

China's extraordinary rise in science and how it will change the world

The nation is on a trajectory to lead the world in science, a development that will reshape technological advancement, innovation and the balance of global power. **By Xiaoying You**

China's President Xi Jinping is betting big on science. At a high-level meeting in Shanghai in April, he urged regional governments, universities and research institutes to strengthen the country's fundamental research.

"We must seize opportunities, rise to challenges, put basic research high on the agenda," he said.

Xi's directive is part of a broad and long campaign by China to up its game in science and technology. Just a month earlier, the country's leaders highlighted the importance of science in China's latest five-year plan.

That policy blueprint calls for substantial investments in fundamental research and innovation, and pledges to accelerate the development of frontier technologies, such as artificial intelligence, quantum applications and controlled nuclear fusion, by the end of this decade.

The fundamental-research push is China's latest effort to grow its scientific and technological might – a campaign that started nearly 50 years ago and has accelerated drastically since 2000.

In 1978, when it opened itself to the world, China had almost no scientific presence on the global stage. Fewer than 120 scientific articles in international journals, or just 0.02% of the global total, were published by researchers in the country, according to Elsevier's Scopus citation database.

But less than 50 years on, China has become a global scientific powerhouse and is on course

to lead the world in research and development (R&D). Currently, it is one of the largest R&D spenders, leads in the number of patent applications and dominates research of dozens of crucial technologies, such as nuclear energy and synthetic biology. Its universities and institutes are rivalling conventional academic giants in the West and have topped the Nature Index chart for the first time.

Beyond numbers and rankings, China's breakthroughs are commanding the world's attention, from developing game-changing AI models to successfully retrieving rock samples from the far side of the Moon for the first time.

And its meteoric ascent in science could even accelerate in the coming years. The country's current target is to raise its overall R&D expenditure, which includes the public and private sectors, by at least 7% per year between now and 2030, which is expected to translate into many billions of dollars of extra investments each year. This contrasts with forecasts for the United States, where President Donald Trump's administration is seeking to cut funding for science and, critics say, has weakened research capabilities.

"China has the potential to fundamentally change the global landscape of science production, technology competition and the geopolitical centre of gravity," says Yanbo Wang, a science-policy researcher at the University of Hong Kong. "For the West, if competing with Japan in the 1980s felt like weathering a storm, then China will bring a tsunami in the years to come."

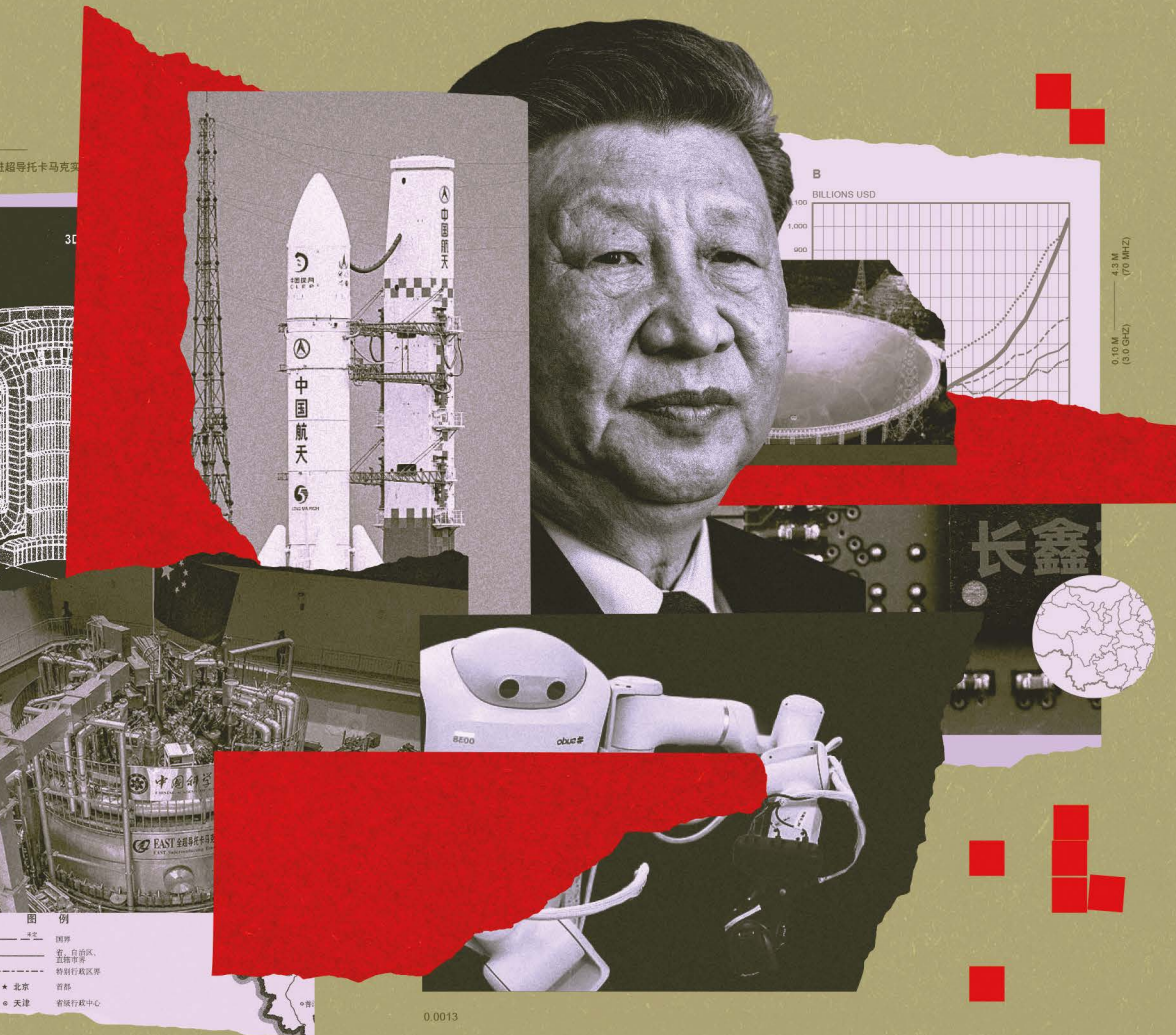
But before that happens, China will have



to deal with some systemic concerns in its research ecosystem. Critics say that the go-fast approach has led to a widespread scientific-misconduct problem, which the government has been trying to tackle for more than a decade. And two deaths that occurred during clinical trials last year have led to questions about the regulations and ethics in cutting-edge biomedical research. Other issues – such as the threat of a slowing economy and geopolitical tensions – could also put the brakes on advances in science and technology.

Rising R&D

For the past three decades, China's leaders have put science and education at the centre of the country's effort to boost its prosperity. The country's overall R&D spending increased by roughly 100 times during the period. Over the past ten years, its spending grew by more than 10% year-on-year on



average, according to statistics published by the Chinese government.

China's surge vastly outstrips spending increases in other nations, according to figures compiled by the Organisation for Economic Co-operation and Development (OECD). In 2024, China overtook the United States – a country widely considered the world's leader in scientific discovery and technology innovation since the end of the Second World War – to become the world's largest spender in gross domestic expenditure on R&D (GERD). The measure includes all spending by public and private sectors.

The OECD adjusted the two countries' GERD values using purchasing power parity (PPP), which takes into account the fact that goods and services in China are cheaper than they are in the United States. But China-based researchers warn against jumping straight to the conclusion that China is now the world's largest R&D spender owing to the

complexity of comparing the R&D spending of two nations. When adjusted by exchange rates, another way of doing the calculations, China's R&D spending was about half of that of the United States in 2024, compared with 8% in 2004, according to the OECD (see 'Money matters').

One of China's biggest advantages in scientific development is its ability to implement long-term plans and follow them through consistently, says Zhang Lin, a science-policy researcher at Wuhan University in China.

"China's centralized system allows it to focus resources on long-term scientific goals more effectively," Zhang says. China's leadership can sustain investments over long periods of time in strategic scientific areas, such as quantum communications, she says. By contrast, political changes in the United States can cause the country to pivot from one priority to another.

For many researchers, what matters isn't China's exact ranking but its strong upward

trajectory. China's ballooning R&D investment shows that it is trying to move from being a producer of goods to a producer of knowledge and frontier technologies, says Hao Bin, an economist at Xi'an Jiaotong-Liverpool University in Suzhou, China.

"Instead of competing mainly through its advantages in low labour costs, China is increasingly competing through its technological abilities, innovation ecosystems and the control of technologies," Hao says.

A clear example is China's long-term plan to develop its semiconductor industry, according to Hao. In 2014, China launched a state-backed investment fund to support the industry with an initial funding round of roughly 100 billion yuan (almost US\$16.3 billion at the time). The fund, combined with coordinated industrial policies, has enabled China to build its capabilities throughout the semiconductor supply chain, from designing chips to manufacturing chip-making equipment, Hao says.

Since the United States imposed a sweeping ban on the sales of advanced semiconductor chips to China in 2022, the Chinese government has stepped up its support, Hao says. The third round of the fund, launched in 2024, is expected to hand out 344 billion yuan (roughly \$50 billion) to companies in the semiconductor industry.

Other strategic areas that China has focused on are biotechnology and biomedicine. The government put a growing emphasis on the R&D of original drugs and translational medicine, which seeks to develop clinical treatments from fundamental research.

The AI race

In early 2025, a small AI company called DeepSeek sent shock waves through global markets when it released a large language model (LLM) that rivalled the performance of the dominant tools developed by US tech giants. DeepSeek, based in Hangzhou, China, achieved this breakthrough at a fraction of the cost spent by Western companies and using many fewer computing resources.

This type of innovation by a private company grew out of sustained support from the central government. Historically, state-run universities and research institutes led R&D efforts in China. But since 2010, when the government started a national campaign to nurture a group of 'strategic emerging industries' – which range from electric vehicles to pharmaceuticals – private firms have been playing an increasingly important part in driving the country's innovation.

"Companies have become more and more active in R&D in China because they realize innovation is key to securing more market shares," Hao says.

The Chinese government says it now hopes that private companies can play an even bigger part. Its latest five-year plan pledges to put more power and resources in the hands of such firms to improve the country's innovation, education and research ecosystems. The move stems partly from the R&D success that some Chinese companies have demonstrated in key technologies in the past few years, from batteries to AI, according to researchers.

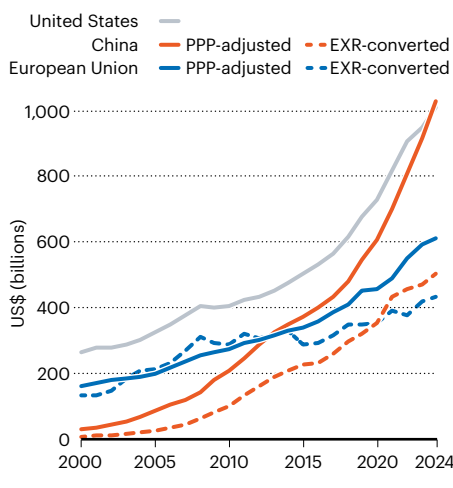
AI has served as a "confidence booster" for China in terms of where it stands in the global technological competition, says Meicen Sun, an information scientist at the University of Illinois Urbana-Champaign.

Space exploration is another area in which China has been gaining confidence. In 2022, it finished building its own space station, Tian-gong or Heavenly Palace, after three decades of planning and building.

That was a milestone for China's space programme, says Xie Gengxin, who studies environmental application in space at Chongqing University in China. "It means that China is now capable of conducting mid-to-long-term

MONEY MATTERS

China has surpassed the United States to become the world's leading spender in research and development (R&D) – when China's spending is adjusted on the basis of its purchasing power parity (PPP), a conversion that seeks to equate costs. But China's R&D spending still lags behind the United States when it is adjusted on the basis of exchange rates (EXR).



research in space," he says.

Another achievement for China was becoming the first nation to land a rover on the far side of the Moon. It intends to land astronauts on the lunar surface by 2030 and launch a mission to Mars in 2028 that aims to bring samples back to Earth three years later.

China now views building its progress in space research as a key national strategy, and Xie expects the government to channel plenty of resources into the sector, from finance to talent. Yuqi Qian, a planetary geologist at the University of Hong Kong, agrees that China considers its space exploration as a long-term effort to boost its technological sovereignty and national power, rather than a short-term geopolitical race to beat the United States.

"There is a narrative of an ongoing China-US space race in the US, but not in China," says Qian, who is participating in China's lunar and deep-space exploration programme.

Boosting basic research

China's staunch scientific support is in part driven by its effort to reduce technological vulnerabilities and dependence, Hao says. Global events in the past decade, such as the COVID-19 pandemic and the semiconductor restrictions imposed by the United States, exposed how relying on foreign technologies can become a strategic weakness for China, he says. During the pandemic, for example, many foreign experts left China and some scientific equipment could not be imported from abroad. This meant that the use of some technologies that relied on these specialists and equipment was affected, according to Hao. "So, R&D spending is increasingly serving as a national security goal."

One step China has taken since 2018 – when Trump launched a trade war on China in his

first term – is to boost its ability to make disruptive and original discoveries. This is widely considered a weak link in the country's scientific system.

China's goal is to significantly increase its global impact in fundamental research – which is intended to develop knowledge rather than specific applications – by 2035, and make China a "major global scientific centre and innovation highland" by the middle of this century, said China's State Council, the country's highest administrative authority, in 2018.

But doing that won't be easy. In 2024, funding for fundamental research accounted for just under 7% of China's overall R&D budget, compared with 14.4% in the United States, according to calculations by Chris Martin, a science-data analyst and president of the Explorative Science Foundation, a non-profit organization in Christchurch, New Zealand, based on data from the OECD. China also lagged behind two of its neighbours, Japan (at 11.6%) and South Korea (at 14.7%). Even though the number rose to a record 7.08% in China last year, it failed to hit the 8% target laid out by China's previous five-year plan that ended in 2025. The new five-year plan does not carry a funding target for it.

But, perhaps, a bigger obstacle is the country's academic culture, which makes it hard for individual researchers to pursue long-term, curiosity-based projects, researchers warn.

Chinese researchers are constantly assessed on the basis of the number of papers they publish in a selection of influential journals and the amount of national grants they secure.

"So, the number of papers coming out of China has been growing quickly in recent years," says Li Jizhen, a researcher of innovation policy at Tsinghua University in Beijing.

Although the government launched a big reform in 2020, in the hope of improving its academic evaluation system, the number of published papers is still being used widely by Chinese universities to determine staff recruitment and promotion, several researchers have told *Nature*.

China is now the top-ranked country or territory for the number of papers its researchers publish in influential journals, having surpassed the United States in 2023, according to Nature Index, which tracks 178 journals in natural, applied, social and health sciences.

"But a large volume of papers won't necessarily lead you to groundbreaking original discoveries that can win you a Nobel prize or a Turing Award, for example," Li says. "The question is how to free researchers from hitting quantity-based targets and allow them to confidently conduct long-term research that may or may not succeed."

The pressure to publish is also contributing to problems with research integrity in China, say some specialists who study this issue. A

Nature investigation of article retractions found that between 2014 and 2024, nearly 60% of retracted papers included authors with affiliations to China.

Science agencies in China have often tried to crack down on research misconduct; in the past few months, five senior Chinese academics have been disciplined after Student Geng, a blogger and former PhD student, flagged data anomalies in their published papers. The penalties came after their universities had launched investigations into their papers and found that the teams had committed academic misconduct.

These events have sparked heated discussions on Chinese social-media platforms about the root causes of data fabrication. The National Natural Science Foundation of China (NSFC), the country's main funding agency for fundamental research, punished four of the five scholars, together with some of their colleagues, in a misconduct crackdown in August.

Chinese researchers say that changes need to be made to the country's academic evaluation system, to encourage scientists to carry out time-consuming and original work without worrying about their career prospects.

New talent hub

Researchers who track scientific publication statistics say that trends over the past two decades reveal a profound shift in the global research landscape. Researchers outside China are now collaborating with Chinese scientists “by default rather than by exception”, Caroline Wagner, a science-policy analyst at The Ohio State University in Columbus, told *Nature* earlier this year. (Wagner died in June.)

China is no longer on the periphery of the global collaboration network; it has become a central hub, she added.

This is reflected in publication statistics: a growing portion of global collaborations is

now led by Chinese academics rather than their Western peers, according to a 2025 study that analysed nearly six million scientific articles (R. Wu *et al. Proc. Natl Acad. Sci. USA* **122**, e2414893122; 2025).

One of the factors that has helped China to grow its presence in global academic partnerships is the increasing number of foreign-educated Chinese researchers who return to China. “Returnees matter precisely because they carry the tacit knowledge that codified publications do not contain,” Wagner said. Capable scientists who would have stayed in the United States a decade ago are now in China, and the global collaboration network is rewiring around them, she added.

The number of scientists returning to China increased after 2018 when the United States launched the ‘China Initiative’, a policy that was designed to combat economic espionage and intellectual-property theft by Chinese government agents and ended in 2022. Almost 5,600 scientists left the United States and returned to China between 2018 and 2021, compared with roughly 6,860 between 2000 and 2017, according to a 2023 study led by Yu Xie, a sociologist at Princeton University in New Jersey (Y. Xie *et al. Proc. Natl Acad. Sci. USA* **120**, e2216248120; 2023).

The majority of Chinese students who study in the United States stay after graduation, according to the most recent data from the US National Science Foundation. In 2024, more than 79% of Chinese doctoral recipients in the United States intended to stay, which is similar to the percentage of people who stayed before a drop during the COVID-19 pandemic. But policies instituted by the Trump administration since early 2025 are making it more difficult for international students and researchers to enter and remain in the country (see ‘Student decline’).

Although Chinese scientists have cited a variety of reasons for going back to China, the nations’ growth and current US domestic policies have converged to form a push-and-pull effect that is encouraging them to return, according to researchers.

“Conditions in China, regarding both work and living standards, have been improving significantly over time. As a result, scientists have a greater incentive to work in China,” says Yu Xie.

“In the meantime, reception of Chinese Americans in the US has got worse, and government support for science in America has also declined. As a result, the incentive to stay in the US has declined,” Yu Xie says.

It’s not just returnees who are flocking to China. The country has been actively recruiting international students to its universities through its Belt and Road Initiative, China’s flagship global infrastructure and development programme.

Although China has many fewer international students than do some other countries,

such as the United States, the United Kingdom and Australia, that number is growing. Among the 380,000 international students who were studying in China in the 2024–25 academic year, 61.1% came from Asia, 16.2% from Africa, 15.6% were from Europe and 7.1% from the Americas and Oceania, according to China’s Ministry of Education.



SCIENTISTS HAVE A GREATER INCENTIVE TO WORK IN CHINA.

Universities across China have developed programmes, often featuring generous scholarships, to attract international students and researchers. Some of these programmes are designed to give students from a particular region a specific skill set that could benefit their own countries’ development. For example, Tongji University in Shanghai offers a master’s course in civil engineering for Kenyan students, and Tianjin University runs a special bachelor’s programme in marine science and technology for applicants from southeast Asia.

Chairina Hanum Siregar, a student from Indonesia, went to China to study developments in digital health at Sichuan University in Chengdu.

“Living and studying in China has allowed me to observe how technologies are being used in health care and how hospitals, patients and the general public react to the trend,” Siregar says. China represents the future of research, she says.

That’s a sentiment that echoes through laboratories and classrooms as China continues to build up its capacity for world-leading research. For China’s leaders, a key part of this strategy is to invest in young people.

The NSFC has said that it will increase funding for entry-level researchers in the country by sponsoring an extra 12,000 research projects from this year. The move reflects the government’s intention to reduce the pressure that young researchers are facing, says Tang Li, a science-policy researcher at Fudan University in Shanghai.

But it also sends a more profound signal. “If China wants more original basic research, it cannot rely only on established senior scientists and large strategic projects,” Tang says. “It needs a much broader and more diverse base of young researchers with the freedom to explore new questions.”

Xiaoying You is a freelance journalist in London.

STUDENT DECLINE

India, China and South Korea contribute the most students to the United States. The number from China has dropped by nearly 30% since it peaked before the COVID-19 pandemic. These figures include undergraduate and graduate students, as well as those working immediately after graduation.

