COMMENT
FUTAO HUANG

QUALITY DEFICIT BELIES THE HYPE

Few Chinese researchers are regarded as global leaders, as the pressure for rapid output prevails.

China's president, Xi Jinping, wants the country to be a world-class innovator by 2050. To achieve this, there are major challenges for the country to overcome — significantly, the quality of its research.

Figures from the United States' National Science Foundation showing China's published science output surpassed that of the US in 2016 have been widely discussed, but other metrics prove celebration is premature.

Data from China's Ministry of Science and Technology suggest that, despite the rapid growth in articles authored by Chinese scholars in the Science Citation Index (SCI) over the decade to 2017, the average number of citations for each article was only 9.4. This is lower than the global average of 11.8, putting China in 15th place by this measure. The SCI tracks articles in high-impact journals.

Tu Youyou, awarded the Nobel Prize in Physiology or Medicine in 2015 for her discovery of a novel therapy against malaria, is the only scientist to have won the prize for research carried out in mainland China. Few Chinese researchers in the 'hard sciences' are regarded as global leaders in their fields compared with researchers in the US, or even Japan, which has much lower output. According to the closely watched Chinese ranking website Netbig, even China's leading laboratories or centres of excellence in such flagship fields as materials research, metals research and chemistry, including those affiliated to the prestigious Chinese Academy of Sciences (CAS), are not ranked among the world's top 10.

Among the reasons is that China's method of evaluating academic research performance values rapid publication output and quick research outcomes over high-quality research with long-term benefits.

My interviews with 19 young researchers and scientists in China over the past two years confirm the pressure they felt to publish articles in SCI journals as quickly as possible. If they don't publish at least half a dozen such articles, and obtain national-level research funding as a principal investigator within their first five years as researchers, they have little hope of being hired as a tenured associate professor or equivalent at a top university, let alone at CAS or the Chinese Academy of Social Sciences.

These evaluation systems have also led to the proliferation of research malpractice, including plagiarism, nepotism, misrepresentation and falsification of records, bribery, conspiracy and collusion. While these problems are not unique to China, the central government's requirement that institutions commit to clear-cut targets for positions in major global ranking systems such as QS or Times Higher Education within a stated time period, mainly by publishing articles in indexed journals, sets China apart. Because institutions and individual researchers stand to benefit greatly from elevating their reputations, no severe punishments have been imposed for academic corruption and malpractice, compared to the US and Japan, although reforms imposing stronger sanctions were announced in May.

Local universities, in particular, view publishing articles in SCI journals as a way



COMMENT
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CITATIONS STRENGTH BEGINS AT HOME

The increasing production of papers and a propensity to cite compatriots makes China likely to win the referencing race.

Nations pride themselves on their research activities, using a variety of indicators to size up their scientific capacity and strength against those of close competitors. Spending on research and development, in which China is now second only to the United States, and publication output, in which China overtook the US in 2016, are closely tracked metrics.

These indicators have drawn global attention to the rapid rise of China and its challenge to the science leadership of the US. Our analysis suggests that China is on a trajectory to dominate citations also, due to tendencies to recognize the work of one's fellow citizens.

On citations, the US has long cornered the market, accounting not only for the lion's share but a disproportionate number of the top 1% most highly cited science and engineering papers. While Europe has been slowly gathering a larger share of the highly cited papers, the biggest growth has been from China, whose papers went from below to just above world average in the last decade. If the trajectory continues, China will outpace the European Union in its production of highly cited papers within the next decade or so.

Similarly, there remains a gap in terms of overall citations: the share of all cited references made to US papers, although decreasing steadily since the mid-1990s, remains slightly higher than that of the EU-28, and far above China, which accounts for only about 6% of all cited references.

This gap is likely to close, given the significant role that patriotism plays in referencing behaviour.

SELF-REFERENTIAL

While many words have been devoted to the self-citing practices of individuals, less is known about the degree to which citations stay close to home at the country level. Although the US and United Kingdom garner a large share of global citations, all countries cite themselves disproportionately. This remains true even when controlling for author-level self-citations.

For the EU, as an example, 40% of all references made and citations received are from other European countries. The US, on the

to boost their reputation, while gaining bigger budgets, winning research grants and attracting subsidies from local authorities. My interviews with dozens of researchers have confirmed that lesser institutions pay approximately US$10,000 directly to individual researchers for publication of an SCI article. At least one university in Guangzhou pays authors approximately US$70,000 as a reward to go towards their future research for a research article published in *Nature* or *Science*. An author at a top university could receive a bonus of about US$900 for a published SCI article.

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Chinese scientists face a tough evaluation system.

STRICT CONTROL

The compulsion for Chinese science to serve the needs of economic growth and geostrategic intentions, as well as political ideology, also hinders the creation of an innovative scientific and technological ecosystem. Research supporting sustainable development, including on issues such as climate change, receives comparatively little attention.

Universities and disciplines singled out for special funding under the newly launched Double World-Class project of 2017 are expected to also focus on producing graduates dedicated to constructing a socialist society. There has been increased ideological control over research and more intensive monitoring of internet activity. An expectation that universities adhere to Marxism and take the pronouncements of Xi Jinping as guiding principles, without clear working definitions of the Chinese characteristics institutions should exhibit, restricts scope for innovative thinking, especially in humanities and social sciences.

A 2012 national survey of more than 3,000 full-time faculty members in Chinese universities revealed that only 3% of faculty members aged 31–40 years old are highly satisfied with their jobs. This is the lowest out of any other age group. My more recent national survey with Shen Wenqin of Chinese doctoral students in 2018 indicated that half of them worried about high stress, low salaries, job insecurity and the multiplication of evaluation systems in research. This is especially true in the 'hard sciences'.

According to my separate survey of almost 400 international faculty at Chinese universities in 2016–2018, including interviews with a dozen of them, among the steady increase in scientists coming to work in Chinese universities or research institutes from abroad, very few are top-level scientists, especially not foreign-born and -educated scholars, possibly because they are wary of the working environments described by local academics.

The government's research strategy should be designed to provide young researchers, including doctoral students, with a more favourable academic environment and more promising career future; to reform and improve the present frameworks evaluating scientific research; to let scientists more freely undertake research with international colleagues; and to recognize the role of academic corruption in holding back China's science. ■

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other hand, has tended to reference itself much more than the EU: between 1980 and 1996, 60% of references in US papers were to other US papers. However, the US is increasingly citing outside the country and, consequently, receiving a lower share of its overall citations from itself. US self-citations fell steadily from 41% to 33% between 1980 and 2013, though they've since gained a few percentage points to 37%.

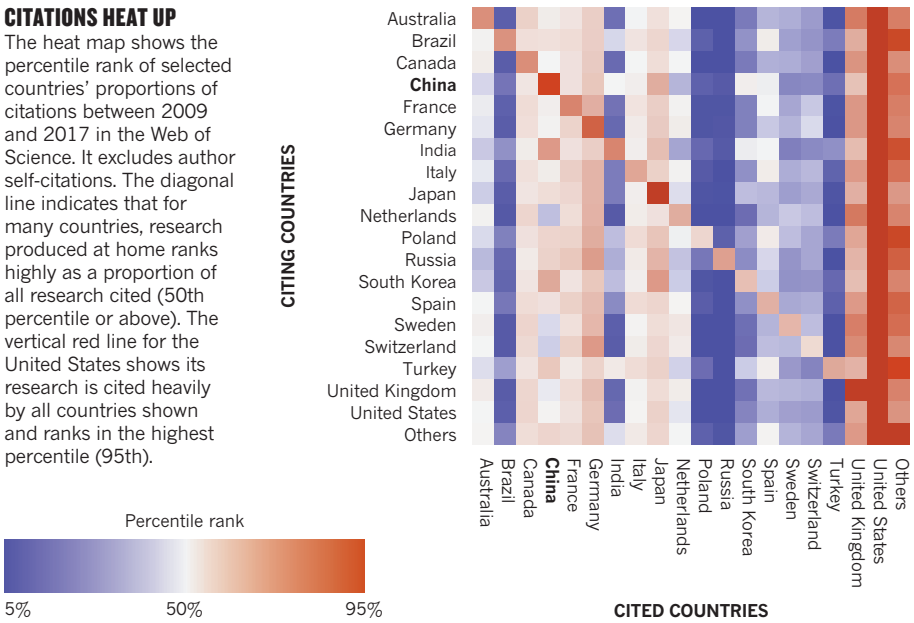
While China's self-references has remained low during the period of assessment, at under 20% of all paper references, Chinese researchers are increasingly citing work from other Chinese researchers. This has resulted in an increase in country self-citations from around 30% in the 1980s to 47% in 2015. China's self-citations as a share of total citations surpassed that of the US in 1999 and is now greater than the US self-citations by 10 percentage points.

The citation payoff is obvious. These trends reveal the tight coupling between paper production and citation: as a country increases production, and therefore a supply of potential references, the country is likely to rely on this capacity and occupy a greater share of the citation space.

Over the past two decades, China has experienced tremendous growth in terms of research investment and production, leading to a larger share of citations. China's increased production is likely to result in a dominance of citations in coming years, and is both a sign and consequence of its rapid maturation as a force in science. ■

CITATIONS HEAT UP

The heat map shows the percentile rank of selected countries' proportions of citations between 2009 and 2017 in the Web of Science. It excludes author self-citations. The diagonal line indicates that for many countries, research produced at home ranks highly as a proportion of all research cited (50th percentile or above). The vertical red line for the United States shows its research is cited heavily by all countries shown and ranks in the highest percentile (95th).



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CORRECTION

The legend for the graphic in the Nature Index article 'Citations strength begins at home' (*Nature* **564**, S70–S71; 2018) incorrectly stated that many countries cite research produced at home more than half the time. It should have said that for many countries, research produced at home ranks highly as a proportion of all research cited (50th percentile or above).