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China's Remarkable Rise as a Global-Class Innovator

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In July 2026, Omar Yaghi, the 2025 Nobel Prize in Chemistry, left the University of California, Berkeley to take up a position at Tsinghua University as a full-time Chair Professor. He had been an Honorary Professor there since 2022 and a Foreign Member of the Chinese Academy of Sciences since 2025.[21][22]. He said that he accepted the appointment at Tsinghua, because he was promised the resources to build a laboratory to pursue global-class cutting-edge science. This statement and action would have been unimaginable only a decade earlier.[1] For the last decade, the Chinese government has accelerated an evolving strategy to transition from an imitator to a global innovator and competitor at the cutting-edge of the most important technologies.

The 15th China Five-Year Plan (2026 – 2030) enunciates a strategic road map for developing new "quality productive forces." One specific aspect of this FYP is to attract Chinese scientists to return to the motherland, as well as recruit non-Chinese scientists to China. This 15th Five-Year Plan anticipates increasing annual R&D spending by 7%. While China just surpassed the US in national R&D (adjusted by purchasing power parity) in 2024, at this rate of increase, China will far outstrip any other country in total R&D spending.

From a geopolitical perspective, the new reality is that the global order of trade is undergoing its most intensive reformation since the creation of the General Agreement on Tariffs and Trade (GATT) in 1947. In our view, the Western economies are at a more fundamental juncture – we

[1] Ahart, J. and Basu, J. 2026. Nobel-winning chemist leaves US to direct AI materials lab in China. *Nature* (July 8). https://www.nature.com/articles/d41586-026-02143-x

are at the end of a long period that began with the expansion of Western European power that ushered in the "Age of Exploration" (early 1500s-late 1700s) and followed by the Enlightenment and the Industrial Revolution. This long period was one where Western technology and science raced ahead.[2] This is also the period within which the European university became more than training academies. Scientist/technologists such as Galileo became important figures (see, for example, Biagioli 2019).[3] Xi Jinping (2025: 96), in his own writings, argued that the greatest Chinese lapse was closing China from the rest of the world during the Ming Dynasty as it missed the Industrial Revolution.[4] By 2026, it seems as though the period of Chinese "backwardness" is over and there is evidence that in many fields of science and technology China has emerged as a global S&T competitor (as we discussed in Chapter One of this book).

In the next section, we outline a few of the key changes as examples of the truly remarkable evolution of the entire Chinese S&T system.

1. Key Areas of Change in the Chinese S&T Perspective

The Chinese S&T system has experienced remarkable changes over the last five decades on nearly every dimension – breadth, depth, scale, and complexity. It is literally impossible to sum up these changes in a single document or even book. In this section, we selectively and briefly discuss a few of the most salient.

1.1. Patenting

Patenting is an important, if imperfect, measurement of innovation. China's opening up to the world meant that it had to transition from the previous Communist system that essentially did not recognize intellectual property (IP) and China was so technologically backward that it generated relatively few patents.[5] However, as it sought to attract multinational enterprise investment, it became incumbent to develop IP protection, which it has gradually done.

The changes in China' patenting performance are truly remarkable. From having essentially no patents, it is now a global patenting leader. In 2000 China recorded only 30,000 patents domestically, but this had grown to 1,044,777 in 2024. This transformation is the result of the Chinese government promulgating policy after policy intent on increasing China's position in the world IP market. These policies included central government subsidies for patent filings by Chinese organizations[6] and even evaluating local government officials by how many patents

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[2] Braudel, F. (1992). *Civilization and Capitalism, 15th-18th Century, Volume. III: The Perspective of the World*. Berkeley: University of California Press; Rosenberg, N. and Birdsell, L.E. Jr. 1986. *How the West Grew Rich: The Economic Transformation of the Industrial World*. New York: Basic Books.

[3] Biagioli, M. 2019. *Galileo's Instruments of Credit: Telescopes, Images, Secrecy*. Chicago: University of Chicago Press.

[4] Xi, Jinping. *The Governance of China, Volume 5*. Beijing: Foreign Language Press P. 96.

[5] Liang, Z., & Xue, L. (2010). The evolution of China's IPR system and its impact on the patenting behaviours and strategies of multinationals in China. *International Journal of Technology Management*, 51(2-4), 469-496.

[6] Rao, W., Wang, Y., and Zhao, T. 2025. Why the Chinese government is reducing domestic patent filing subsidies and how rights holders can adapt. *World Trade Review* (September 15).

were filed from their jurisdictions.[7] Unsurprisingly, the result has been a massive outpouring of Chinese patents, many of which were of low quality. The Chinese government recognized this problem and in 2021 began phasing out these subsidies.

The question in 2026 is whether this wave of patenting is simply ever more low-quality patents or an indicator of China becoming an innovation economy. In one of the most careful recent evaluations, Josh Lerner and colleagues found that in 12 critical technologies, to quote "Chinese patents in virtually all critical technologies gained textual importance relative to U.S. patents between 2006 and 2021."[8] Lerner and colleagues found that the improvement in Chinese patents is similar to the increase in highly cited Chinese academic articles and the widely accepted fact that China has developed a leadership position in industries ranging from transportation equipment such as electric vehicles. and high-speed trains to rare earth minerals lithium, and many more. Assuming that Chinese scientists are as good as those in Taiwan, and Korea, then it is not unreasonable to expect that China will out-distance the US not only in total patents, but also in high-quality patents.

1.2. Returning China Scientists and the Recruitment of Non-Chinese Scientists

Returnees have a long history in China going back to the mid-1800s. Many of the key founders of the Communist and Nationalist parties returned from abroad. The founding leaders of the Chinese nuclear and space programs were returnees. More recently, this has been evident in science and technology and not politics. From the 1949 Revolution, a time during which many key Chinese scientists left the country, it has been government policy to convince them to return.

After the 1980s, when China recognized how backward it really was, policies were introduced to encourage the return of earlier emigrants. Program after program has been introduced at the national and provincial level to recruit Chinese scientists and entrepreneurs educated and working abroad to return.[9] The goal of encouraging returnees was multiple. These came to include not only "hard technology" transfer, but also know-how on how to fund, conduct and organize global-class research. In 2020, Cao et al. found that returnee university professors were more highly cited than their Chinese colleagues[10] and not surprisingly served as bridges to the

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https://www.worldtrademarkreview.com/guide/china-managing-the-ip-lifecycle/2026/article/why-the-chinese-government-reducing-domestic-patent-filing-subsidies-and-how-rights-holders-can-adapt

[7] Chen, B., Wang, H., & Wang, X. (2024). Innovation like China: Evidence from Chinese local officials' promotions. *China Economic Review*, 86, 102203.

[8] Lerner, J., Narain, N., Papanikolaou, D., Seru, A., and Xu, Z. W. 2026. Chinese Sputnik Moments? (July 13). https://ssrn.com/abstract=7114818. P. 5.

[9] For an early discussion, Wang, H., Zweig, D., & Lin, X. (2011). Returnee Entrepreneurs: Impact on China's globalization process. *Journal of Contemporary China*, *20*(70), 413-431.

[10] Cao, C., Baas, J., Wagner, C. S., & Jonkers, K. (2020). Returning scientists and the emergence of China's science system. *Science and Public Policy*, *47*(2), 172-183.

international scientific community. This recruitment framed to serve the needs of state-owned enterprises, private firms and public universities and research institutions.

One of the most publicized of these programs is "The Thousand Talents Plan (TTP)," or "Qianren Jihua" (千人计划), launched in 2008 was intended to reverse the brain drain of China scientific diaspora and perhaps more challenging also attract elite foreign scholars to Join Universities and national institutes in China. The Thousand Talents Plan (TTP), or "Qianren Jihua" (千人计划), was launched in 2008. was intended to reverse the brain drain of China scientific diaspora and attract elite foreign experts. The TTP emerged from the "Talent Superpower Strategy" of the 17th National Congress in 2007, which aimed to bolster China's innovation and international science and technology competitiveness. By 2019, it was rebranded as the "National High-end Foreign Experts Recruitment Plan" under the Ministry of Industry and Information Technology. It focused on Chinese nationals educated at top overseas institutions—such as MIT, Harvard, and Imperial College London—who have excelled as researchers. It also focused on recruiting a select group of foreign-born scientists with critical skills, often holders of prestigious awards like the Nobel Prize or Fields Medal, who have made significant contributions to fields vital to China's technological goals. The program offered incentives, such as a one-time bonus of 1 million RMB (approximately $140,000 USD in 2025), research funding, visa privileges, and the prestigious title of "Thousand Talents Plan Distinguished Professor."

These programs to encourage scientists and engineers to return to China has prompted concerns and criticisms abroad. Australian Strategic Policy Institute estimates that more than 300 scholars at Australian institutions are linked to it, and U.S. reports suggest that over 150 scientists and technology specialists at Los Alamos National Laboratory. Data from Chinese sites like the TTP's archived portal (via web.archive.org) and the Ministry of Science and Technology confirm their focus on STEM fields critical to national goals from aerospace to biotechnology. The FBI, CSIS, and South Korean authorities have flagged the TTP as enabling intellectual property theft and espionage, citing cases like Charles Lieber's 2021 conviction for concealing TTP ties and a 2023 arrest in Seoul for stealing medical robotics files. These countries were delighted to attract and take advantage of these Chinese technologists, but now that some are returning to China far greater concern is being expressed. These concerns expose the many contradictions in the long-time policy of recruiting foreign scientists, as the advantages now are becoming disadvantages amid the concern that China's pursuit of self-reliance is prompting accusations of exploiting the global research ecosystem.

That returnees have had an impact is undoubted.[11] And yet, the scale of the impact is debated, as, for example, Martin Kenney et al. suggested that their impact was magnified as China became

[11] See, for example, Qiao, Y., Ascani, A., Bruschi, S., & Morrison, A. (2024). Returnees and innovation: evidence from Chinese publicly listed firms. *Science and Public Policy*, *51*(5), 861-878.

more capable of absorbing the knowledge they brought.[12] Josh Lerner et al.'s 2026 analysis of Chinese patenting in critical technologies found that:

> Fewer than ten percent of Chinese critical technology patent publications involve an inventor with prior U.S. work experience, a share that has declined since 2019. The fraction involving inventors with U.S. PhDs remains below one percent.[13]

The previous paragraphs suggest that returnees have played a role in the China Science and Technology catchup phase. What is particularly interesting is that in 2026 about 105 top-tier scientists and engineers left the US and Europe. In addition to Omar Yaghi mentioned in our opening, a small number of other mid-career scientists are relocating to China, where they believe they can undertake globally recognized research. The increasingly shrill concerns about Chinese scientists in US research institutions was not due to cutbacks in in Federal Funding which the US congress fully funded, but the executive branch has been reluctant to award. https://www.insidehighered.com/news/faculty/research/2026/09/11/top-scientists-lead-exodus-chinese-academics-us

1.3. The Upgrading of Chinese Universities

By all measures, there has been a massive improvement in the research at many Chinese universities. This has occurred in terms of breadth and excellence. In 2025, according to the Shanghai Rankings 101 Chinese universities were in the top global 500. In contrast, the US still led with 111 universities in the global top 500. In 2023, there were 161 US universities and only 9 Chinese universities. From this it would be fair to conclude that the Chinese university system was globally irrelevant twenty years ago. Today, Tsinghua University is ranked #18 up from #201-250 in 2003 and #202-301 in 2004 again reiterating the near total irrelevance of Chinese universities. In pursuit of building global-class universities, beginning in the early 2000s, China launched programs such as the 211 and 985 Programs and many more that infused funds and raised standards to increase the research (and teaching) quality of their universities.[14]

The improvement was not only in terms of research quality. In previous decades, Chinese universities were criticized for not having strong linkages to industry and undertaking research that contributed to Chinese economic development.[15] To address this criticism, there have been innumerable programs to increase technology transfer from local universities to firms across all

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[12] Kenney, M., Breznitz, D., & Murphree, M. (2013). Coming back home after the sun rises: Returnee entrepreneurs and growth of high-tech industries. *Research Policy*, *42*(2), 391-407.
[13] Lerner, J., Narain, N., Papanikolaou, D., Seru, A., and Xu, Z. W. 2026. Chinese Sputnik Moments? (July 13). https://ssrn.com/abstract=7114818. p.4.
[14] See, for example, Zhang, H., Patton, D., & Kenney, M. (2013). Building global-class universities: Assessing the impact of the 985 Project. *Research Policy*, 42(3), 765-775.
[15] Chen, Aihua, Donald Patton, and Martin Kenney. "University technology transfer in China: a literature review and taxonomy." *Journal of Technology Transfer* 41.5 (2016): 891-929.

industries.[16] As an example, in the early days of the development of EVs and, in particular, batteries, the connections between universities and industry to do cooperative research was pursued by the central government and actualized by local governments bringing university and corporate researchers together. In the 10th FYP period (2001-2005), the central government invested 880 million RMB (about US$125 million) in the "863" Electric Vehicle Major Science and Technology Project meant to support automobile manufacturers and universities to form partnerships to develop technology. Following that, in the 11th FYP period (2006-2011), the government funded 270 science and technology projects of NEV based on the "863" Energy-Saving and New Energy Vehicle R&D Major Project.[17] These projects are only one example of the remarkable, relatively new-found ability that China has to develop productive linkages between existing firms and university researchers, while not reducing universities to "job shops" for industry.

Chinese universities have a long history of establishing their own firms to commercialize the innovations of their researchers.[18] More recently, a number of the important Chinese AI startups, such as, DeepSeek, Moonshot, Zhipu, et al. have formed; many of which have collaborations with Chinese universities. There are many examples of Chinese universities contribution to technological development. For example, recently new photovoltaic materials invented in university research laboratories are being commercialized by spinoffs.[19]

Finally, in the last decade, several research-oriented private universities have been established and recruit faculty not only from existing Chinese universities, but also from abroad. While this phenomenon is relatively small, it indicates that China is experimenting with new methods of university governance.

China has had some form of higher educational institutions for at least a thousand years. And yet, it was only in the 1890s that the first Western-style universities were established. However, given China's poverty and the near-constant political disruptions, these universities were largely confined to teaching undergraduates. After the 1949 Communist Revolution, China adopted the Russian system, where universities were largely confined to teaching, as research was largely done by various specialized research institutes. Beginning with the opening up in the 1980s, the Chinese leadership came to believe that the US university model that undertook both teaching,

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[16] See, Guan, J. C., Yam, R. C., & Mok, C. K. (2005). Collaboration between industry and research institutes/universities on industrial innovation in Beijing, China. *Technology Analysis & Strategic Management*, *17*(3), 339-353; Suttmeier, R. P., & Cao, C. (1999). China faces the new industrial revolution: achievement and uncertainty in the search for research and innovation strategies. *Asian Perspective*, *23*(3), 153-200.
[17] Kenney, M., Lewin, A, Shu, E. and Liang, M. 2025. *The Demise of the Global ICE Industry: China's Stunning Role in Leading the BEV Revolution*. Cambridge: Cambridge University Press.
[18] Baark, E. (2001). Technology and entrepreneurship in China: Commercialization reforms in the science and technology sector. *Review of Policy Research*, *18*(1), 112-129; Kroll, H., & Liefner, I. (2008). Spin-off enterprises as a means of technology commercialisation in a transforming economy—Evidence from three universities in China. *Technovation*, 28(5), 298-313.
[19] Guo Q. and Zhan Y. (2024). Chinese university spin-offs spearhead the perovskite photovoltaic industrial revolution. *Innovation Energy* 1(3): 100045. https://doi.org/10.59717/j.xinn-energy.2024.100045.

but particularly research, was the global standard. With this realization, China began a sustained policy of building the research capabilities of its universities – a process that is continuing and that by 2026 resulted in a number of Chinese universities becoming global-class research institutions that contribute both to the local science commons and local economic development.

While the growth and improvement in Chinese universities has been remarkable, perhaps, the only comparable example is the US universities after World War Two and then Sputnik. And yet, this improvement has also spawned problems including serious academic misconduct, unauthorized medical testing, exploitation of graduate students, plagiarism, and undisclosed use of AI. These problems are unlikely to arrest the continuing advance of Chinese universities but do remain obstacles to complete confidence in Chinese science and technology.

1.4. The Role of Local Governments

For a country that is admittedly centralized like China, escaping from the pitfalls of centralization such as slow decision making, group think, disconnection from local needs, and learning from the market. One of the key policies introduced in the liberalization of the early 1980s was the loosening of central control and the devolution of much decision making to local governments. A process that Keyu Jin has referred to as the rise of the "Mayor Economy", where local mayors have immense power to allocate resources for economic development.[20] And, over the last two decades, local government officials have increasingly been evaluated on the basis of their jurisdiction's performance in patenting, the creation and growth of entrepreneurial firms, among other criteria. Effectively, one of the tasks of local government officials is to identify and support entrepreneurial firms with new technologies, particularly those highlighted as important by the central government. This entails the central government also learning from the local initiatives. For example, regarding internet firms, the local governments through their interaction with entrepreneurs identified concepts such as e-commerce or social media before the central government understood their significance.[21]

As China moves to the cutting edge of S&T and copying from abroad is no longer viable, the initiatives of local entrepreneurs will only become more important. In some cases, the central government through identifying key technologies in the five-year plan will signal a general direction, in other cases it can be local entrepreneurs that pioneer the new directions.

1.5. US S&T-Related Sanctions

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[20] On this topic, please see Ang, Y. Y. (2018). *How China Escaped the Poverty Trap*. Ithaca: Cornell University Press.

[21] Sun, J., Jia, K., & Kenney, M. (2025). Entrepreneurial local governments and the development of the decentralised platform economy in China. *Regional Studies*, *59*(1), 2514961.

During the last decade, the United States but also, to a lesser degree, Europe have implemented multiple waves of sanctions to frustrate Chinese efforts to improve their industrial capabilities. It is difficult to evaluate whether these sanctions have delayed or prevented Chinese technological advance. What is clear is that in fields such as AI, Chinese models, despite not having access to the latest Nvidia chips, perform nearly as well as US models released by OpenAI, Anthropic, and Google.

The most damaging US sanctions are related to semiconductor design and production. The sanction that has received the greatest attention is the prevention of the Dutch firm, ASML, from exporting EUV machines used for the fabrication of the most advanced semiconductor chips. However, these US sanctions extend to many other types of semiconductor fabrication equipment made by US firms.[22] The Chinese response has been massive investments to circumvent the various embargos[23]. And while there have been successes, overtaking the specialist Western firms has been difficult. In EUV, thus far, depending upon the point of view, have been disappointing. As we discuss below, in AI itself, China has experienced significant success catching up to the US leaders and Chinese models appear to be rapidly gaining global market share.

The use of export and technology transfer sanctions to impede Chinese technological, scientific, and innovatory success appears to be having increasingly limited success. The only area of significant leverage left is in both direct export of the most advanced semiconductors and advanced fabrication equipment, especially photolithography. Chinese substitutes for these technologies are being introduced though, at this time, they appear to be inferior in performance.[24] Further, as China continues to advance and assume leadership in many technologies, there is a danger that China will withhold technologies or the products of those technologies from the West, as is occurring now with processed rare earths. Put differently, the advancement of Chinese industry and technology make it possible for China to retaliate to Western sanctions in palpable ways.

1.6. Reflections on Institutions

We have only explored a few of the institutions that have emerged and matured as China advanced from being a largely backward economy undertaking low-level assembly work to a nation innovating in a myriad of industries. We did not discuss the role of key multinational corporations ranging from Apple, Dell, and Nokia to Walmart, Costco, Nike, and so many more

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[22] Perlo, J. 2026. Bill to ban sale of key AI chipmaking equipment to China introduced in House. (April 2)https://www.nbcnews.com/tech/tech-news/senate-bill-ban-sale-key-ai-chipmaking-machines-china-rcna265186.
[23] Huang, K. G., Jia, N., & Ge, Y. (2024). Forced to innovate? Consequences of United States' anti-dumping sanctions on innovations of Chinese exporters. *Research Policy*, *53*(1), 104899
[24] Kharpal, A. 2026. China's reported chip breakthrough comes with some big caveats. CNBC. (July 28). https://www.cnbc.com/2026/07/28/china-chipmaking-duv-tool-asml-explained.html.

in teaching the Chinese how to manufacture global-class products. Similarly, we did not explore the role of financial institutions such as banks, venture capital, and others in financing the transition to becoming an R&D giant. Today, China has developed a series of remarkable regional innovation systems and institutions that, when considered holistically, rival those in any other country including the US. In the next section, we briefly discuss the three technologies, AI, Cleantech (CT) (in the case of CT, package of technologies), and biotechnology that many believe will shape the next few decades.

2. China and Three Key Technologies of Mid-21st Century[25]

In 2026, there are two powerful technological revolutions underway and biotechnology continues to generate important innovations.[26] The first is artificial intelligence (AI) and the second is the interconnected complex of technologies comprising solar energy, batteries, and electric vehicles, which we label as the Cleantech (CT). The final one is the broad complex of technologies, referred to as biotechnology. In AI, CT and biotechnology, the US was the first mover in so far as developing and introducing the fundamental technological developments, but in one, AI, while the US remains the leader, China and Chinese firms have become the only serious competitor.[27] In contrast, for CT China dominates all facets of this new technology, which is transforming the global energy system. Below, we briefly describe the state of play in these two technologies. In biotechnology, while China still lags the US, it has become increasingly capable.

2.1. Artificial Intelligence and China[28]

AI has become the most anticipated and hyped technology, perhaps, in human history. The US has been the leader in AI, but, more recently, as Liang et al. (in this book) point out, by most measures, Chinese open-weight AI models have essentially the same performance than the far more expensive closed-weight models provided by US firms such as OpenAI, Anthropic, and Google. There is ample evidence that Chinese AI models are rapidly becoming popular globally.[29] The danger to the US of Chinese success in AI is that these open Chinese models are free to anyone anywhere who wants to download and use them. Given that they are roughly as capable as the expensive US models, there has been massive global adoption, however this

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[25] This section draws heavily upon the chapter by Zhang et al. in this book.
[26] For an elaboration on the comparison between AI and CT, see Kenney, M. 2026. AI or Clean Technology: Which will form the basis of the next technoeconomic Paradigm? *Le Grand Continent*. Forthcoming.
[27] Human-Centered Artificial Intelligence. 2026. The 2026 AI Index Report. https://hai.stanford.edu/ai-index/2026-ai-index-report
[28] This section draws heavily upon Kenney, M. 2026. Et si la vrait revolution technologique n'était pas l'IA? *Le Grande Continent* (August 10)
[29] See, for example, Nguyen, K. P. 2026. China AI models capture 63% of U.S. OpenRouter usage as Xi pushes Global Rules. *Yahoo Finance* (July 20). https://finance.yahoo.com/technology/ai/articles/china-ai-models-capture-63-205130859.html; Mozur, P., Satariano, A., and Krolik, A. 2026. China's A.I. is surging across Africa. *New York Times* (August 5). https://www.nytimes.com/2026/08/05/technology/ai-china-africa.html

threatens the ability of the expensive-to-use US models to earn a return. Since US AI investment is so massive, its continuation is important for the growth of the economy. China is also making significant investment, but it is far less than that of the US and this investment is not as central to the entire economy.

The important point is that the China is developing a different model from that of the US for commercializing AI. This model is meant to make global-class AI models freely available to any users globally. Further, as Liang et al. (2026) show, China is making a major effort to "embody" AI in various physical machines such as drones, humanoid and non-humanoid robots, factory machinery and all manner of other machines with the goal of increasing their efficiency.

2.2. Clean Technologies and China

Driven by the need to import fossil fuels and increasing environmental problems already in the 1990s, Chinese policymakers began calling for and investing in non-fossil field-based alternatives. Over the next three decades, China became the center, first for manufacturing and now for R&D for the entire value chains of solar photovoltaics, batteries, electric motors, and BEVs. China is on the verge of becoming the first "Electrostatic," where fossil fuels are replaced by renewable sources of energy to become the primary source of energy for mobility and heating.

For example, China has led the transition to lithium-ion batteries, as the most important form of energy storage. Further, Chinese firms are leading the development and commercialization of sodium-based batteries. What is most remarkable is that China dominates the entire battery value chain and in R&D for new chemistries. Similarly, China is a leader in the development of high-efficiency electric motors and chargers.[30] The sole important player in the West is the Silicon Valley firm, Tesla, headed by Elon Musk.

2.3. Biotechnology/Pharmaceuticals

The biotechnology/pharmaceutical industry is an industry based on science instead of engineering, while the two previously discussed industries are more dependent upon engineering. Countries catching up, such as Japan, despite great effort were never able to overtake the US and Western European leaders. For example, in 2026 the largest Japanese pharmaceutical firm in terms of revenue was nineteenth in world! The other East Asian nations such as Korea, are not significant. In terms of biomedical research, East Asian universities are also not yet important. However, here again, Chinese universities are rapidly improving their biomedical research, in part, by merging independent medical schools with comprehensive universities[31] and making

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[30] On batteries, see Levine, E., Chiang, Y-M., Murray, F. E. 2026. Recharging Our Future: Can the U.S. Manufacture Batteries? (January 23). https://tcip.org/wp-content/uploads/2026/03/TCIP-Center-Policy-Report-Recharging-Our-Future.pdf.

[31] Liu, Q., Patton, D., & Kenney, M. 2018. Do university mergers create academic synergy? Evidence from China and the Nordic Countries. Research Policy, 47(1), 98-107.

massive investments in biomedical research, though China still lags in the most innovative new therapeutics.[32]

It is this context that makes China's recent success in developing new pharmaceuticals is so surprising. To illustrate, Chinese success in 2025 is shown by the fact that global pharmaceutical firms licensed drugs worth more than $137 billion. In fact, according to Goldman Sachs nearly 50% of all licensing deals were of Chinese developed molecules.[33] To quote an American pharmaceutical executive, "the reality today is that Chinese innovation is bringing genuinely new molecules and modalities to market."[34] The scale of this licensing has attracted the attention of the US government, which is exploring bans on drug licensing deals between US and Chinese pharmaceutical firms. To recapitulate, even in biomedical fields, China is increasingly becoming a global leader in discovering and developing innovative therapeutic molecules – a surprising result that only a decade ago would have been inconceivable.

2.4. Summary

AI, CT, and biotechnology are three very different technologies and in each of them China has achieved remarkable results, and its firms now operate at the global cutting-edge. Of course, these three notable sectors are not the only ones within which China is becoming increasingly competitive. CT, and, especially, batteries, will transform many other technologies including robots -- humanoid and non-humanoid robots[35], drones, space exploration, and many other industrial applications. China is developing its embodied-AI model, which it hope will make its machines and factories more efficient than ever. In science-based biotechnology, which in China as in the US, is intimately tied to university, China is becoming a vital player and becoming integrated into the global drug-development industry. All these industries of the future are driven by research and development. The trajectory in each of these suggest that China is becoming a global S&T powerhouse.

3. Potential Obstacles to the Chinese Innovation Economy's Success

[32] Yuan, Y. 2026. How Chinese labs race for the next 'first-in-class' breakthrough. Chemical and Engineering News (March 12) https://cen.acs.org/policy/china-research-labs-energy-materials-biotech-breakthrough

[33] Goldman Sachs. 2025. China is increasing its share of global drug development. (December 17). https://www.goldmansachs.com/insights/articles/china-is-increasing-its-share-of-global-drug-development,

[34] Hollan, M. and Stanford, J. 2026. Why Chinese biotech licensing deals became attractive to US investors. *Pharmaexec.com* (July 29) https://www.pharmexec.com/view/chinese-biotech-licensing-deals-became-attractive-us-investors

[35] The decision to develop humanoid robots to replace human beings may be wrong-headed. For example, why should a robot undertaking, for example, folding clothes have only two hands, when there is no limitation to the number of hands a robot might control. The point is that new technologies often are initially limited by the imaginations of their creators. As the new technology is adopted and becomes familiar it can result in better understanding of the ways to use it.

When considering the future for any nation and, by extension, its innovation system, there are many uncertainties, and it is particularly difficult to recognize when a turning point may occur. In our 2016 version, we were uncertain that China could go beyond the catch-up phase arguing that demographic issues and the already enormous real estate bubble might slow Chinese innovative progress -- we were far too pessimistic.

China has had a remarkable and almost unbroken record of success first in low-end assembly and other such industries, but then in many higher-level industries. The macro-level challenges such as the real estate bubble and demographic issues still exist. This is in addition to excessive local government indebtedness and some uncertainty about what will happen after Xi Jinping's retirement. The phenomenon of un- or under-employment, particularly of college graduates, is creating social issues that previously were less common. There is further concern that AI could exacerbate these problems. The final problem, over-capacity, and ruinous price wars means that, in many industries, profits are low, especially when compared to those typical of Western countries and firms. And yet, in 2026, it is unlikely that these internal problems are sufficient to lead to significant upheaval or insoluble difficulties.

Chinese industrial and innovative success has not gone unnoticed in the West. For the previous three decades, the US had largely neglected Chinese efforts to import technology. Beginning already in 2008, the Obama Administration announced “a pivot to Asia” to address what was defined as a rising threat from China in advanced industries. Beginning in 2017, the new Trump Administration openly began singling out China as the key adversary and accelerated attempts to block Chinese access to US information and communication technologies. The Biden Administration continued and even reinforced efforts to block technology transfer particularly in AI and advanced semiconductors, and access to the US market. Further, it increasingly demanded US allies, especially Europe to block Chinese access. This includes a virtual ban on Chinese purchase of technology-rich Western firms, thereby closing that avenue of technology transfer. Under Trump attempts to stifle technology transfer have increased. It is possible that this stifling of technology transfer and, increasingly, all scientific exchanges are halted as the US increases its attempts to decouple the two economies. The impact of these efforts thus far have had little impact on the advancement of Chinese R&D and innovation, though they do appear to limiting scientific cooperation.[36]

The success of Chinese exports in global markets is putting pressure on countries globally to regulate imports from China for all types of goods but, in particular, the clean technologies where China is the global leader and Chinese open-weight AI models. If this effort to isolate

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[36] Wang, J, Li, X., and Wang, Y. 2026. Geopolitical tensions with the US accelerate Chinese firms’ leveraging of science. *Science* 393(6817): 1196-1199.

China from the global S&T community is successful, it might influence Chinese success, but China is rapidly reorienting its trade to the rapidly growing Global South.

These developments have implications for so many different facets of the global political economy. One issue is that in this changing world order, the US will (and perhaps can) no longer advocate and defend the rules-based global trading order that it created as reflected in the WTO but recently has abandoned. President Trump's action such as levying sanctions and tariffs on all manner of countries is convincing traditional allies such as Canada to become more open to Chinese products such as BEVs. In most cases, when the Chinese threatened retaliation such as cutting purchases of US agricultural and other products and cutting off access to rare earths, it was the US that retreated, as Chinese countersanctions were so threatening to US industry.

The rise of Chinese manufacturing also impacts the political economic situation of Europe which is particularly vulnerable in the machinery industries. This was compounded by the July 27, 2025 agreement EU Commission President Ursula von der Leyen and U.S. President Donald Trump signed in Turnberry, Scotland. They agreed to a precedent setting EU-U.S. trade pact negotiated a tariff ceiling of 15% on most European exports to the U.S. in exchange for the EU eliminating import duties on U.S. industrial goods and certain agricultural products. The key parameters of the agreement include various tariff ceilings. While Europe had to agree to nearly all the US demands, China, a far more important exporter, pushed back against US demands and the US retreated when China refused to accept the US tariffs.

The internal and external contradictions in the system that propelled China's rise are surfacing. The question is whether these contradictions and US actions attempting slow Chinese progress will be sufficient to halt or dramatically slow its rise to global parity in science and technology. As with all trajectories of growth, the most difficult thing to predict is when the internal and external difficulties resolve into a turning point.

4. The Future

In the first edition of this book published in 2016, we underestimated the progress in innovation, technology and science that China would experience. The accomplishments of the last decade likely have no parallel in human history. Previous flowerings of human technological achievement have been over longer time frames, does this suggest that the current remarkable Chinese success could lead to stagnation as occurred in the case of the earlier Japanese "Miracle."

Chinese S&T success has not been without tensions. As we discussed, in the previous section the intense pressure to patent and publish is leading to ethical lapses and questionable publications and patents and the rampant questionable use of AI. The hierarchical structure of Chinese institutions may also contribute to other questionable practices such as forced adding of co-authors. Chinese universities have been said to be victims of significant bureaucratic inertia that

may be slowing the pace of research, though these tension, at this point, do not appear to have slowed the advance of Chinese scientific and engineering research.

Some Western scholars have suggested that some in China are awaiting the retirement President Xi Jinping prior to making any significant changes in direction. Whether this is correct or not, the progress of the Chinese innovation system is unlikely to be slowed by this uncertainty. Of course, there are developments such as a depression-like economic event or a world war that might interrupt Chinese development, though the US Great Depression did not slow US manufacturing advances during the 1930s. What is certain is the rise of China as an innovative economy will challenge US and European S&T leadership in ways they have not experienced since the Industrial Revolution.

China's Remarkable Rise as a Global-Class Innovator

Forthcoming in *China's Innovation Challenge* Arie Lewin, Martin Kenney, and Ei Shu (Eds.) Cambridge: Cambridge University Press.

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In July 2026, Omar Yaghi, the 2025 Nobel Prize in Chemistry, left the University of California, Berkeley to take up a position at Tsinghua University as a full-time Chair Professor. He had been an Honorary Professor there since 2022 and a Foreign Member of the Chinese Academy of Sciences since 2025.[21][22]. He said that he accepted the appointment at Tsinghua, because he was promised the resources to build a laboratory to pursue global-class cutting-edge science. This statement and action would have been unimaginable only a decade earlier.[1] For the last decade, the Chinese government has accelerated an evolving strategy to transition from an imitator to a global innovator and competitor at the cutting-edge of the most important technologies.

The 15th China Five-Year Plan (2026 – 2030) enunciates a strategic road map for developing new "quality productive forces." One specific aspect of this FYP is to attract Chinese scientists to return to the motherland, as well as recruit non-Chinese scientists to China. This 15th Five-Year Plan anticipates increasing annual R&D spending by 7%. While China just surpassed the US in national R&D (adjusted by purchasing power parity) in 2024, at this rate of increase, China will far outstrip any other country in total R&D spending.

From a geopolitical perspective, the new reality is that the global order of trade is undergoing its most intensive reformation since the creation of the General Agreement on Tariffs and Trade (GATT) in 1947. In our view, the Western economies are at a more fundamental juncture – we

[1] Ahart, J. and Basu, J. 2026. Nobel-winning chemist leaves US to direct AI materials lab in China. *Nature* (July 8). https://www.nature.com/articles/d41586-026-02143-x

are at the end of a long period that began with the expansion of Western European power that ushered in the "Age of Exploration" (early 1500s-late 1700s) and followed by the Enlightenment and the Industrial Revolution. This long period was one where Western technology and science raced ahead.[2] This is also the period within which the European university became more than training academies. Scientist/technologists such as Galileo became important figures (see, for example, Biagioli 2019).[3] Xi Jinping (2025: 96), in his own writings, argued that the greatest Chinese lapse was closing China from the rest of the world during the Ming Dynasty as it missed the Industrial Revolution.[4] By 2026, it seems as though the period of Chinese "backwardness" is over and there is evidence that in many fields of science and technology China has emerged as a global S&T competitor (as we discussed in Chapter One of this book).

In the next section, we outline a few of the key changes as examples of the truly remarkable evolution of the entire Chinese S&T system.

1. Key Areas of Change in the Chinese S&T Perspective

The Chinese S&T system has experienced remarkable changes over the last five decades on nearly every dimension – breadth, depth, scale, and complexity. It is literally impossible to sum up these changes in a single document or even book. In this section, we selectively and briefly discuss a few of the most salient.

1.1. Patenting

Patenting is an important, if imperfect, measurement of innovation. China's opening up to the world meant that it had to transition from the previous Communist system that essentially did not recognize intellectual property (IP) and China was so technologically backward that it generated relatively few patents.[5] However, as it sought to attract multinational enterprise investment, it became incumbent to develop IP protection, which it has gradually done.

The changes in China' patenting performance are truly remarkable. From having essentially no patents, it is now a global patenting leader. In 2000 China recorded only 30,000 patents domestically, but this had grown to 1,044,777 in 2024. This transformation is the result of the Chinese government promulgating policy after policy intent on increasing China's position in the world IP market. These policies included central government subsidies for patent filings by Chinese organizations[6] and even evaluating local government officials by how many patents

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[2] Braudel, F. (1992). *Civilization and Capitalism, 15th-18th Century, Volume. III: The Perspective of the World*. Berkeley: University of California Press; Rosenberg, N. and Birdsell, L.E. Jr. 1986. *How the West Grew Rich: The Economic Transformation of the Industrial World*. New York: Basic Books.

[3] Biagioli, M. 2019. *Galileo's Instruments of Credit: Telescopes, Images, Secrecy*. Chicago: University of Chicago Press.

[4] Xi, Jinping. *The Governance of China, Volume 5*. Beijing: Foreign Language Press P. 96.

[5] Liang, Z., & Xue, L. (2010). The evolution of China's IPR system and its impact on the patenting behaviours and strategies of multinationals in China. *International Journal of Technology Management*, 51(2-4), 469-496.

[6] Rao, W., Wang, Y., and Zhao, T. 2025. Why the Chinese government is reducing domestic patent filing subsidies and how rights holders can adapt. *World Trade Review* (September 15).

were filed from their jurisdictions.[7] Unsurprisingly, the result has been a massive outpouring of Chinese patents, many of which were of low quality. The Chinese government recognized this problem and in 2021 began phasing out these subsidies.

The question in 2026 is whether this wave of patenting is simply ever more low-quality patents or an indicator of China becoming an innovation economy. In one of the most careful recent evaluations, Josh Lerner and colleagues found that in 12 critical technologies, to quote "Chinese patents in virtually all critical technologies gained textual importance relative to U.S. patents between 2006 and 2021."[8] Lerner and colleagues found that the improvement in Chinese patents is similar to the increase in highly cited Chinese academic articles and the widely accepted fact that China has developed a leadership position in industries ranging from transportation equipment such as electric vehicles. and high-speed trains to rare earth minerals lithium, and many more. Assuming that Chinese scientists are as good as those in Taiwan, and Korea, then it is not unreasonable to expect that China will out-distance the US not only in total patents, but also in high-quality patents.

1.2. Returning China Scientists and the Recruitment of Non-Chinese Scientists

Returnees have a long history in China going back to the mid-1800s. Many of the key founders of the Communist and Nationalist parties returned from abroad. The founding leaders of the Chinese nuclear and space programs were returnees. More recently, this has been evident in science and technology and not politics. From the 1949 Revolution, a time during which many key Chinese scientists left the country, it has been government policy to convince them to return.

After the 1980s, when China recognized how backward it really was, policies were introduced to encourage the return of earlier emigrants. Program after program has been introduced at the national and provincial level to recruit Chinese scientists and entrepreneurs educated and working abroad to return.[9] The goal of encouraging returnees was multiple. These came to include not only "hard technology" transfer, but also know-how on how to fund, conduct and organize global-class research. In 2020, Cao et al. found that returnee university professors were more highly cited than their Chinese colleagues[10] and not surprisingly served as bridges to the

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https://www.worldtrademarkreview.com/guide/china-managing-the-ip-lifecycle/2026/article/why-the-chinese-government-reducing-domestic-patent-filing-subsidies-and-how-rights-holders-can-adapt

[7] Chen, B., Wang, H., & Wang, X. (2024). Innovation like China: Evidence from Chinese local officials' promotions. *China Economic Review*, 86, 102203.

[8] Lerner, J., Narain, N., Papanikolaou, D., Seru, A., and Xu, Z. W. 2026. Chinese Sputnik Moments? (July 13). https://ssrn.com/abstract=7114818. P. 5.

[9] For an early discussion, Wang, H., Zweig, D., & Lin, X. (2011). Returnee Entrepreneurs: Impact on China's globalization process. *Journal of Contemporary China*, *20*(70), 413-431.

[10] Cao, C., Baas, J., Wagner, C. S., & Jonkers, K. (2020). Returning scientists and the emergence of China's science system. *Science and Public Policy*, *47*(2), 172-183.

international scientific community. This recruitment framed to serve the needs of state-owned enterprises, private firms and public universities and research institutions.

One of the most publicized of these programs is "The Thousand Talents Plan (TTP)," or "Qianren Jihua" (千人计划), launched in 2008 was intended to reverse the brain drain of China scientific diaspora and perhaps more challenging also attract elite foreign scholars to Join Universities and national institutes in China. The Thousand Talents Plan (TTP), or "Qianren Jihua" (千人计划), was launched in 2008. was intended to reverse the brain drain of China scientific diaspora and attract elite foreign experts. The TTP emerged from the "Talent Superpower Strategy" of the 17th National Congress in 2007, which aimed to bolster China's innovation and international science and technology competitiveness. By 2019, it was rebranded as the "National High-end Foreign Experts Recruitment Plan" under the Ministry of Industry and Information Technology. It focused on Chinese nationals educated at top overseas institutions—such as MIT, Harvard, and Imperial College London—who have excelled as researchers. It also focused on recruiting a select group of foreign-born scientists with critical skills, often holders of prestigious awards like the Nobel Prize or Fields Medal, who have made significant contributions to fields vital to China's technological goals. The program offered incentives, such as a one-time bonus of 1 million RMB (approximately $140,000 USD in 2025), research funding, visa privileges, and the prestigious title of "Thousand Talents Plan Distinguished Professor."

These programs to encourage scientists and engineers to return to China has prompted concerns and criticisms abroad. Australian Strategic Policy Institute estimates that more than 300 scholars at Australian institutions are linked to it, and U.S. reports suggest that over 150 scientists and technology specialists at Los Alamos National Laboratory. Data from Chinese sites like the TTP's archived portal (via web.archive.org) and the Ministry of Science and Technology confirm their focus on STEM fields critical to national goals from aerospace to biotechnology. The FBI, CSIS, and South Korean authorities have flagged the TTP as enabling intellectual property theft and espionage, citing cases like Charles Lieber's 2021 conviction for concealing TTP ties and a 2023 arrest in Seoul for stealing medical robotics files. These countries were delighted to attract and take advantage of these Chinese technologists, but now that some are returning to China far greater concern is being expressed. These concerns expose the many contradictions in the long-time policy of recruiting foreign scientists, as the advantages now are becoming disadvantages amid the concern that China's pursuit of self-reliance is prompting accusations of exploiting the global research ecosystem.

That returnees have had an impact is undoubted.[11] And yet, the scale of the impact is debated, as, for example, Martin Kenney et al. suggested that their impact was magnified as China became

[11] See, for example, Qiao, Y., Ascani, A., Bruschi, S., & Morrison, A. (2024). Returnees and innovation: evidence from Chinese publicly listed firms. *Science and Public Policy*, *51*(5), 861-878.

more capable of absorbing the knowledge they brought.[12] Josh Lerner et al.'s 2026 analysis of Chinese patenting in critical technologies found that:

> Fewer than ten percent of Chinese critical technology patent publications involve an inventor with prior U.S. work experience, a share that has declined since 2019. The fraction involving inventors with U.S. PhDs remains below one percent.[13]

The previous paragraphs suggest that returnees have played a role in the China Science and Technology catchup phase. What is particularly interesting is that in 2026 about 105 top-tier scientists and engineers left the US and Europe. In addition to Omar Yaghi mentioned in our opening, a small number of other mid-career scientists are relocating to China, where they believe they can undertake globally recognized research. The increasingly shrill concerns about Chinese scientists in US research institutions was not due to cutbacks in in Federal Funding which the US congress fully funded, but the executive branch has been reluctant to award. https://www.insidehighered.com/news/faculty/research/2026/09/11/top-scientists-lead-exodus-chinese-academics-us

1.3. The Upgrading of Chinese Universities

By all measures, there has been a massive improvement in the research at many Chinese universities. This has occurred in terms of breadth and excellence. In 2025, according to the Shanghai Rankings 101 Chinese universities were in the top global 500. In contrast, the US still led with 111 universities in the global top 500. In 2023, there were 161 US universities and only 9 Chinese universities. From this it would be fair to conclude that the Chinese university system was globally irrelevant twenty years ago. Today, Tsinghua University is ranked #18 up from #201-250 in 2003 and #202-301 in 2004 again reiterating the near total irrelevance of Chinese universities. In pursuit of building global-class universities, beginning in the early 2000s, China launched programs such as the 211 and 985 Programs and many more that infused funds and raised standards to increase the research (and teaching) quality of their universities.[14]

The improvement was not only in terms of research quality. In previous decades, Chinese universities were criticized for not having strong linkages to industry and undertaking research that contributed to Chinese economic development.[15] To address this criticism, there have been innumerable programs to increase technology transfer from local universities to firms across all

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[12] Kenney, M., Breznitz, D., & Murphree, M. (2013). Coming back home after the sun rises: Returnee entrepreneurs and growth of high-tech industries. *Research Policy*, *42*(2), 391-407.
[13] Lerner, J., Narain, N., Papanikolaou, D., Seru, A., and Xu, Z. W. 2026. Chinese Sputnik Moments? (July 13). https://ssrn.com/abstract=7114818. p.4.
[14] See, for example, Zhang, H., Patton, D., & Kenney, M. (2013). Building global-class universities: Assessing the impact of the 985 Project. *Research Policy*, 42(3), 765-775.
[15] Chen, Aihua, Donald Patton, and Martin Kenney. "University technology transfer in China: a literature review and taxonomy." *Journal of Technology Transfer* 41.5 (2016): 891-929.

industries.[16] As an example, in the early days of the development of EVs and, in particular, batteries, the connections between universities and industry to do cooperative research was pursued by the central government and actualized by local governments bringing university and corporate researchers together. In the 10th FYP period (2001-2005), the central government invested 880 million RMB (about US$125 million) in the "863" Electric Vehicle Major Science and Technology Project meant to support automobile manufacturers and universities to form partnerships to develop technology. Following that, in the 11th FYP period (2006-2011), the government funded 270 science and technology projects of NEV based on the "863" Energy-Saving and New Energy Vehicle R&D Major Project.[17] These projects are only one example of the remarkable, relatively new-found ability that China has to develop productive linkages between existing firms and university researchers, while not reducing universities to "job shops" for industry.

Chinese universities have a long history of establishing their own firms to commercialize the innovations of their researchers.[18] More recently, a number of the important Chinese AI startups, such as, DeepSeek, Moonshot, Zhipu, et al. have formed; many of which have collaborations with Chinese universities. There are many examples of Chinese universities contribution to technological development. For example, recently new photovoltaic materials invented in university research laboratories are being commercialized by spinoffs.[19]

Finally, in the last decade, several research-oriented private universities have been established and recruit faculty not only from existing Chinese universities, but also from abroad. While this phenomenon is relatively small, it indicates that China is experimenting with new methods of university governance.

China has had some form of higher educational institutions for at least a thousand years. And yet, it was only in the 1890s that the first Western-style universities were established. However, given China's poverty and the near-constant political disruptions, these universities were largely confined to teaching undergraduates. After the 1949 Communist Revolution, China adopted the Russian system, where universities were largely confined to teaching, as research was largely done by various specialized research institutes. Beginning with the opening up in the 1980s, the Chinese leadership came to believe that the US university model that undertook both teaching,

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[16] See, Guan, J. C., Yam, R. C., & Mok, C. K. (2005). Collaboration between industry and research institutes/universities on industrial innovation in Beijing, China. *Technology Analysis & Strategic Management*, *17*(3), 339-353; Suttmeier, R. P., & Cao, C. (1999). China faces the new industrial revolution: achievement and uncertainty in the search for research and innovation strategies. *Asian Perspective*, *23*(3), 153-200.
[17] Kenney, M., Lewin, A, Shu, E. and Liang, M. 2025. *The Demise of the Global ICE Industry: China's Stunning Role in Leading the BEV Revolution*. Cambridge: Cambridge University Press.
[18] Baark, E. (2001). Technology and entrepreneurship in China: Commercialization reforms in the science and technology sector. *Review of Policy Research*, *18*(1), 112-129; Kroll, H., & Liefner, I. (2008). Spin-off enterprises as a means of technology commercialisation in a transforming economy—Evidence from three universities in China. *Technovation*, 28(5), 298-313.
[19] Guo Q. and Zhan Y. (2024). Chinese university spin-offs spearhead the perovskite photovoltaic industrial revolution. *Innovation Energy* 1(3): 100045. https://doi.org/10.59717/j.xinn-energy.2024.100045.

but particularly research, was the global standard. With this realization, China began a sustained policy of building the research capabilities of its universities – a process that is continuing and that by 2026 resulted in a number of Chinese universities becoming global-class research institutions that contribute both to the local science commons and local economic development.

While the growth and improvement in Chinese universities has been remarkable, perhaps, the only comparable example is the US universities after World War Two and then Sputnik. And yet, this improvement has also spawned problems including serious academic misconduct, unauthorized medical testing, exploitation of graduate students, plagiarism, and undisclosed use of AI. These problems are unlikely to arrest the continuing advance of Chinese universities but do remain obstacles to complete confidence in Chinese science and technology.

1.4. The Role of Local Governments

For a country that is admittedly centralized like China, escaping from the pitfalls of centralization such as slow decision making, group think, disconnection from local needs, and learning from the market. One of the key policies introduced in the liberalization of the early 1980s was the loosening of central control and the devolution of much decision making to local governments. A process that Keyu Jin has referred to as the rise of the "Mayor Economy", where local mayors have immense power to allocate resources for economic development.[20] And, over the last two decades, local government officials have increasingly been evaluated on the basis of their jurisdiction's performance in patenting, the creation and growth of entrepreneurial firms, among other criteria. Effectively, one of the tasks of local government officials is to identify and support entrepreneurial firms with new technologies, particularly those highlighted as important by the central government. This entails the central government also learning from the local initiatives. For example, regarding internet firms, the local governments through their interaction with entrepreneurs identified concepts such as e-commerce or social media before the central government understood their significance.[21]

As China moves to the cutting edge of S&T and copying from abroad is no longer viable, the initiatives of local entrepreneurs will only become more important. In some cases, the central government through identifying key technologies in the five-year plan will signal a general direction, in other cases it can be local entrepreneurs that pioneer the new directions.

1.5. US S&T-Related Sanctions

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[20] On this topic, please see Ang, Y. Y. (2018). *How China Escaped the Poverty Trap*. Ithaca: Cornell University Press.

[21] Sun, J., Jia, K., & Kenney, M. (2025). Entrepreneurial local governments and the development of the decentralised platform economy in China. *Regional Studies*, *59*(1), 2514961.

During the last decade, the United States but also, to a lesser degree, Europe have implemented multiple waves of sanctions to frustrate Chinese efforts to improve their industrial capabilities. It is difficult to evaluate whether these sanctions have delayed or prevented Chinese technological advance. What is clear is that in fields such as AI, Chinese models, despite not having access to the latest Nvidia chips, perform nearly as well as US models released by OpenAI, Anthropic, and Google.

The most damaging US sanctions are related to semiconductor design and production. The sanction that has received the greatest attention is the prevention of the Dutch firm, ASML, from exporting EUV machines used for the fabrication of the most advanced semiconductor chips. However, these US sanctions extend to many other types of semiconductor fabrication equipment made by US firms.[22] The Chinese response has been massive investments to circumvent the various embargos[23]. And while there have been successes, overtaking the specialist Western firms has been difficult. In EUV, thus far, depending upon the point of view, have been disappointing. As we discuss below, in AI itself, China has experienced significant success catching up to the US leaders and Chinese models appear to be rapidly gaining global market share.

The use of export and technology transfer sanctions to impede Chinese technological, scientific, and innovatory success appears to be having increasingly limited success. The only area of significant leverage left is in both direct export of the most advanced semiconductors and advanced fabrication equipment, especially photolithography. Chinese substitutes for these technologies are being introduced though, at this time, they appear to be inferior in performance.[24] Further, as China continues to advance and assume leadership in many technologies, there is a danger that China will withhold technologies or the products of those technologies from the West, as is occurring now with processed rare earths. Put differently, the advancement of Chinese industry and technology make it possible for China to retaliate to Western sanctions in palpable ways.

1.6. Reflections on Institutions

We have only explored a few of the institutions that have emerged and matured as China advanced from being a largely backward economy undertaking low-level assembly work to a nation innovating in a myriad of industries. We did not discuss the role of key multinational corporations ranging from Apple, Dell, and Nokia to Walmart, Costco, Nike, and so many more

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[22] Perlo, J. 2026. Bill to ban sale of key AI chipmaking equipment to China introduced in House. (April 2)https://www.nbcnews.com/tech/tech-news/senate-bill-ban-sale-key-ai-chipmaking-machines-china-rcna265186.
[23] Huang, K. G., Jia, N., & Ge, Y. (2024). Forced to innovate? Consequences of United States' anti-dumping sanctions on innovations of Chinese exporters. *Research Policy*, *53*(1), 104899
[24] Kharpal, A. 2026. China's reported chip breakthrough comes with some big caveats. CNBC. (July 28). https://www.cnbc.com/2026/07/28/china-chipmaking-duv-tool-asml-explained.html.

in teaching the Chinese how to manufacture global-class products. Similarly, we did not explore the role of financial institutions such as banks, venture capital, and others in financing the transition to becoming an R&D giant. Today, China has developed a series of remarkable regional innovation systems and institutions that, when considered holistically, rival those in any other country including the US. In the next section, we briefly discuss the three technologies, AI, Cleantech (CT) (in the case of CT, package of technologies), and biotechnology that many believe will shape the next few decades.

2. China and Three Key Technologies of Mid-21st Century[25]

In 2026, there are two powerful technological revolutions underway and biotechnology continues to generate important innovations.[26] The first is artificial intelligence (AI) and the second is the interconnected complex of technologies comprising solar energy, batteries, and electric vehicles, which we label as the Cleantech (CT). The final one is the broad complex of technologies, referred to as biotechnology. In AI, CT and biotechnology, the US was the first mover in so far as developing and introducing the fundamental technological developments, but in one, AI, while the US remains the leader, China and Chinese firms have become the only serious competitor.[27] In contrast, for CT China dominates all facets of this new technology, which is transforming the global energy system. Below, we briefly describe the state of play in these two technologies. In biotechnology, while China still lags the US, it has become increasingly capable.

2.1. Artificial Intelligence and China[28]

AI has become the most anticipated and hyped technology, perhaps, in human history. The US has been the leader in AI, but, more recently, as Liang et al. (in this book) point out, by most measures, Chinese open-weight AI models have essentially the same performance than the far more expensive closed-weight models provided by US firms such as OpenAI, Anthropic, and Google. There is ample evidence that Chinese AI models are rapidly becoming popular globally.[29] The danger to the US of Chinese success in AI is that these open Chinese models are free to anyone anywhere who wants to download and use them. Given that they are roughly as capable as the expensive US models, there has been massive global adoption, however this

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[25] This section draws heavily upon the chapter by Zhang et al. in this book.
[26] For an elaboration on the comparison between AI and CT, see Kenney, M. 2026. AI or Clean Technology: Which will form the basis of the next technoeconomic Paradigm? *Le Grand Continent*. Forthcoming.
[27] Human-Centered Artificial Intelligence. 2026. The 2026 AI Index Report. https://hai.stanford.edu/ai-index/2026-ai-index-report
[28] This section draws heavily upon Kenney, M. 2026. Et si la vrait revolution technologique n'était pas l'IA? *Le Grande Continent* (August 10)
[29] See, for example, Nguyen, K. P. 2026. China AI models capture 63% of U.S. OpenRouter usage as Xi pushes Global Rules. *Yahoo Finance* (July 20). https://finance.yahoo.com/technology/ai/articles/china-ai-models-capture-63-205130859.html; Mozur, P., Satariano, A., and Krolik, A. 2026. China's A.I. is surging across Africa. *New York Times* (August 5). https://www.nytimes.com/2026/08/05/technology/ai-china-africa.html

threatens the ability of the expensive-to-use US models to earn a return. Since US AI investment is so massive, its continuation is important for the growth of the economy. China is also making significant investment, but it is far less than that of the US and this investment is not as central to the entire economy.

The important point is that the China is developing a different model from that of the US for commercializing AI. This model is meant to make global-class AI models freely available to any users globally. Further, as Liang et al. (2026) show, China is making a major effort to "embody" AI in various physical machines such as drones, humanoid and non-humanoid robots, factory machinery and all manner of other machines with the goal of increasing their efficiency.

2.2. Clean Technologies and China

Driven by the need to import fossil fuels and increasing environmental problems already in the 1990s, Chinese policymakers began calling for and investing in non-fossil field-based alternatives. Over the next three decades, China became the center, first for manufacturing and now for R&D for the entire value chains of solar photovoltaics, batteries, electric motors, and BEVs. China is on the verge of becoming the first "Electrostatic," where fossil fuels are replaced by renewable sources of energy to become the primary source of energy for mobility and heating.

For example, China has led the transition to lithium-ion batteries, as the most important form of energy storage. Further, Chinese firms are leading the development and commercialization of sodium-based batteries. What is most remarkable is that China dominates the entire battery value chain and in R&D for new chemistries. Similarly, China is a leader in the development of high-efficiency electric motors and chargers.[30] The sole important player in the West is the Silicon Valley firm, Tesla, headed by Elon Musk.

2.3. Biotechnology/Pharmaceuticals

The biotechnology/pharmaceutical industry is an industry based on science instead of engineering, while the two previously discussed industries are more dependent upon engineering. Countries catching up, such as Japan, despite great effort were never able to overtake the US and Western European leaders. For example, in 2026 the largest Japanese pharmaceutical firm in terms of revenue was nineteenth in world! The other East Asian nations such as Korea, are not significant. In terms of biomedical research, East Asian universities are also not yet important. However, here again, Chinese universities are rapidly improving their biomedical research, in part, by merging independent medical schools with comprehensive universities[31] and making

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[30] On batteries, see Levine, E., Chiang, Y-M., Murray, F. E. 2026. Recharging Our Future: Can the U.S. Manufacture Batteries? (January 23). https://tcip.org/wp-content/uploads/2026/03/TCIP-Center-Policy-Report-Recharging-Our-Future.pdf.

[31] Liu, Q., Patton, D., & Kenney, M. 2018. Do university mergers create academic synergy? Evidence from China and the Nordic Countries. Research Policy, 47(1), 98-107.

massive investments in biomedical research, though China still lags in the most innovative new therapeutics.[32]

It is this context that makes China's recent success in developing new pharmaceuticals is so surprising. To illustrate, Chinese success in 2025 is shown by the fact that global pharmaceutical firms licensed drugs worth more than $137 billion. In fact, according to Goldman Sachs nearly 50% of all licensing deals were of Chinese developed molecules.[33] To quote an American pharmaceutical executive, "the reality today is that Chinese innovation is bringing genuinely new molecules and modalities to market."[34] The scale of this licensing has attracted the attention of the US government, which is exploring bans on drug licensing deals between US and Chinese pharmaceutical firms. To recapitulate, even in biomedical fields, China is increasingly becoming a global leader in discovering and developing innovative therapeutic molecules – a surprising result that only a decade ago would have been inconceivable.

2.4. Summary

AI, CT, and biotechnology are three very different technologies and in each of them China has achieved remarkable results, and its firms now operate at the global cutting-edge. Of course, these three notable sectors are not the only ones within which China is becoming increasingly competitive. CT, and, especially, batteries, will transform many other technologies including robots -- humanoid and non-humanoid robots[35], drones, space exploration, and many other industrial applications. China is developing its embodied-AI model, which it hope will make its machines and factories more efficient than ever. In science-based biotechnology, which in China as in the US, is intimately tied to university, China is becoming a vital player and becoming integrated into the global drug-development industry. All these industries of the future are driven by research and development. The trajectory in each of these suggest that China is becoming a global S&T powerhouse.

3. Potential Obstacles to the Chinese Innovation Economy's Success

[32] Yuan, Y. 2026. How Chinese labs race for the next 'first-in-class' breakthrough. Chemical and Engineering News (March 12) https://cen.acs.org/policy/china-research-labs-energy-materials-biotech-breakthrough

[33] Goldman Sachs. 2025. China is increasing its share of global drug development. (December 17). https://www.goldmansachs.com/insights/articles/china-is-increasing-its-share-of-global-drug-development,

[34] Hollan, M. and Stanford, J. 2026. Why Chinese biotech licensing deals became attractive to US investors. *Pharmaexec.com* (July 29) https://www.pharmexec.com/view/chinese-biotech-licensing-deals-became-attractive-us-investors

[35] The decision to develop humanoid robots to replace human beings may be wrong-headed. For example, why should a robot undertaking, for example, folding clothes have only two hands, when there is no limitation to the number of hands a robot might control. The point is that new technologies often are initially limited by the imaginations of their creators. As the new technology is adopted and becomes familiar it can result in better understanding of the ways to use it.

When considering the future for any nation and, by extension, its innovation system, there are many uncertainties, and it is particularly difficult to recognize when a turning point may occur. In our 2016 version, we were uncertain that China could go beyond the catch-up phase arguing that demographic issues and the already enormous real estate bubble might slow Chinese innovative progress -- we were far too pessimistic.

China has had a remarkable and almost unbroken record of success first in low-end assembly and other such industries, but then in many higher-level industries. The macro-level challenges such as the real estate bubble and demographic issues still exist. This is in addition to excessive local government indebtedness and some uncertainty about what will happen after Xi Jinping's retirement. The phenomenon of un- or under-employment, particularly of college graduates, is creating social issues that previously were less common. There is further concern that AI could exacerbate these problems. The final problem, over-capacity, and ruinous price wars means that, in many industries, profits are low, especially when compared to those typical of Western countries and firms. And yet, in 2026, it is unlikely that these internal problems are sufficient to lead to significant upheaval or insoluble difficulties.

Chinese industrial and innovative success has not gone unnoticed in the West. For the previous three decades, the US had largely neglected Chinese efforts to import technology. Beginning already in 2008, the Obama Administration announced “a pivot to Asia” to address what was defined as a rising threat from China in advanced industries. Beginning in 2017, the new Trump Administration openly began singling out China as the key adversary and accelerated attempts to block Chinese access to US information and communication technologies. The Biden Administration continued and even reinforced efforts to block technology transfer particularly in AI and advanced semiconductors, and access to the US market. Further, it increasingly demanded US allies, especially Europe to block Chinese access. This includes a virtual ban on Chinese purchase of technology-rich Western firms, thereby closing that avenue of technology transfer. Under Trump attempts to stifle technology transfer have increased. It is possible that this stifling of technology transfer and, increasingly, all scientific exchanges are halted as the US increases its attempts to decouple the two economies. The impact of these efforts thus far have had little impact on the advancement of Chinese R&D and innovation, though they do appear to limiting scientific cooperation.[36]

The success of Chinese exports in global markets is putting pressure on countries globally to regulate imports from China for all types of goods but, in particular, the clean technologies where China is the global leader and Chinese open-weight AI models. If this effort to isolate

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[36] Wang, J, Li, X., and Wang, Y. 2026. Geopolitical tensions with the US accelerate Chinese firms’ leveraging of science. *Science* 393(6817): 1196-1199.

China from the global S&T community is successful, it might influence Chinese success, but China is rapidly reorienting its trade to the rapidly growing Global South.

These developments have implications for so many different facets of the global political economy. One issue is that in this changing world order, the US will (and perhaps can) no longer advocate and defend the rules-based global trading order that it created as reflected in the WTO but recently has abandoned. President Trump's action such as levying sanctions and tariffs on all manner of countries is convincing traditional allies such as Canada to become more open to Chinese products such as BEVs. In most cases, when the Chinese threatened retaliation such as cutting purchases of US agricultural and other products and cutting off access to rare earths, it was the US that retreated, as Chinese countersanctions were so threatening to US industry.

The rise of Chinese manufacturing also impacts the political economic situation of Europe which is particularly vulnerable in the machinery industries. This was compounded by the July 27, 2025 agreement EU Commission President Ursula von der Leyen and U.S. President Donald Trump signed in Turnberry, Scotland. They agreed to a precedent setting EU-U.S. trade pact negotiated a tariff ceiling of 15% on most European exports to the U.S. in exchange for the EU eliminating import duties on U.S. industrial goods and certain agricultural products. The key parameters of the agreement include various tariff ceilings. While Europe had to agree to nearly all the US demands, China, a far more important exporter, pushed back against US demands and the US retreated when China refused to accept the US tariffs.

The internal and external contradictions in the system that propelled China's rise are surfacing. The question is whether these contradictions and US actions attempting slow Chinese progress will be sufficient to halt or dramatically slow its rise to global parity in science and technology. As with all trajectories of growth, the most difficult thing to predict is when the internal and external difficulties resolve into a turning point.

4. The Future

In the first edition of this book published in 2016, we underestimated the progress in innovation, technology and science that China would experience. The accomplishments of the last decade likely have no parallel in human history. Previous flowerings of human technological achievement have been over longer time frames, does this suggest that the current remarkable Chinese success could lead to stagnation as occurred in the case of the earlier Japanese "Miracle."

Chinese S&T success has not been without tensions. As we discussed, in the previous section the intense pressure to patent and publish is leading to ethical lapses and questionable publications and patents and the rampant questionable use of AI. The hierarchical structure of Chinese institutions may also contribute to other questionable practices such as forced adding of co-authors. Chinese universities have been said to be victims of significant bureaucratic inertia that

may be slowing the pace of research, though these tension, at this point, do not appear to have slowed the advance of Chinese scientific and engineering research.

Some Western scholars have suggested that some in China are awaiting the retirement President Xi Jinping prior to making any significant changes in direction. Whether this is correct or not, the progress of the Chinese innovation system is unlikely to be slowed by this uncertainty. Of course, there are developments such as a depression-like economic event or a world war that might interrupt Chinese development, though the US Great Depression did not slow US manufacturing advances during the 1930s. What is certain is the rise of China as an innovative economy will challenge US and European S&T leadership in ways they have not experienced since the Industrial Revolution.