
VIRGINIE BLANQUART/GETTY

The flow of the Shenzhen River mirrors the extraordinary dynamism of the city it passes, home to innovative manufacturers and a commercial transformation.

THE CHANGING FACE OF INDUSTRY

Amid fierce international competitiveness, governments at all levels are responding by orchestrating collaborations between industry and academic institutions.

BY DAVID CYRANOSKI

Like many nations, China is hotly pursuing innovation and the economic benefit of bringing ideas to the market. But China's drive to embrace an innovation-based economy in favour of its reliance on manufacturing is daunting. Most big companies are state owned and traditionally averse to funding research. Despite a dramatic increase in basic research output over the past two decades, only a small percentage is converted to industrial application.

Yet as Shenzhen, Beijing and Wuhan show, an industrial base built on cutting-edge science has matured quickly in some regions, often with local policy support. These cities host many of the Chinese corporations with the highest growth in research output published in the Nature Index's 68 high-impact journals between 2012 and 2014 (see 'Industry champions'). With a swag of intellectual property and revenue as proof, these regions are leading China in its quest for transformation.

SHENZHEN

WFC rank China: ***21***
AC: ***165***

Shenzhen, in the country's southeast, has had the most marked transformation to a research-based industry hub of any city in China, and probably the world. Just 35 years ago it was a fishing village; now it's a thriving metropolis that links Hong Kong with China's mainland. Companies based there account for almost half of the country's international patent filings.

Most of these filings are in telecommunications and electronics, with Huawei and ZTE leading the way. These two ICT multinationals, along with Shenzhen-based rechargeable battery-maker BYD Co., Ltd, boast China's three biggest patent portfolios.

Shenzhen is also home to the Kuang-chi Institute of Advanced Technology, a manufacturer of radar absorbent materials used in stealth technology. It was founded by a group of Chinese scientists returning from stints working in the United States.

Casting a broader net, the Shenzhen Institutes of Advanced Technology, one of the most industrially prolific units of the Chinese Academy of Sciences (CAS), has established collaborations with more than 150 companies during its 10-year history.

The genomics sequencing powerhouse BGI, in particular, has successfully melded basic research in Shenzhen with commercial operations. It's one of China's biggest contributors to high-impact scientific publications, holds some 400 patents and has another 300 pending. More than half are related to genes, especially in the areas of agriculture and rare human diseases. Another third relate to sequencing technology, and the rest are special applications. BGI also holds the crown for the Chinese company with the highest 2014 WFC. Indeed, it is in the world's top 20 corporate contributors to the Nature Index.

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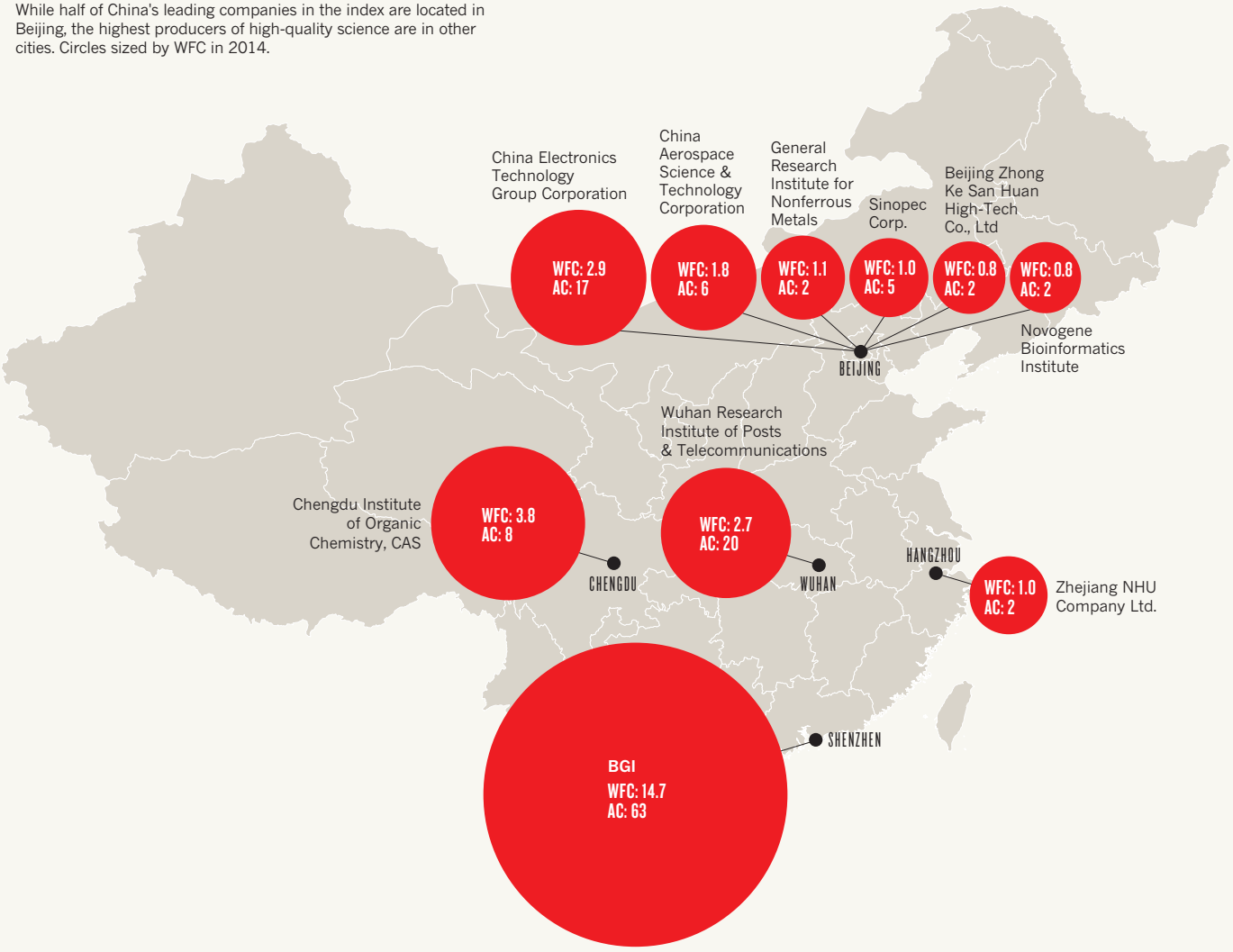
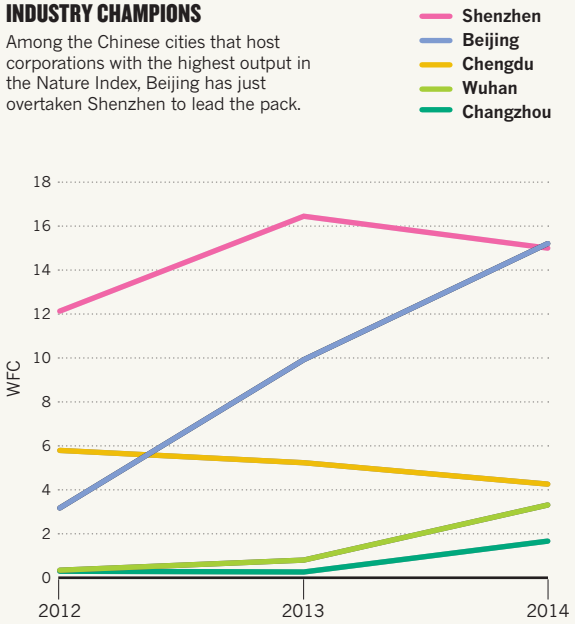
CHINA'S TOP 10

While half of China's leading companies in the index are located in Beijing, the highest producers of high-quality science are in other cities. Circles sized by WFC in 2014.



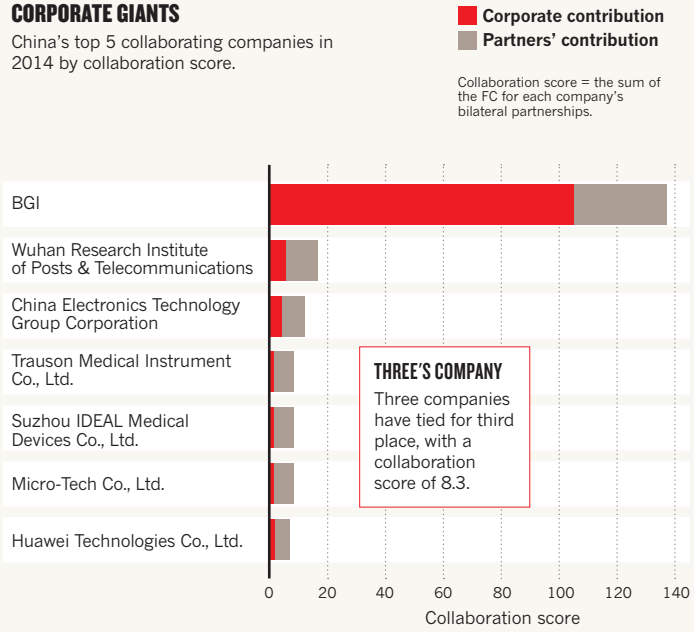
INDUSTRY CHAMPIONS

Among the Chinese cities that host corporations with the highest output in the Nature Index, Beijing has just overtaken Shenzhen to lead the pack.



CORPORATE GIANTS

China's top 5 collaborating companies in 2014 by collaboration score.



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BRENT LEWIN/BLOOMBERG VIA GETTY

Funding support for greener production improves conditions for car and battery manufacturer, BYD.

The success of BGI and other Shenzhen companies, says executive director of BGI Research, Xu Xun, has been bolstered by the city's history as China's first special economic zone in 1980, an initiative that made it easier to start a company and interact with foreign companies. "In other cities, many companies are founded by or supported by the government. Patents are not important for them," says Xu. "Here, there are a lot of private companies and they need intellectual property so we put a lot of effort into it."

BGI is presently celebrating the first harvest of a drought-tolerant millet strain that was bred on the strength of discoveries from a sequencing project at the company. BGI hopes this new millet will find a large market in a China where there are increasing concerns about water resources. BGI will also expand into the clinical sequencing market with a new line of desktop sequencers, trying to take advantage of China's move towards personalized medicine.

The Shenzhen government uses the number of patents as one measure of a company's value to the city, with companies deemed significant enjoying benefits such as special fast-track approval processes. It also gives annual awards for the most impressive innovations. "We get pressure to have good intellectual property both from the government and from our needs as a private company," says Xu. "Shenzhen always finds ways to support innovation."

BEIJING

WFC rank in China: 1
AC: 5,163

While Shenzhen might have flexible rules and an entrepreneurial environment, Beijing has its own advantages to make it a bustling and innovative industrial centre, says Jin Qinxian, head of the technology transfer office at Tsinghua University. The city's numerous universities — most notably Tsinghua and Peking University — and a slew of institutes either independent or affiliated with the CAS have provided fertile ground for technology transfer. "The history, the culture, the number of institutes and universities make Beijing very powerful," says Jin. Beijing also has a number of highly talented, internationally renowned researchers who have returned from working or studying abroad.

Among their number is Wang Xiaodong, a former Howard Hughes researcher at the University of Texas Southwestern, in the United States, who designed and now directs the National Institute of Biological Sciences in Beijing. He also founded BeiGene, a company with several large and small molecule cancer treatments in development and which received US$97 million in financing this spring. It has already partnered with Merck Serono on two drugs. Beijing also has a sequencing company, Novogene, run by an ex-BGI employee, and now competing with BGI. Novogene rounds out the top 10 Beijing companies with the highest 2014 WFC (see 'China's top 10').

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Tsinghua, which ranks first for research funding in China, has a particularly rich field of scientists active in commercialization, transferring technology that has helped China become a leader in carbon nanotubes and high-speed computing. It has also contributed to a broad range of biomedical breakthroughs including cancer biomarkers and medical devices such as pacemakers.

Many of these are interdisciplinary projects. A team led by chemical engineer Dehua Liu, for example, designed a new enzymatic process for converting renewable oils and fats to biodiesel. A bioenergy production plant is now pumping out 20,000 tons of biodiesel per year — a figure that will jump five-fold next year — and the technology has been transferred to companies in several countries, including Germany and Brazil.

In 2014 alone, Tsinghua had 2,010 domestic patent applications (1,360 of which have been accepted) and 264 more in the United States. It received 150 million RMB from 61 transfer or licensing agreements.

Specific local programmes help, says Jin. Beijing's municipal government provides start-up funds in exchange for shares in the companies. It also nurtures companies with initiatives such as making the first purchase order for products, before they are even proven, from Beijing firms.

But what has really pushed the city's industrial blossoming are the rich human resources, concentrated especially in the massive Zhongguancun industrial zone and technology hub that neighbours both Tsinghua and Peking universities. "Companies come and they get access to students, to laboratories, to professors," says Jin.

WUHAN

WFC rank China: 4
AC: 619

Wuhan is one of the fastest growing cities in China in terms of the scientific output of its corporations, and it is quick to capitalize (see 'Industry champions'). The Huazhong University of Science and Technology (HUST), for example, has a long list of successful spin-off companies based on optical fibre development for high intensity laser and 3D printing. With the success of research intensive companies such as Huagong Tech, which produces lasers, holograms, and optical communication devices, and Guide Infrared, which manufacturers a cutting-edge night vision camera, Wuhan has taken a place at the forefront of China's optoelectronics and telecommunications boom.

Tang Jiang, a thin-film photovoltaics researcher at Wuhan National Laboratory for Optoelectronics, says the presence of many leading universities in Wuhan, such as HUST, which ranked 19 in engineering in the *US News* global survey of universities, has played a major role in gearing up this industrial output.

Tang's institute has several examples of technology transfer, including blue photoluminescent materials for organic light-emitting diodes (OLEDs), a UV lighting diode used for solidification in printing and a 'micro-optical tomography system' for brain imaging.

Local government policies have promoted technology transfer from universities, establishing a requirement that a research team receives at least a 70% share of the technology transfer profit. "These policies significantly encourage professors in universities to focus on application orientated research and the consequent technology transfer," Tang explains.

Tang has yet to commercialize his own research, infrared photodetection and the creation of new materials based on the promising thermoelectric antimony selenide. This work could lead to non-toxic and cheap next-generation flexible solar cells. But once his devices reach an energy conversion efficiency threshold of 10%, from the current best of 5.6%, he will reach out to industry. ■

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