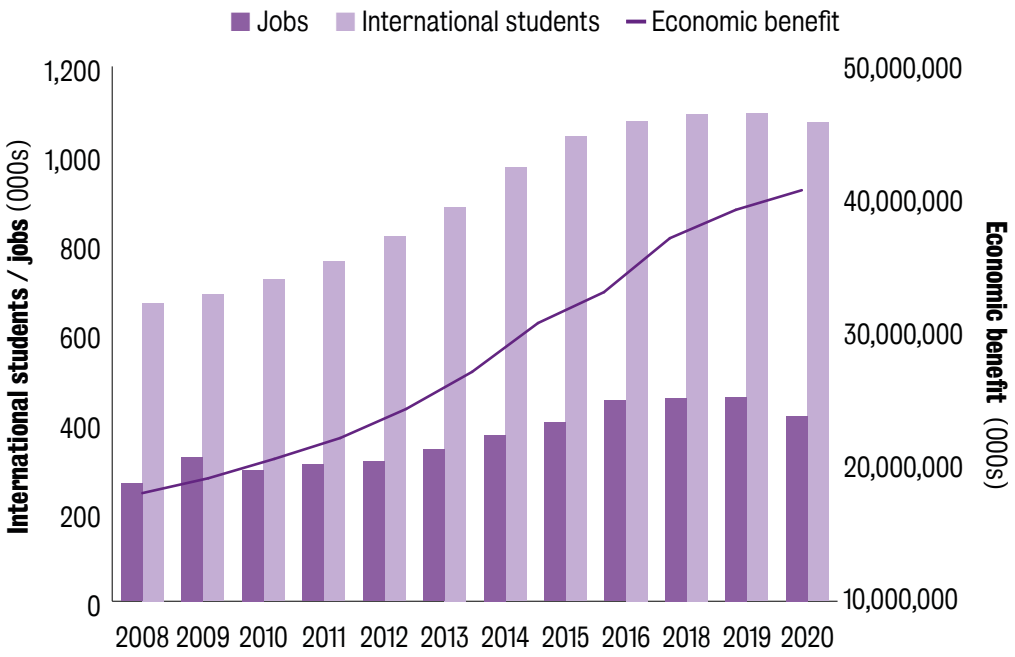
The visa application process, social and political environment and cost of tuition are key factors in the decline of international enrolment in the US. Countries that are proactively establishing national policies and marketing strategies to keep students in-country after graduation are, however, having more success in recruiting and retaining international students. Canada, for example, has created friendly international student policies, including expedited visa processing, three-year post-graduate work visas and an easier immigration process, as well as other work-related benefits for students.

International student enrolment decline in the US

At the height of international student enrolment in 2018, 1,095,299 international students added US$41 billion to the US economy and created more than 458,000 jobs. The 369,548 Chinese students in the US that year contributed at least US$13 billion (over one third of the economic contribution). NAFSA, an international education advocacy group, estimates that "for every seven international students, three US jobs are created and supported by spending occurring in the HE, accommodation, dining, retail, transportation, telecommunications and health insurance sectors".[117]

However, just one year later, in the 2019–2020 academic year, economic contribution fell by more than 4.4 per cent, or nearly US$2 billion, due to a 2 per cent decline in international student enrolment. This is the fourth consecutive year in which the number of international students enrolled in the US has fallen. Consequently, the number of jobs created or supported by international students fell by 42,294 or 9.2 per cent. Institutions and economists alike are nervously awaiting the 2020–2021 data as it is estimated international student enrolment fell by 43 per cent in the autumn of 2020.

FIGURE 23
THE ECONOMIC BENEFITS OF INTERNATIONAL STUDENT ENROLMENT TO THE US, 2008–2019

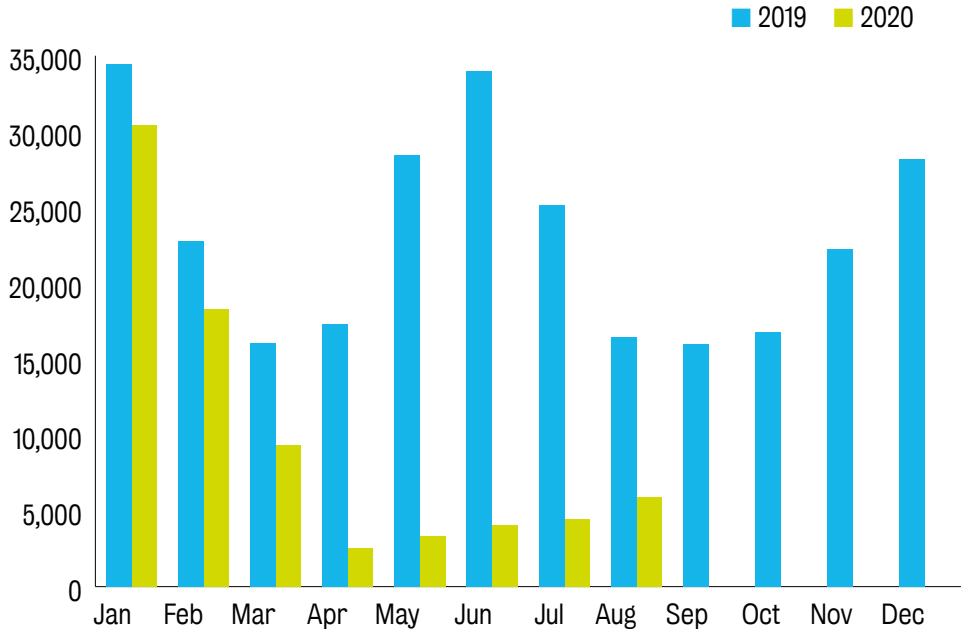


Australia: a similar story

International education represents a large proportion of Australia's export income and is the largest source of and a significant supplier of jobs in Sydney and Melbourne. In 2019, the Minister of Education, Dan Tehan, noted that international education contributes A$37.6 billion to the economy, an increase of A$5 billion from the previous year.

Covid-19 has dramatically reduced the number of international students enrolling in Australian universities, in particular Chinese students, who represent 27 per cent of all international students. For the quarter ending in June 2020, 130 new international students arrived, while 22,820 international students left. This trend will likely continue. The drop off in numbers can also be seen through visa applications (see Figure 24).

FIGURE 24:
INTERNATIONAL STUDENT VISA APPLICATIONS IN AUSTRALIA, 2019–20[118]



The education sector in Australia is predicted to lose A$19 billion in student revenue and fees by 2023 as a result of declining international student enrolment. An additional A$20–38 billion could be lost in related income for Australian businesses, adding up to A$30–60 billion in lost income and potential job losses of 21,000.

Conclusion

Over the past two decades the UK has made significant strides in attracting Chinese students to UK HEIs. Students from China report very high rates of satisfaction with their courses and are among the least likely to drop out. International private schools in China, which act as a pipeline to universities in the West, are seeing continued demand and are becoming increasingly common across China. In addition, students from China report very high rates of satisfaction with their courses in the UK, and are among the least likely to drop out. Yet, as described throughout this chapter,

there are a number of factors negatively affecting Chinese student enrolment in the UK. The increasing quality and capacity of Chinese universities, long-term shifts in behaviour as a result of Covid-19, and early data showing the decreasing value of an international degree in China, are all factors which policymakers should continue to monitor as they seek to attract the next generation of Chinese students.

4. China's reshaping of the global HE system

Key messages:

- China aims to build its HE capability through the BRI, the overarching strategy for international trade and economic cooperation with partner countries. Estimates suggest that about two-thirds of China's international students, around 317,000 in 2017, hail from its BRI partners.

- China's investment in science and R&D is at the heart of its approach to delivering a world-class global HE industry. The country is projected to overtake the US as the world's leading investor in R&D by 2022, with a focus on areas of competitive advantage in technology. These include artificial intelligence, quantum information, integrated circuits, life and health science, neural science, biological breeding and aerospace technology.

- The Chinese Scholarship Council offered around £380 million to foreign students wishing to study in China under its National Scholarship Fund (NSF) in 2018, including awards given to around 10,000 students from BRI countries. The country continues to attract a growing number of students from overseas (international enrolments rose from 52,000 in 2000 to almost 500,000 in 2018).

- China's strategic ambition to become a global powerhouse in HE is supported by the global spread of Confucius Institutes, which offer Chinese language and cultural teaching in almost 550 universities across the globe.

- Barriers prevent China from supplanting the Western-centric international order in higher education, including the lack of institutional autonomy and academic freedom, language barriers and the ongoing impact of broader geopolitical struggles, as evidenced by the tensions around trade, technology security, and democracy and surveillance.

Although the domination by Chinese students of the international HE market is frequently commented upon, there is considerably less focus on the increasing numbers of international students travelling to China. According to data from China's Ministry of Education, these figures increased seven-fold from 52,150 in 2000 to 397,635 in 2015.[119] This trend is an integral part of China's strategic aspirations for the coming two decades and is, therefore, significant to the UK HE's own objectives regarding international student numbers. Drawing on China's expansive network of international relationships through the BRI, the country is quietly reshaping the global education system through its efforts to attract students from across the globe, shifting the international student market's centre of gravity away from the UK and North America. This chapter examines the evidence of growth in HE enrolments in China from international students, including those from the UK and countries with signed BRI Memoranda of Understanding. It demonstrates how this trend reflects China's broader ongoing strategic commitment to becoming a global HE powerhouse in market share and R&D. Finally, it will explore the forecasts for international enrolment in China and remaining barriers preventing China from supplanting the current axis of US and Western dominance in international HE.

Domestic investment in HE is a strategic priority for the CCP

Growth in HE enrolments in China from overseas students

The number of international students in China has increased markedly over the past two decades. According to data from China's Ministry of Education, these figures increased seven-fold from 52,150 in 2000 to 397,635 in 2015.[120] By 2018, this number had increased further to almost 500,000 international students.[121]

TABLE 12: NUMBER OF INTERNATIONAL STUDENTS IN CHINA BY COUNTRY OF ORIGIN, 2018[123]

Rank	Country	Number
No.1	South Korea	50600
No.2	Thailand	28608
No.3	Pakistan	28023
No.4	India	23198
No.5	United States	20996
No.6	Russia	19239
No.7	Indonesia	15050
No.8	Laos	14645
No.9	Japan	14230
No.10	Kazakhstan	11784
No.11	Vietnam	11299
No.12	Bangladesh	10735
No.13	France	10695
No.14	Mongolia	10158
No.15	Malaysia	9479

Almost 60 per cent of these students came from Asia, with South Korea, Thailand, Pakistan and India sending the greatest number of students to study at Chinese universities. 16.6 per cent of international students came from Africa, 15 per cent from Europe and 7.3 per cent from the US.[122]

Similar trends are also evident in student migration from the UK. Recent evidence shows a 17 per cent year-on-year growth in the number of students spending short periods in China as part of their studies at a UK university.[124] In 2017–18, China hosted the most TNE students from the UK (those enrolled in a HE degree programme, which leads to a domestic qualification but is based in a country outside the home country) across the world (75,925, or 10.9 per cent).[125] In addition, China now ranks 9th as a destination for UK students studying full degrees abroad.[126]

> “...two-thirds of China’s international students ... hail from countries that have partnered with China through the BRI

The role of education in the BRI

China’s appeal as a powerhouse for HE is best observed in relation to its broader strategies of international trade and economic cooperation. As of March 2020, 138 countries had signed Memoranda of Understanding with China, as part of the BRI, including 18 members of the EU.[127]

While much of the initiative focuses on major infrastructure development, the “soft infrastructure” of education is a central part of China’s vision for the evolution of the BRI.[128] In July 2016, the Ministry of Education released the Education Action Plan for the BRI, which acts as a blueprint for building educational links across the network. The document references three priority areas for cooperation.

The first centres on improving educational connectivity through coordination of education policy, the mutual recognition of academic credits and an increase in the number of joint degrees. It also refers to the simplification of visa application processes for students from BRI countries and the establishment of joint research labs and international technology transfer centres with BRI counterparts. Another key element is the expansion of Confucius Institutes and Confucius Classrooms to break down language barriers between nations, with plans to increase the number of Mandarin teachers in countries with a BRI agreement.[129]

The second area describes deepening cooperation on the cultivation and training of talent, including the introduction of the Silk Road Scholarship to support the training of technicians along the BRI routes. A number of teacher exchange programmes, efforts to “turn China into a popular destination for students from the Belt and Road countries” and national scholarships for Chinese students who study in BRI countries are also described.[130]

The third area references work to establish “concrete mechanisms of cooperation”, through international organisations, like UNESCO, and bilateral and multilateral mechanisms of cooperation, such as the Shanghai Cooperation Organization, the China-Arab States Cooperation Forum, and the China-Pakistan Economic Corridor.[131] It also outlines proposals for the coordination of education assistance

packages in the least-developed countries along the BRI routes, with a particular focus on "South-South Cooperation".[132]

As a result of this plan, about two-thirds of China's international students (317,000 in 2017) hail from countries that have partnered with China through the BRI.[133]

Chinese universities are now thought to be producing nine times more graduates than the US in science and technology-related subjects

As was first outlined in the 2016 Education Action Plan for the BRI, and subsequently in China's more recent Education Modernisation plans, the country aims to further deepen education links by increasing international education in Chinese culture and language, and the number and quality of institutions run in partnership with other governments. To support this, the Ministry of Education's budget increased by 36 per cent for outbound study abroad funding and 18 per cent for inbound study funding in 2019.[134]

These strategies suggest that China is committed to the internationalisation of its HE system, developed and delivered as part of a wider set of policy objectives, through which it aims to project its interests across the globe and capture an ever-larger share of a highly competitive market for international students. China is delivering on this strategic commitment through its increasing share of global R&D spending, growth in the number of scholarships for international students in China and Chinese students overseas, its commitment to international partnerships, and efforts to formalise the mutual recognition of qualifications through international partners.

China's approach to delivering a world-class global HE industry

China's increased share of global R&D spending and investment in science

As chapter 1 shows, science and technology are central to China's increased presence in international HE. Chinese universities are now thought to be producing nine times more graduates than the US in science and technology-related subjects,[135] China is estimated to have spent US$658 billion on R&D in 2018, and it is projected to overtake the US as the world's leading investor in R&D by 2022.[136]

The fifth plenary meeting of the 19th CPC Central Committee, which took place in October 2020, indicated that investment in R&D would continue as a strategic priority for the CCP in the 14th five-year plan, due to be published in Spring 2021. Observers expect the plan to focus on seven areas of competitive advantage in technology: artificial intelligence, quantum information, integrated circuits, life and health science, neural science, biological breeding, and aerospace technology. China has already made significant strides in many of these fields. For example, R&D expenditure by Chinese pharmaceutical firms rose from around US$5.5 billion in 2014 to around US$7.5 billion by 2017.[137] In addition, five out of the 10 largest biotechnology firms providing initial public offerings (IPOs) in 2019 were based in China.[138]

As outlined in chapter 3, the Double First Class Initiative is already active in ensuring that the rapid scaling of the country's R&D capability across its top universities is squarely focused on these areas of critical national importance.

The increase in R&D spending will also likely further propel Chinese universities up the global rankings of elite universities. The Times Higher Education World University Rankings grouped performance indicators into five categories for its 2020 publication. These were: Teaching (the learning environment); Research (volume, income and reputation); Citations (research influence); International outlook (staff, students and research); and Industry Income (knowledge transfer).[139] Research constituted 30 per cent of a university's overall score. As China's research output increases and Chinese universities continue to climb the global league tables, the country may become increasingly attractive as an HE destination for domestic and international students alike.

> The development of transnational partnerships between international universities is key to China's strategy to boost its HE power

Scholarships for international study

The CCP has supported the prioritisation of HE by significantly increasing the number of scholarships available for international students in China and Chinese students overseas, particularly in countries with a signed BRI Memorandum of Understanding.

The CSC offered around £380 million to foreign students to study in China under its NSF in 2018.[140] These scholarships covered tuition, accommodation costs and a monthly stipend, though students were not permitted to leave China for more than 15 days at a time while in receipt of funding from the government.[141] Currently, almost 300 Chinese universities offer NSF scholarships to foreign students.[142] The CSC also includes the Silk Road Scholarship, which supports around 10,000 students from BRI countries studying in China, and has sought to further intra-Asia student mobility through the Jasmine Jiangsu Association of Southeast Asian Nations (ASEAN) scholarship programme.[143] Chinese scholarship programmes are also helping Chinese students to study abroad; in 2017, 66,100 Chinese students, 3,679 of them on government scholarships, studied in 37 BRI countries.[144] This is a 15.7 per cent increase in the number of Chinese students studying in BRI countries compared to the 2016 figures.[145]

Notably, tuition fees in China are similar for both domestic and international students, unlike in the UK, where fees are significantly higher for international students. At the University of Oxford, for example, international students are charged between £26,770 and £37,510 in tuition fees each year, while the equivalent figure at the University of Manchester is £21,000. This compares to fees of £9,250 per year for domestic students at both universities. In contrast, the Chinese Ministry of Education subsidised tuition fees for international students at a rate of 3.3 billion yuan (approximately £375 million) in 2018.[146]

International institutional partnerships

The development of transnational partnerships between international universities is key to China's strategy to boost its HE power. Three such partnerships have been established in Southeast Asia: Soochow University opened a campus in Laos in 2012, and Bangkok Business School was created in collaboration between the Yunnan University of Finance and Economics and the Rangsit University in Thailand.[147] Most notably, Xiamen University, a major research institution ranked in the top 600

global institutions by the Times Higher Education's World University Rankings, opened a campus in Kuala Lumpur, Malaysia, in 2016.[148]

Building on the work of the Forum on China-Africa Cooperation (FOCAC), a Sino-Africa Joint Research Centre is now operational in Kenya. Jomo Kenyatta University of Agriculture and Technology manages the day-to-day operations of the centre, which provides scientific research on biodiversity and ecology, and trains master's and PhD students.[149] It is managed by the Sino-Africa Joint Research Centre, which is overseen by the Wuhan Botanical Garden, Chinese Academy of Sciences and Jomo Kenyatta University of Agriculture and Technology. Broader alliances, between, for example, the University Alliance of the Silk Road and the University Consortium of the 21st Century Maritime Silk Road, have also both been developed with bases in leading Chinese institutions and an international network of partners.

"The CCP has sought to establish Confucius Institutes across the world to promote Chinese culture and language

Mutual recognition of qualifications

As detailed in the BRI Education Action Plan and subsequent documents, the CCP has pursued mutual recognition of academic qualifications internationally. A total of 47 agreements have been signed to date in support, including 24 agreements with BRI countries.[150]

China is pursuing institutional support for this goal. It has strongly advocated for UNESCO's Asia-Pacific Regional Convention on the Recognition of Qualifications in Higher Education, proposed in 2011 and enforced in February 2018, and is supporting efforts at UNESCO for a global convention to support the mutual recognition of qualifications.[151] The Global Convention on the Recognition of Qualifications concerning HE was adopted by the UNESCO General Conference in November 2019 and is now awaiting ratification by member states. [152]

Confucius Institutes

The CCP has sought to establish Confucius Institutes across the world to promote Chinese culture and language, supported by China's Ministry of Education. As of June 2018, there were almost 550 Institutes internationally, including 135 Institutes across 51 BRI countries[153]and 29 in the UK.[154] While most form part of established universities, Confucius Classrooms also operate at secondary school level, with a presence at three UK schools and in the Chicago Public School system.

The role of Confucius Institutes has, however, been somewhat controversial. In early 2020, the University of Maryland chose to close its Confucius Institute, following the introduction of the 2019 National Defense Authorization Act, which required schools to choose between maintaining their Confucius Institutes or accessing language funding from the US Defense Department.[155] Commentary from Human Rights Watch suggests that at least 29 of more than 100 US universities have closed their Confucius Institutes over the past six years, mostly after the passage of the Defense Authorization Act.[156]

Barriers preventing China from supplanting the US and Western HE systems

Reputational risk, research integrity and ethics

The CCP has, through increased R&D spending, BRI partnerships and scholarships, demonstrated its commitment to the internationalisation of its HE system and, over time, China and the West have become increasingly closely linked. As collaboration between UK and Chinese HE has become more common, however, concerns around institutional and reputational risk and issues of research integrity and ethics have increasingly been raised. While these concerns might apply to any transnational collaboration, regardless of the country of origin, research ethics and integrity have been particularly prominent in commentary on the relationship between China and the UK.

> Reputational risks associated with China-UK collaborations, if managed properly, may be mitigated

A number of high-profile cases regarding the nature of China's relationship with international HEIs have been aired publicly in the media, reflecting poorly on the dynamics of Chinese partnerships. In one case, Newcastle University in Australia came under scrutiny from the Chinese consulate[157] and suffered heavy social media backlash[158] when a lecturer listed Hong Kong and Taiwan as separate territories. This event has been used as an example to raise concerns around self-censorship and the limits of neutrality in Chinese-related teaching and research.[159]

Chinese HEIs, and partnerships with China, are also criticised for their state-sponsored, rather than autonomous, nature, which can affect the type of research being conducted, impacting on the researchers and research partnerships involved. The relationship between Cambridge University and Huawei, for example, sparked a media storm and accusations of "reputation laundering"[160] when the almost-entirely Huawei-funded white paper on global governance reforms in communications and technology presented the firm in a favourable light. The adoption of clear risk management strategies and guidelines around funding and the strategic or perceived influence of research partners could limit the occurrence of similar incidents in the future. Any guidelines "should spell out clearly and without naivety the risks, and opportunities, of doing work with China and on China [and] should also offer some ideas on how to manage issues such as demands from Chinese partners".[161]

Reputational risks associated with China-UK collaborations, if managed properly, may be mitigated. However, cultural differences between UK and Chinese HE, in research standards, ethics, and professional expectations, may continue to provide challenges. A small body of literature has reviewed issues around research ethics in China, including data fabrication, data falsification and plagiarism.[162] [163] While the number of peer-reviewed papers by Chinese researchers being indexed in the Web of Science overtook the UK in 2008, China also produces a disproportionate amount of fraudulent, plagiarised or fake peer-review papers.[164] This has in a large part been attributed to pressures for publication and output.

Lack of institutional autonomy and academic freedom in China

As mentioned above, the lack of institutional autonomy and resulting limits to academic freedom are of common concern and may constrain China's development as an attractive HE destination students and research academics, and institutions

looking to form partnerships in the country. In 2019, the Australian government published a comprehensive set of guidelines designed to protect its university sector from overseas interference.[165] Focused on governance and risk frameworks, due diligence, communication, knowledge-sharing and cyber security, the report offers a range of questions designed to help universities assess emerging risks from foreign interference in research projects. A staff report from the US Senate's Homeland Security and Governmental Affairs Committee, entitled *Threats to the US Research Enterprise: China's latest talent recruitment plans*, and a subsequent subcommittee hearing, with evidence from both security experts and researchers quickly followed the Australian guidelines.[166]

> Fears around academic freedom through partnerships with China are not unfounded

Concerns around the security implications of academic collaboration have also been raised in the UK, with the Commons Foreign Affairs Select Committee warning that the government's current focus on protecting universities from intellectual property theft and the risks arising from joint research was insufficient. It should, the report argued, place a broader focus on preventing financial, political or diplomatic pressure which seeks to shape the research focuses or academic curricula of UK universities.[167] As part of the UK's response, UUK issued detailed guidelines to combat the risks of international collaboration. This includes strengthening existing frameworks and introducing new policies to protect students, for example, by introducing the Chatham House rule to seminars and allowing students to submit coursework anonymously.[168] China is not named explicitly in the report.

Pascal Lamy, former Director-General of the World Trade Organization (WTO), echoed these concerns: "If you collaborate with China, the question of who has the leadership is, I think, quite easy to answer... If you want to collaborate on something with China you better watch that you can hold reasonably firm the terms of some kind of arrangement that benefits both [countries]".[169] Whilst his statement highlights the increasing focus of governments and institutions on mutually beneficial agreements, China's ability to create international HE links will likely be limited without compliance to a broad international framework of collaborative norms.

Fears around academic freedom through partnerships with China are not unfounded; a 2018 survey of over 500 China scholars across the globe, for example, concluded that "repressive research experiences are a rare but real phenomenon, and collectively represent a barrier"[170] in establishing the country as a true international power in HE. 26 per cent of scholars conducting archival research had been denied access to archives,[171] five per cent of respondents reported difficulty obtaining a visa, and around 9 per cent reported having been "taken for tea", a euphemism for being monitored and questioned by Chinese state officials.[172] The study also notes that "the risks of research conduct in China are uncertain, highly individualized, and often not easily discernible from public information".[173] This makes the choice to pursue a sensitive research project a very personal one.[174]

Students, as well as scholars, face pressure from Chinese government officials. Chinese Student and Scholars Associations (CSSAs) operate in universities across the UK and the US and aim to maintain "close connections with the intellectual community in China and other CSSA members across the world".[175] CSSA membership is now reportedly mandatory for Chinese PhD students overseas

and CSSA chapters have close links to embassies, with named consulate officials communicating government information to association presidents.[176] Former CSSA presidents in the US reportedly felt uncomfortable with "what they felt was growing ideological pressure from the embassy and consulates",[177] including requests for them to distribute pro-CCP materials and hold events to coincide with CCP activity. Embassies and consulates also regularly fund CSSA chapters, and presidential candidates for the Southwest CSSA, the umbrella organisation that oversees all CSSAs on the West Coast of the US, require approval from the Chinese Consulate in Los Angeles.[178] Such examples demonstrate the significant level of control that Chinese government officials exert while students study abroad.

While some academics and students may face constraints set by Chinese officials, new CCP regulations may be disincentivising collaboration with international partners. Since 2017, foreign universities operating in China, including joint ventures where 49 per cent of the institution is controlled by a foreign university and 51 per cent is managed by a Chinese HEI,[179] have been required to establish an internal Communist party committee to gain approval to operate in the country. International universities operating within existing Chinese institutions and based on the Chinese model can gain approval in less than six months.[180] Approval for joint ventures, which maintain some of the processes and standards of their home market, can, however, take three to five years.[181]When set alongside broader limits on academic freedom and concerns over research integrity and autonomy, global partners will likely continue to view partnerships with China with nervousness. Without this trust, the ability for China to play a major global role in HE will be constrained.

> "...geopolitical tensions continue to spill over into HE

Language barriers

Mastering the language, necessary for higher-level study and life in China, remains a barrier for many students and academics pursuing closer ties with the country. While China is seeking to expand the numbers of people learning Mandarin and other major dialects through Confucius Institutes and other language programmes, and classes at joint institutions in China are often taught in English, language barriers remain an important challenge in building a globally competitive HE sector. At American universities, for example, enrolments in Chinese-language programmes dropped to around 52,000 in 2016, a reduction of more than 8,000 compared to three years earlier.[182]

Geopolitical tensions

Finally, and perhaps most critically, geopolitical tensions continue to spill over into HE. In recent years, a number of international academics have faced challenges in gaining visas and accessing archives and Chinese experts for interviews.[183] The tense nature of relations between China and the West, linked to trade, technology security, and democracy and surveillance, risk acting as an ongoing barrier to China establishing itself as an alternative to Western-dominated HE. The CCP's response to protests in Hong Kong, Huawei and the treatment of the Uighur minority have each become flashpoints for institutions looking to engage with China. With little sign that such actions by the CCP will subside any time soon, we can expect a toughening of the UK's relationship with China, with potentially significant implications for flows of Chinese students internationally and the establishment of China as an attractive destination for a new generation of global learners.

Conclusion

In its approach to HE in China, the UK should keep in mind the power and reach of China's own international HE programmes, which have the potential to reshape the global axis of power in HE and research. Of particular interest should be China's BRI, which provides an example of long-term strategic and well-resourced policy to promote China's HE system and its broader economic and diplomatic interests. Such developments also undermine bullish attempts to unilaterally disengage from China which assume the continued dominance of UK/US HE in both the international student market and R&D. Instead, policymakers should plan on the basis that China's HE capacity and market share will continue to grow, while proceeding with caution to ensure collaboration does not come at the cost of research autonomy, surveillance, or continued human rights abuses. New strategies can and need to be implemented to engage with some of the reputational risk, research integrity and ethical standard differences as outlined here.

5. Conclusions and policy implications

Over the last decade, China has become deeply embedded in the UK HE and research system. The benefits of international student mobility from China, and collaboration with Chinese institutions in scientific domains related to climate change and the achievement of the Sustainable Development Goals, are substantial. As geopolitical tensions mount, however, the risk of a backlash is becoming increasingly real. Disorderly disengagement would damage the UK university system, with significant costs for tertiary education and the performance of the UK knowledge economy.

What follows is a series of policy recommendations, intended to contribute towards the management of risks arising from the UK HE and research systems' relations with China:

1. The government should include HE policy in a flexible and pragmatic whole-of-government approach to China, enabling a principled defence of UK interests and values. 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. Given the evident benefits of working with China and the clear value of people-to-people links created through international study, severing ties would be unwise. Instead, the UK must manage and mitigate contingent risks, real or perceived.

2. The government should reaffirm that it has no plans to introduce limits on the number of genuine international students.[184] It should also rule out introducing caps on the numbers of international students from China or any other country. At the same time, it should recognise that reliance on significant tuition fee income from Chinese students to cross-subsidise loss-making research creates a strategic dependency and potential vulnerability. The Office for Students should be required to monitor this risk and ensure individual institutions have plans to mitigate it, including through recruitment diversification strategies.

3. The need for cross-subsidies from international student tuition fees should be reduced, by committing to progressively increasing the proportion of block grant and Quality Related funding in public research spending, as part of a detailed financial roadmap for achieving R&D spending of 2.4 per cent by 2027.

4. HE and research collaborations should feature prominently in new free trade agreements, to maximise the reach of the new Turing student mobility schemes and increase the number of collaboration-enabling science and technology agreements.

5. The new Office for Talent should be commissioned to make an assessment of the UK's dependence on overseas STEM postgraduates and introduce measures to boost the domestic STEM talent pipeline, including increased investment in funding for high-cost subjects such as science and engineering.

6. Universities should be assisted in diversifying their international student intake, by continuing to monitor and improve on the competitiveness of the UK visa offer, with respect to fees, processing times and post-study work rights, a critical factor in sustaining demand from countries such as India.

7. Systems should be introduced to track and regularly publish data relating to The Academic Technology Approval Scheme (ATAS) applications and rejections by country and subject, to allow greater transparency into overseas demand for postgraduate qualifications in sensitive science and engineering subjects.

8. A commitment to principles of open science, relying on the free exchange of unclassified fundamental research between scientists around the world, should be maintained, while strengthening controls over access to specific (usually national security-related) applications of fundamental research.

9. UKRI should provide the government with a more detailed picture of the UK's international collaboration. The science funding body should be required to measure and report annually on "brain circulation" into and out of the UK, and trends in academic research partnerships with foreign countries.

10. The constitution of a new government-sponsored entity, working with UKRI and the Centre for the Protection of National Infrastructure, should be considered, to contribute unique research and analytic capacity on foreign engagement risk and establish a unified point of contact about it for the research enterprise.

11. UKRI should be expected, as part of its horizon-scanning work, to publish an annual risk assessment of the UK's dependence on third countries across different areas of research and development, and to operate a traffic light system to warn policy-makers of overdependence in particular areas of research.

12. UKRI should undertake a full audit of current projects with China. It should also establish clear, common contractual arrangements for bilateral research, using a template agreed between UUK, UKRI and government, and require HEIs to use the common contractual framework (or explain why they do not). It should also work with regulators and funders in other liberal western democracies to create a common approach and set of standards for contracting with China.[185]

13. Steps should be taken to ensure a more transparent two-way flow of knowledge, supported by more reciprocal access and based on regular partnership visits to Chinese laboratories and schemes, with enhanced incentives to place UK researchers in China.

14. All registered HE providers should develop processes and mechanisms through which staff and students can report any concerns and receive support in relation to issues connected to conflicts of interest, research integrity, academic freedom and freedom of speech.

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For the appendix to this report, visit:
www.kcl.ac.uk/policy-institute/assets/appendix-the-china-question.pdf

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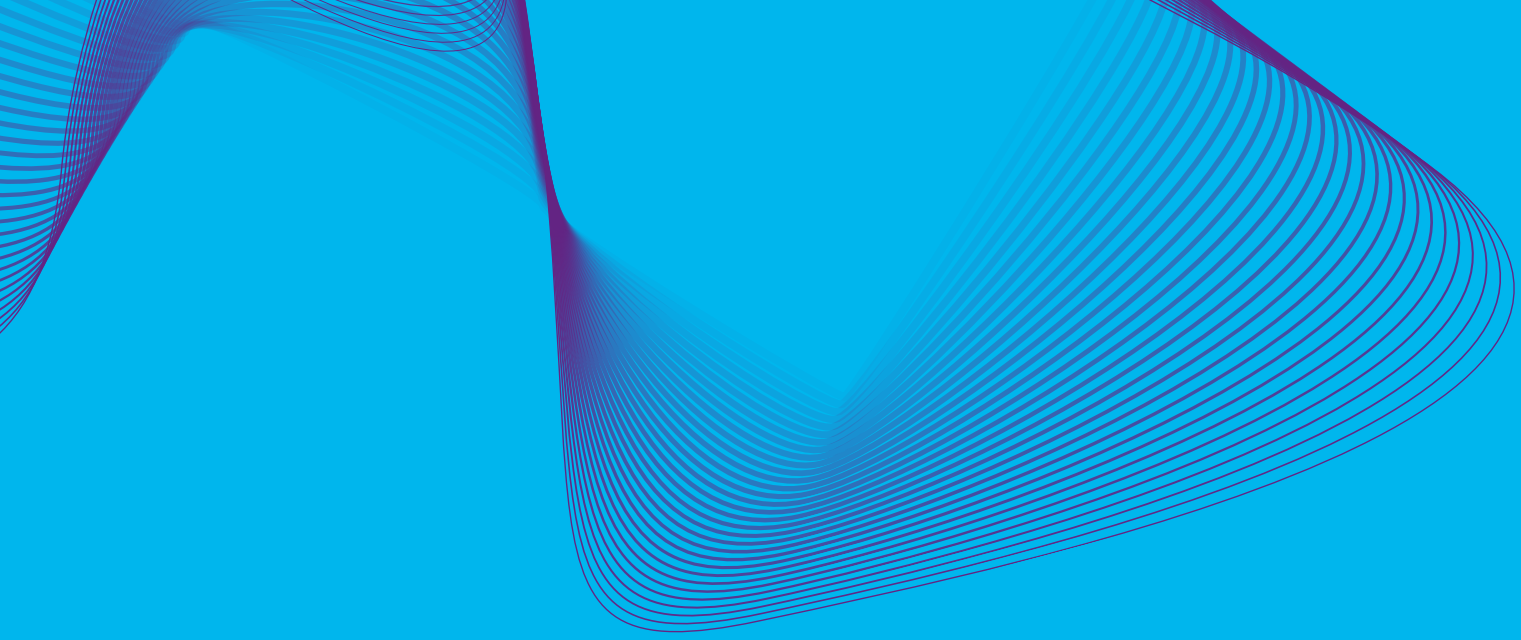
185. The authors are grateful to Edwin M. Truman, Senior Fellow at the Mossavar-Ramani Centre for Business and Government, for his insights.



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