

China

Increased investment levels continue to signal China's intention of becoming a global research leader and structural reform has been implemented to encourage collaboration on the country's acute needs — such as clean energy.

ARTICLE COUNT (AC): **8,632**
 FRACTIONAL COUNT (FC): **6,323.43**
 WEIGHTED FRACTIONAL COUNT (WFC): **6,032.51**

As 2015 dawned, Chinese scientists sent images around the world of exotic marine life found while exploring the bottom of the ocean in the country's first manned deep-sea submarine. Jiaolong, the record-breaking submersible, capable of reaching depths of more than 7,000 meters, is a source of great pride. "Jiaolong marks a milestone as one of the major advances in China's marine technology," says physical oceanographer, Wu Lixin, of the Ocean University of China in Qingdao. Soon after Jiaolong's journey, the Chinese Academy of Sciences (CAS) and The European Space Agency put out a call for mission proposals for their joint robotic space mission, scheduled to launch in 2021. Both these adventurous forays are examples of a concentrated investment in Chinese science that began around the turn of the century.

Since then China has been accelerating science investment levels to match the spending commitments of other developed countries. The country's research and development spending has increased by an average 23% a year over the past decade, with a goal of reaching 2.5% of its gross domestic product (GDP) by 2020, up from 1% in 2000.

China's leaders have long-term plans to reap the practical benefits of research. A 15-year plan announced in 2006 committed the country to developing strategies for indigenous

innovation and set targets of turning China into a technology powerhouse by 2020 and a global leader by 2050. Goals outlined include limiting China's reliance on imported technology to 30%, and for the country to rank in the world's top five for invention patents and most cited scientific academic papers. China's recent leap into inner space and efforts to reach outer space show just how far the country has already come.

“RESEARCHERS INCREASINGLY SEE SCIENCE AS A MEANS TO IMPROVE SOCIETY”

IMPROVED PUBLICATIONS

The OECD Science, Technology and Industry Outlook 2014 biennial report predicted that if China continues on its high-spending trajectory, the country will overtake the United States in R&D spending by the end of the decade (it surpassed Japan in 2008 and the European Union in 2013). The outcomes of this investment are evident not only in technological achievement, but also in academic

research. In the 2014 Nature Index, China ranks second in publishing output — only behind the United States, but it out-published China by nearly three times. CAS, however, leads the world as the top publishing institution, beating second-place Harvard University by 1.5 times.

To further improve China's research output, Beijing has announced comprehensive structural reform to science policy. These changes aim to encourage richer collaboration and make the funding process more transparent. In October 2014, the government unveiled a radical overhaul of spending, which included establishing a new agency to unify the planning and assessment of scientific projects. A centralized platform for distributing grants will be introduced to replace the large, fragmented system currently overseen by 30 different departments.

In addition, the government is going back to basics on research funding. While China's total expenditure on research and development has increased rapidly, the portion of that devoted to basic research has remained less than 5% — insignificant compared to the 10–25% in many developed countries.

At the 12th National People's Congress in 2014, Premier Li Keqiang said that basic research spending would increase by 12.5% — to US\$6.6 billion — and would be directed

CHINA ANALYSIS

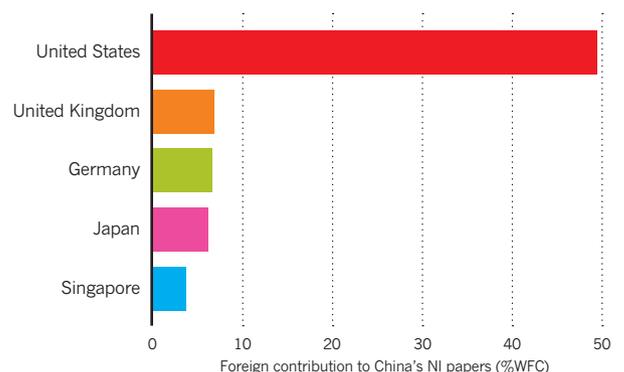
Top ten institutions

The Chinese Academy of Sciences' contribution to Nature Index (NI) was nearly five times larger — based on its WFC — than China's second largest contributor.

RANK	INSTITUTION	WFC 2014	AC 2014
1	Chinese Academy of Sciences (CAS)	1,303.86	3,114.00
2	Peking University (PKU)	291.45	932.00
3	Tsinghua University (TH)	205.48	605.00
4	Nanjing University (NJU)	201.91	469.00
5	University of Science & Technology of China (USTC)	190.96	536.00
6	Zhejiang University (ZJU)	188.39	349.00
7	Fudan University	162.89	343.00
8	Shanghai Jiao Tong University (SJTU)	106.78	281.00
9	Lanzhou University (LZU)	106.27	174.00
10	Jilin University (JLU)	101.87	184.00

Top five collaborators

Most NI articles with Chinese authors (70%) include no international collaborators. The USA accounts for almost half the contribution to papers with non-Chinese authors.



towards areas such as pollution, supercomputers and neurodegenerative disease. The recent drive to revitalize Chinese science follows decades of low spending that left China lagging. China's catch-up period may now be coming to an end: "In the next 15 years, Chinese science will switch to the period of performing original research and finally take over the leading position," predicts Lei Jiang of the CAS Institute of Chemistry, one of the nation's most influential scientists. Notably, 60.3% of China's publications in the 2014 Nature Index are in chemistry.

There are clear signs of a concerted push for more indigenous innovation in China taking place across the board, from basic research funding to industrial reform. The changes to China's central government funding framework should encourage scientists to put their creativity to more effective use, says Chen Liwei, a nanotechnologist at the Suzhou Institute of Nanotech and Nanobionics. "Chinese scientists are increasingly seeing the purpose of science as not just about the number of publications, but improving our society," he says.

CLEAN-AIR CHALLENGES

In fact, science could work to alleviate social problems in China. The country remains largely dependent on foreign energy, importing more than half its crude oil from overseas. Developing new cleaner energy sources and moving away from smog-producing coal-fired power stations is key to the country's future economic stability, meeting carbon targets and tackling air pollution. Sixteen of the world's 20 most polluted cities are in China. Beijing battled unusually thick smog in January 2013, a problem often seen in the two years since. However, less than 4% of China's 2014 scientific publications were in environmental science.

Government events and programmes have brought to light the concern over such environmental problems. At the Asia-Pacific Economic Cooperation summit in Beijing



The deep-sea submersible Jiaolong returns from hydrothermal vents in the south China sea.

last November, for instance, President Barack Obama and President Xi Jinping announced an agreement to stem the greenhouse gas emission levels of their two countries. As a result, Chinese scientists are looking for applied research solutions to help meet their leader's goals: to get 20% of its energy from non-fossil-fuel sources by 2030 — up from less than 12% in 2011 — and for its overall carbon dioxide emissions to start decreasing in the same year.

To combat air pollution, China's nuclear research community has been told to bring forward its deadline to build the first working experimental nuclear reactor to be fuelled with thorium rather than uranium. The \$350 million project based at the Shanghai Institute of Nuclear and Applied Physics started in 2014, and the government is pushing to see a finished product by 2024 — 15 years earlier than originally planned. It's a daunting challenge. Gu Zhongmao, an official at the China Institute of Atomic Energy, has pointed out that so-called fourth-generation reactors

remain troubled by technological issues that he says could take decades to resolve.

COMMERCIAL IMPACT

Some of the highest impact science is going on in the private sector. BGI-Shenzhen, the world's largest genomics research centre, having sequenced more than 57,000 human genomes, last year bought its biggest competitor, US-based Complete Genomics — a company that developed a custom-built genome sequencing platform, plus software that can be used to study disease treatment and prevention.

According to George Baeder, director of China Global Insight, there has been a marked increase in Chinese participation in the pharmaceuticals market. He says: "At a recent JP Morgan healthcare conference in San Francisco, by far the most impressive thing was the number of Chinese companies that clearly have aspirations in innovative medicine and bringing those to a global market." China is already the world's third-biggest pharmaceuticals market and sales have been growing by 25% each year since 2009.

At the research level, scientists are working more collaboratively to become leaders in key areas of pharmacological research. China has the world's second highest number of obese citizens — exceeded only by the United States. For the past year, Liu Feng, director of the Metabolic Syndrome Research Center in Changsha, has been working with partner institutes across the country to tackle the problem. Last year, Liu's team identified a key regulator that promotes the activation of brown and beige fat, which are more easily burned off by the body to produce heat. The finding could lead to better weight-loss solutions.

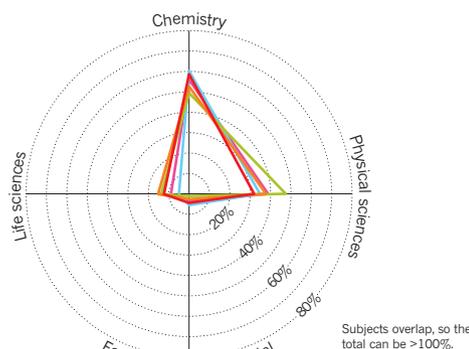
The combination of academic and industrial research, plus commercial successes, sets China up for further opportunities. It takes more than a few commercial successes to become a global leader in applied science and technology, but reforms underway could be just what it takes to put China at the front end of innovation. ■

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Institutional subject spread

All of China's top five institutions are strong in chemistry and physical sciences — in all cases accounting for more than 90% of the NI WFC.

- Chinese Academy of Sciences
- Peking University
- Tsinghua University
- Nanjing University
- University of Science & Technology of China



Nature and Science ratio

The percentages of China's NI publications in these top journals all lag behind the global average.

