2015	**10339.1**	**104.3**
2016	**10892.9**	**102.9**
2017	**11577.1**	**102.8**
2018	**12131.5**	**102.7**

Source: 12-3, Gross Output Value of Agriculture, Animal Husbandry and Fishery and Related Indices, China Statistical Yearbook 2019
URL: http://www.stats.gov.cn/tjsj/ndsj/2019/indexeh.htm

China: Output of Aquatic Products from 1978-2018

(10 000 tons)

Year Region	Total Aquatic Products	Seawater Aquatic Products	Naturally Grown	Artificially Cultured	Fish	Shrimps, Prawns and Crabs	Shellfish	Algae	Others	Freshwater Aquatic Products	Naturally Grown	Artificially Cultured	Fish	Shrimps, Prawns and Crabs	Shellfish	Others
1978	465.4	359.5	314.5	45.0	256.1	50.6	26.8	26.0		105.9	29.6	76.2	99.7	3.8	2.4	
1980	449.7	325.7	281.3	44.4	234.1	42.1	23.4	26.2		124.0	33.9	90.2	116.3	5.2	2.5	
1985	705.2	419.7	348.5	71.2	274.5	70.6	47.3	27.3		285.4	47.6	237.8	276.5	5.5	3.4	
1990	1237.0	713.3	550.9	162.4	423.1	107.0	147.3	27.5	8.2	523.7	78.3	445.4	504.9	9.5	7.6	1.8
1995	2517.2	1439.1	1026.8	412.3	758.1	184.8	392.3	74.9	29.0	1078.1	137.3	940.8	1018.6	27.3	20.5	11.6
2000	3706.2	2203.9	1275.9	928.0	896.7	257.9	901.7	106.1	41.5	1502.3	193.4	1308.9	1358.4	76.3	40.0	27.7
2005	4419.9	2465.9	1255.1	1210.8	913.9	281.3	1008.1	133.9	128.6	1954.0	221.0	1733.0	1737.2	140.3	46.3	30.2
2006	4583.6	2509.6	1245.4	1264.2	892.1	299.4	1046.7	137.6	133.8	2074.0	220.4	1853.6	1822.5	167.8	50.9	32.8
2007	4747.5	2550.9	1243.6	1307.3	891.3	298.9	1068.2	138.8	153.7	2196.6	225.6	1971.0	1908.5	202.1	50.5	35.5
2008	4895.6	2598.3	1258.0	1340.3	864.3	288.8	1072.5	142.3	122.1	2297.3	224.8	2072.5	1998.5	210.1	50.1	38.7
2009	5116.4	2681.6	1276.3	1405.2	880.8	303.6	1120.0	148.4	131.0	2434.8	218.4	2216.5	2109.9	228.8	52.0	44.2
2010	5373.0	2797.5	1315.2	1482.3	906.3	310.4	1170.4	156.6	142.1	2575.5	228.9	2346.5	2225.6	248.1	53.8	47.9
2011	5603.2	2908.0	1356.7	1551.3	1075.2	321.8	1212.8	162.9	135.3	2695.2	223.2	2471.9	2343.7	248.8	53.9	48.8
2012	5502.1	2889.6	1314.4	1575.2	957.3	345.7	1264.8	179.0	142.8	2612.5	204.0	2408.5	2235.9	268.7	54.0	54.0
2013	5744.2	2992.4	1327.7	1664.7	972.8	362.6	1327.6	188.5	140.9	2751.9	204.2	2547.7	2366.5	277.0	52.8	55.5
2014	6001.9	3136.3	1403.9	1732.4	1042.5	382.9	1371.7	202.9	136.2	2865.7	202.5	2663.2	2470.7	288.7	51.4	54.8
2015	6211.0	3232.3	1435.7	1796.6	1078.0	386.3	1414.0	211.5	142.5	2978.7	199.3	2779.3	2571.9	300.2	51.6	54.9
2016	6379.5	3301.3	1386.0	1915.3	1063.1	396.1	1476.9	219.3	145.8	3078.2	200.3	2877.9	2653.8	316.1	52.5	55.8
2017	6445.3	3321.7	1321.0	2000.7	1115.8	370.7	1481.4	224.8	129.0	3123.6	218.3	2905.3	2702.6	320.8	46.7	53.6
2018	6457.7	3301.4	1270.2	2031.2	1091.5	368.2	1487.0	236.2	118.5	3156.2	196.4	2959.8	2691.4	369.7	40.8	54.4

Source: 12-15 , Output of Aquatic Products from China Statistical Yearbook 2019
URL: http://www.stats.gov.cn/tjsj/ndsj/2019/indexeh.htm

8.7.3 Chemistry, Materials Science and Nanotechnology

8.7.3.1 Chemistry

8.7.3.1.1 UNESCO Science Report 2015: China

"China in UNESCO Science Report: Towards 2030" covering China's Section (Pg 621-641) authored by Cong Cao published in 2015, Paris UNESCO, excerpts from the report are mentioned below:

According to the Institute of Scientific and Technical Information of China, which is affiliated with the **Ministry of Science and Technology (MoST)**, China contributed about one-quarter of all articles published in materials science and chemistry and 17% of those published in physics between 2004 and 2014 but just 8.7% of those in molecular biology and genetics. This nevertheless represents a steep rise from just 1.4% of the world share of publications in molecular biology and genetics over 1999–2003.

Reform has accelerated under the new leadership

The current reform of the country's science and technology system was initiated against such a backdrop. It got under way in early July 2012, when a National Conference on Science, Technology and Innovation was convened shortly before the transition in leadership. One key outcome of the conference was an official document, Opinions on Deepening the Reform of the Science and Technology System and Accelerating the Construction of the National Innovation System, released in September. Produced by the CCP's Central Committee and State Council, this document furthered implementation of the National Medium- and Long-Term Plan for the Development of Science and Technology (2006–2020), which was released in 2006.

It was also in September 2012 that a new State Leading Group of Science and Technology System Reform and Innovation System Construction convened its first meeting. Made up of representatives from 26 government agencies and headed by Liu Yandong, a member of the Central Committee Politburo and state councilor, the leading group is mandated to guide and co-ordinate the reform and the construction of China's national innovation system, in addition to discussing and approving key regulations. When the country's top leadership changed a few months later, Liu not only kept her party position but was also promoted to vice premier in the state apparatus, thereby ensuring continuity and confirming the importance attached to scientific affairs.

The reform of the S&T system has accelerated since the change in political leadership. In general, the reform conducted by the Xi–Li tandem is characterized by so-called 'top-level design' (dingceng sheji), or strategic considerations in formulating the guidelines, so as to ensure that the reform is comprehensive, coordinated and sustainable; a balanced and focused approach towards reform which takes into consideration the interests of the CCP and country; and a focus on overcoming institutional and structural barriers, not to mention deep-seated contradictions, while promoting coordinated innovation in economic, political, cultural, social and other institutions. Of course, the 'top-level design' has been more broadly exercised in the reforms under the Xi–Li administration. In particular, the reform of the S&T system has strong political backing, with Xi Jinping's aforementioned visit to CAS and the Politburo's Zhongguancun group study setting the course. On several occasions, Xi has taken time off from his busy schedule to preside over the presentation of reports by the relevant government agencies on progress with the reform and the innovation-driven development strategy. He has also been very hands-on when it comes to the reform of China's elite academician (yuanshi) system at CAS and the Chinese Academy of Engineering (CAE), the broader reform of CAS and that of funding mechanisms for the centrally financed national science and technology programs.

A mid-term review of the Medium- and Long-Term Plan

In addition to the political leadership's concerns about the mismatch between the soar in R&D input and the relatively modest output in science and technology, coupled with the necessity of harnessing science and technology to restructuring China's economy, the desire for reform may have been spurred by the mid-term review of the National Medium and Long-term Plan for the Development of Science and Technology (2006–2020). As we saw in the UNESCO Science Report 2010, the Medium- and Long-term Plan set several quantitative goals for China to achieve by 2020, including:

- raising investment in R&D to 2.5% of GDP;
- raising the contribution of technological advances to economic growth to more than 60%;
- limiting China's dependence on imported technology to no more than 30%;
- becoming one of the top five countries in the world for the number of invention patents granted to its own citizens;
- ensuring that Chinese-authored scientific papers figure among the world's most cited.

CAS employs a staff of 60 000 and counts 104 research institutes. It operates on a budget of roughly RMB 42 billion (circa US$ 6.8 billion), just under half of which comes from the government.

Rethinking government funding of research

China has seen rising central government expenditure on science and technology over the past decade. With RMB 236 billion (US$ 38.3 billion) in 2013, spending on science and technology accounted for 11.6% of the central government's direct public expenditure. Of this, R&D expenditure has been estimated at about RMB 167 billion (US$ 27 billion) by the National Bureau of Statistics (2014). As new national science and technology programs had been added over the years, especially the mega-engineering programs introduced under the Medium- and Long-Term Plan after 2006, funding had become decentralized and fragmented, resulting in widespread overlap and an inefficient use of funds. he Central Leading Group for Financial and Economic Affairs turned down several drafts of the reform proposal.

The reform re-organizes the nation's R&D programs into five categories:

- Basic research through the National Natural Science Foundation of China, which currently distributes many of the small-scale competitive grants;
- Major national science and technology programs, which are presumably the mega-science and mega-engineering programs under the Medium- and Long-Term Plan to 2020;
- Key national research and development programs, which presumably succeed the State High-Technology R&D programs, also known as the 863 programs, and the State Basic Research and Development programs, also known as the 973 programs;
- A special fund to guide technological innovation;
- Special programs to develop human resources and infrastructure.

These five categories translate into some RMB 100 billion (US$ 16.36 billion), or 60% of the central government's funding for research in 2013, which will be handled by professional organizations specializing in research management by 2017.

The inter-ministerial conference mechanism is led by MoST with the participation of the Ministry of Finance, National Development and Reform Commission (NDRC) and others. The inter-ministerial conference is responsible for planning and reviewing strategies for

S&T development, determining national S&T programs and their key tasks and guidelines and overseeing the professional research management organizations that will be formed to review and approve funding for national science and technology programs.

MoST and the Ministry of Finance will be responsible for reviewing and supervising the performance evaluation of the funding for national science and technology programs, evaluating the performance of members of the strategic consulting and comprehensive review committee and the performance of the professional research management organizations.

In conclusion, the smooth running of China's S&T system and, indeed, the economy as a whole, can be impacted by unstable domestic developments and unexpected external shocks.[1354]

Key Targets for China
• Raise GERD to 2.50% of GDP by 2020; • Raise the contribution of technological advances to economic growth to more than 60% by 2020; • Limit China's dependence on imported technology to no more than 30% by 2020; • Become, by 2020, one of the top five countries in the world for the number of invention patents granted to its own citizens and ensure that Chinese-authored scientific papers figure among the world's most cited; • Reduce (unit GDP) CO2 emissions by 40–50% by 2020 from 2005 levels; • Increase the share of non-fossil fuels in the primary energy mix from 9.8% (2013) to 15% by 2020; • Cap annual coal consumption at roughly 4.2 billion tons by 2020, compared to 3.6 billion tons in 2013, and lower the share of coal in the national energy mix from 66% at present to less than 62% by 2020; • Raise the share of natural gas to above 10% by 2020; • Produce 30 billion m3 of both shale gas and coal bed methane by 2020; • Achieve an installed nuclear power capacity of 58 Gigawatts (GW) and installations with a capacity of more than 30 GW under construction by 2020; • Increase the capacity of hydropower, wind and solar power to 350 GW, 200 GW and 100 GW respectively by 2020; • Boost energy self-sufficiency to around 85%.

Source: China in UNESCO Science Report: Towards 2030 (2015)
URL: https://unesdoc.unesco.org/ark:/48223/pf0000235406/PDF/235406eng.pdf.multi

Excerpts from an article **"Brain research has become a policy focus for China"** written by **Prof. Cong Cao** dated **April 30, 2018** mentioned that the launch of the **Chinese Institute for Brain Science** in Beijing may represent a significant departure from the current policy focus on applied research and development.

[1354] China in UNESCO Science Report: Towards 2030" covering China's Section (Pg 621-641) authored by Cong Cao published in 2015, Paris UNESCO, available online at URL: https://unesdoc.unesco.org/ark:/48223/pf0000235406/PDF/235406eng.pdf.multi

China devoted 5.1% of total research spending to basic research in 2015, according to the UNESCO Institute for Statistics. This is up from 4.8%, on average, over the past decade, but less than in 2004 (6.0%). The prolonged policy focus on experimental development has resulted in enterprises contributing three-quarters of Chinese research spending (77% of total expenditure on R&D in 2015). Experimental development accounted for as much as 97% of total research expenditure in the business enterprise sector by 2015.

In its *Medium and Long-Term Plan for the Development of Science and Technology (2006–2020)*, China fixed itself the target of devoting 2.5% of GDP to research and development by 2020. The UNESCO Institute for Statistics reports that domestic research spending stood at 2.07% of GDP in 2015 and that the figures for the years 2013 and 2014 had been revised slightly downward since the *UNESCO Science Report* was published.

In parallel, the government launched a sweeping reform of government research funding. National research programs were reorganized into five categories. One of these covers basic research, funded by the National Natural Science Foundation of China through small-scale competitive grants. A second category has been created for special programs designed to develop human resources and infrastructure. The other three categories cater to mega-science and engineering programs, technological innovation and high-tech projects. China contributed about one-quarter of all articles published in materials science and chemistry and 17% of those published in physics between 2004 and 2014 but just 8.7% of those in molecular biology and genetics', it says. 'This nevertheless represents a steep rise from just 1.4% of the world share of publications in molecular biology and genetics over 1999–2003.[1355]

Excerpts from Mc Kinsey and Company: Chemicals published article titled "China's chemical industry: New strategies for a new era" dated March 2019, written by Sheng Hong, Yifan Jie, Xiaosong Li, and Nathan Liu is given below:

China's fast-growing chemical industry has been the largest in the world by revenue since 2011, and its growth rate continues to outpace by far other major chemical-producing regions.

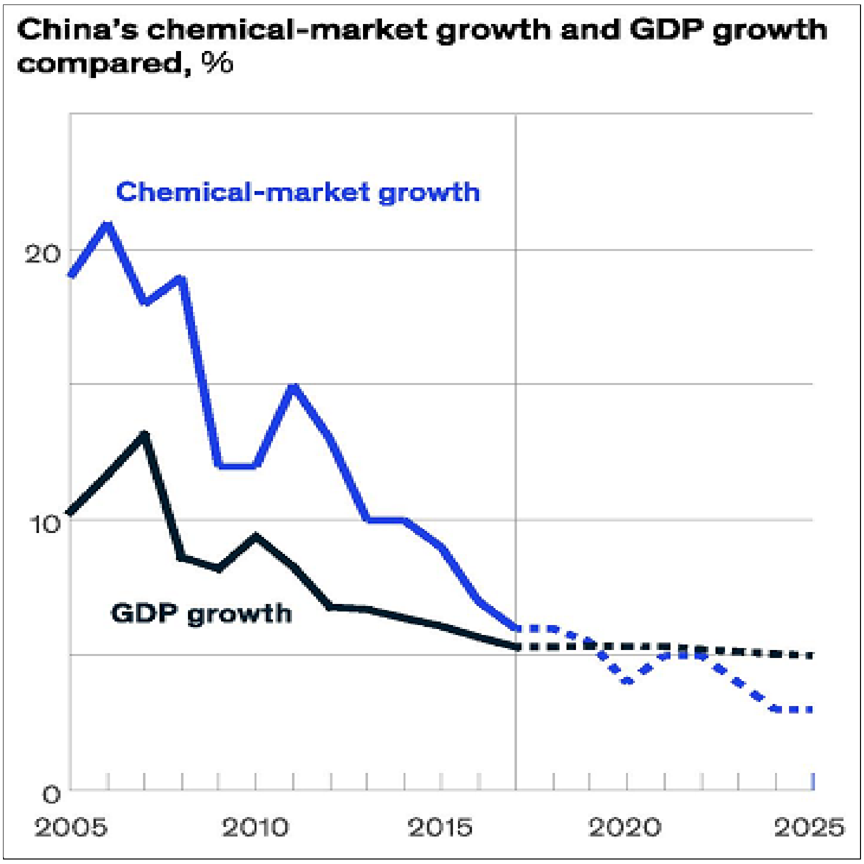
China's new chemical-market dynamics

China's chemical market has contributed half of the growth of the world chemical market over the past two decades. Increasing economic turbulence since mid-2018, related to China's economic slowdown and US–China trade relations, adds new uncertainties to the short-term outlook. While the chemical market's growth rate is expected to slow as the country's overall economy matures, we expect that, in the medium term, the growth rate will remain positive. China's chemical market growth has slowed as the country's GDP has decelerated, and the trend is projected to continue.

[1355] Excerpts from an UNESCO: Science, Technology and Innovation Policy article titled "Brain research has become a policy focus for China" written by Prof. Cong Cao* dated April 30, 2018, available online at URL: http://www.unesco.org/new/en/natural-sciences/science-technology/single-view-sc-policy/news/brain_research_has_become_a_policy_focus_for_china/

***Professor Cong Cao,** a scholar of innovation studies at the Faculty of Business within the University of Nottingham Ningbo China and author of the chapter on China in the UNESCO Science Report (2015).

China's Chemical Market growth and GDP growth comparison in %



Source: Mc Kinsey and Company: Chemicals
URL:https://www.mckinsey.com/industries/chemicals/our-insights/chinas-chemical-industry-new-strategies-for-a-new-era

The enormous base that China's chemical industry now constitutes around $1.5 trillion of sales in 2017, amounting to nearly 40 percent of global chemical-industry revenue means that, even at lower overall growth rates, the growth of absolute volume is still very large.

Upgrading innovation and technological capabilities to strengthen the industry

An embrace of R&D is under way across the chemical industry, from sector giants, such as Sinochem with its "In science we trust" slogan, to start-up companies working in a wide array of leading-edge areas, such as enzymes, catalysis, Nano materials, and battery materials. China's chemical-R&D spending is now among the world's leaders. The structure of China's chemical-industry R&D has also changed, moving from one in which initiatives were under government direction to one primarily driven by individual companies within an ecosystem of collaboration with government research institutions and universities and that has a strengthened regime to protect intellectual property.

China's chemical-technology capabilities are rapidly advancing. There are many examples of Chinese companies gaining technological parity with Western companies. One in the petrochemical field has been Wanhua Chemical, which has developed its own methylene-diphenyl-diisocyanate (MDI) technology. Wanhua is now the world's largest MDI producer in what had historically been a close-knit sector dominated by a handful of

Western companies due to isocyanates chemistry's challenging technology-entry barriers.

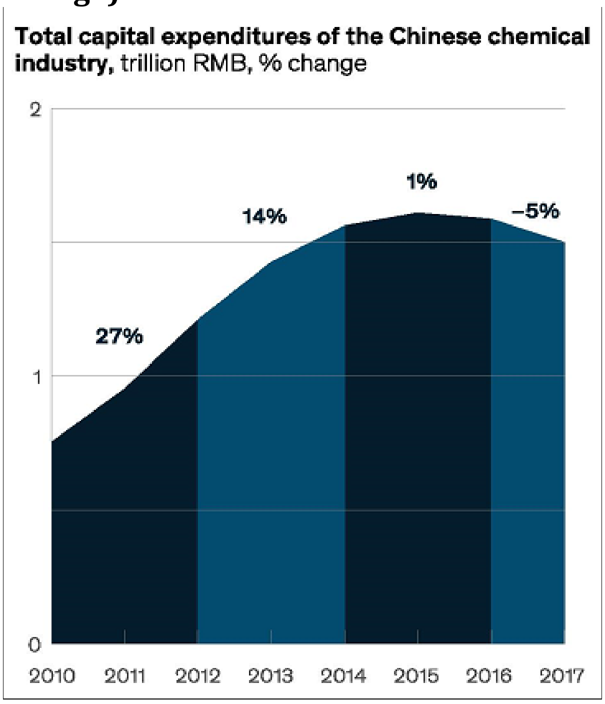
Opening the industry up to new investors

Several POEs are aggressively investing upstream into building-block petrochemical production, reshaping China's petrochemical industry. There are nine POE-backed projects accounting for over half the 20 million metric tons per year of new ethylene capacity being planned in China. For example, Hengli Petrochemical is moving upstream into oil refining to source raw materials for its purified terephthalic acid and polyester production.

Tightening of financing availability

The industry is also operating under new constraints. The Chinese government's policy to tighten credit across the country's economy has been a particular handicap for the capital-intensive chemical industry that has in the past benefited from low-cost capital to expand capacity. Annual chemical capital expenditures had risen rapidly in the 2010 to 2015 period, when China's chemical demand was growing at more than 10 percent a year, more than doubling to reach 1.61 trillion Renminbi in 2015. Spending peaked in 2015 and fell back 7 percent, to 1.5 trillion Renminbi, by 2017. Pressure on financing has led the Chemical Industry to pull back on capital expenditures.

Total capital expenditure of the Chinese Chemical Industry, (trillion RMB, % change)

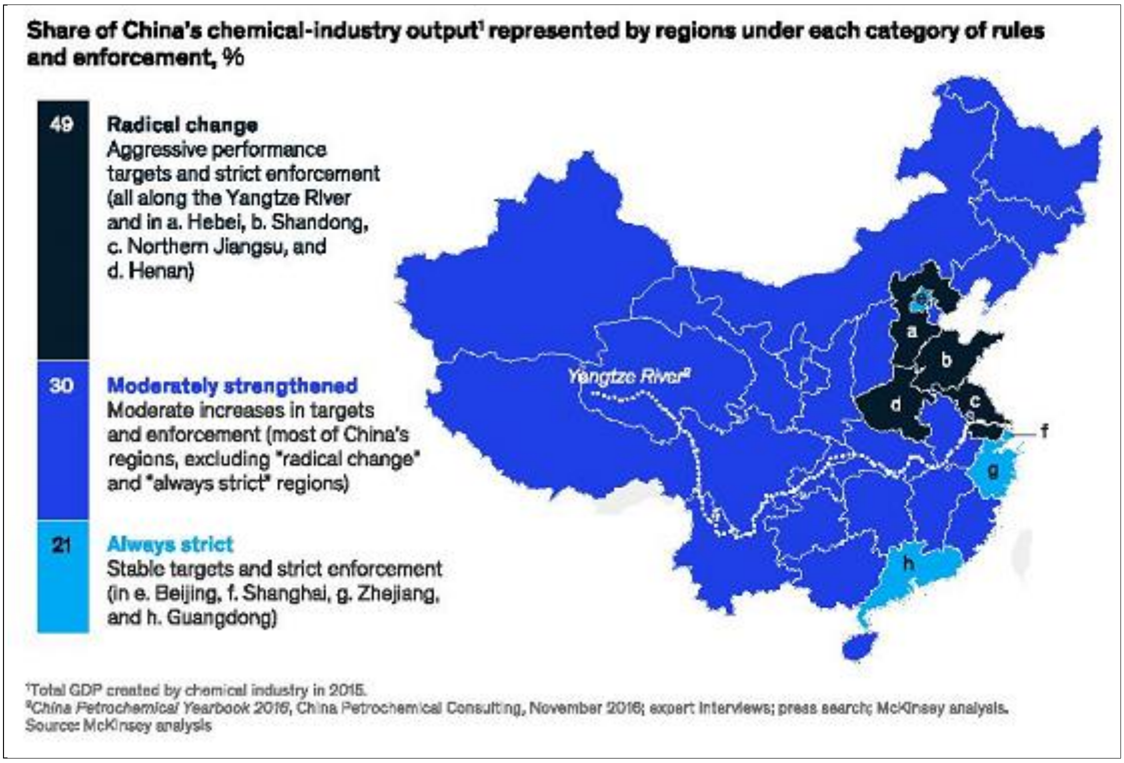


Source: Mc Kinsey and Company: Chemicals
URL:https://www.mckinsey.com/industries/chemicals/our-insights/chinas-chemical-industry-new-strategies-for-a-new-era

New environmental regulations leading to restructuring

China’s chemical buildup over the past two decades had prioritized growth over environmental quality. The 13th Five-Year Plan for environmental protection published in 2016 enshrining “clear waters and lush mountains” as a national policy has marked a sharp shift, as China’s authorities have started to address environmental degradation.
Looking ahead over the next three to five years, we expect China’s environmental authorities to continue to push enforcement energetically in the designated “radical change” regions, which account for nearly 50 percent of China’s chemical production, as well as push for improvements in the “moderately strengthened” enforcement regions.

Share of China’s chemical industry output represented by regions under each category of rules and enforcement, %



Source: Mc Kinsey and Company: Chemicals
URL:https://www.mckinsey.com/industries/chemicals/our-insights/chinas-chemical-industry-new-strategies-for-a-new-era

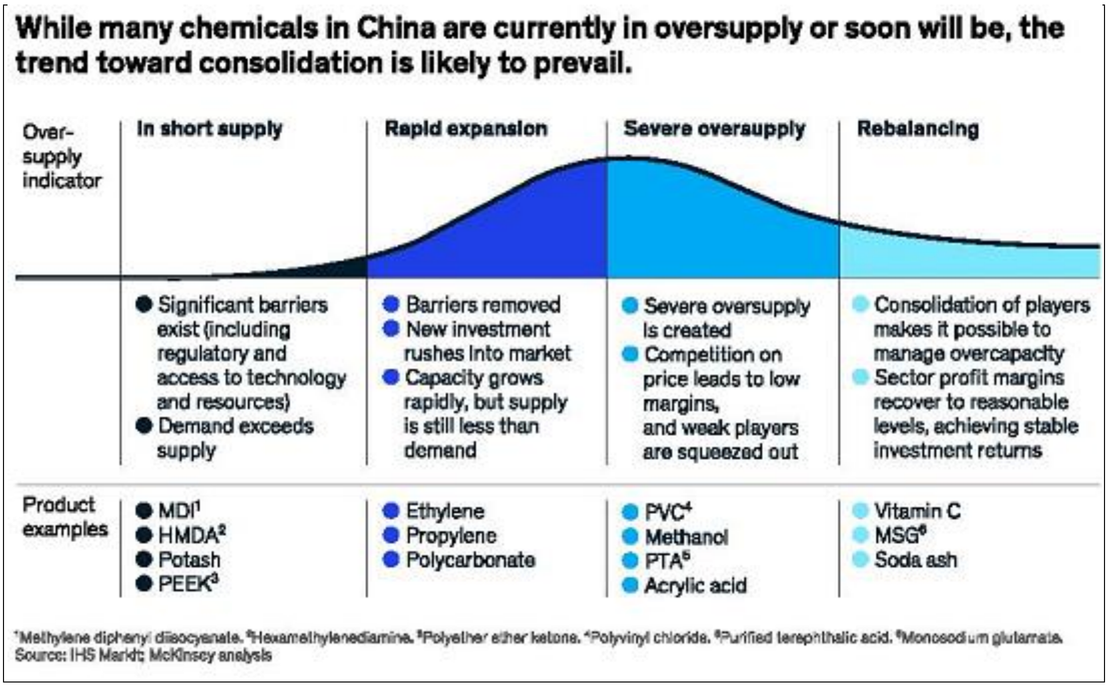
This is likely to cause continuing disruptions in specialty-chemical markets. The impact can be substantial: environmental enforcement during 2017 and 2018 shut down 30 to 40 percent of all Chinese production capacity for monosodium glutamate and certain dyestuffs and pesticides.

Survival of the fittest, China style

The evolution of the country’s different chemical-industry segments is likely to continue to follow broadly the pattern it has shown over the past two decades. This consists of a phase of massive overinvestment and oversupply as state-owned enterprises (SOEs) often with MNC partners and POEs rush to move in and produce chemicals that have historically been in short supply in China due to either lack of feedstock or lack of access to process technology. A number of segments ranging from commodities, such as soda ash, to specialties, such as vitamin C and monosodium glutamate have reached that phase.

However, there is an impressive list of chemicals for which the battle to ascertain the winner is still very much under way.

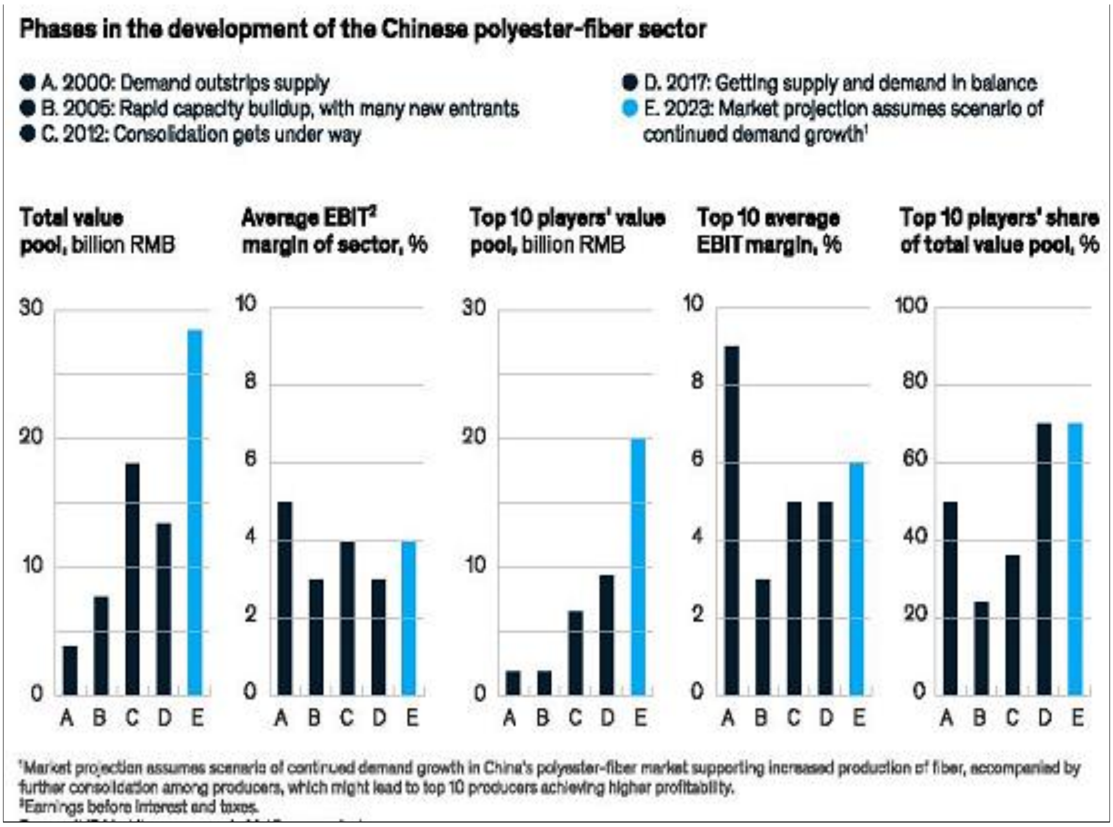
China: Chemical Supply



Source: Mc Kinsey and Company: Chemicals
URL:https://www.mckinsey.com/industries/chemicals/our-insights/chinas-chemical-industry-new-strategies-for-a-new-era

It's important to underline that there are still important segments of the chemical industry notably ethylene and propylene for which China's demand continues to outstrip domestic production capacity. Our projections suggest that even with the investments that have been announced, ethylene production will continue to lag demand in 2023. However, the rules opening the petrochemical segment to new players means that capacity is likely to continue to build up. The polyester fiber market provides a good example of the pattern of market evolution and how it affects a segment's value pool over time. Value pools in China's chemical industry: In polyrster, the top ten players have consistently increased their profits, outpacing the rest of the field.

Phases in the development of the Chinese polyester-fiber sector



Source: Mc Kinsey and Company: Chemicals
URL:https://www.mckinsey.com/industries/chemicals/our-insights/chinas-chemical-industry-new-strategies-for-a-new-era

How players in China's chemical industry can position themselves for the new era

State-owned enterprises: Diverging fortunes and roles?

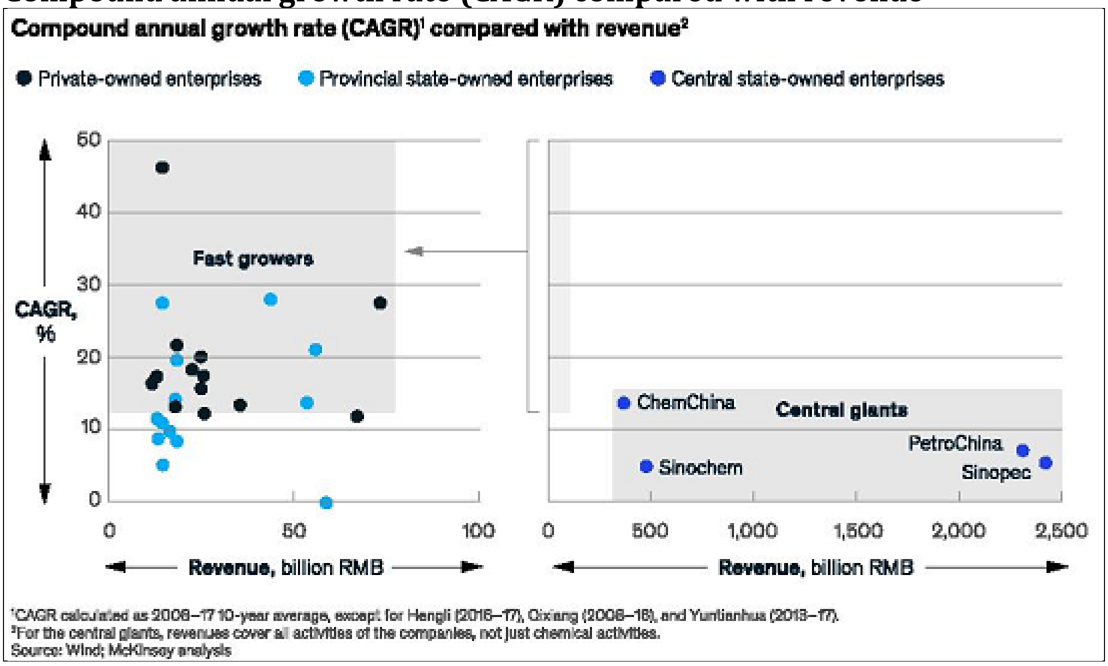
SOEs have led China's chemical-industry development over the past two decades, but it is important to look at this group more closely to see how future developments may unfold. Best known are the central SOEs, while the groups of SOEs owned by provincial governments are sometimes overlooked. A number of players in this latter group have, in fact, followed a more dynamic and entrepreneurial trajectory than has the central-SOE group. One example is the previously mentioned MDI maker Wanhua, of which the majority owner is Shandong province. Wanhua's path to MDI leadership started 40 years ago making synthetic leather, and it now has impressive profitability and aggressive expansion plans, including a world-scale MDI project on the US Gulf Coast. Some SOEs struggle with centralization, siloed organizational structure, and layers of bureaucracy that may handicap them in developing a strong specialties segment. Such specialties businesses typically move at a fast pace and depend on cross-functional collaboration among R&D, manufacturing, and sales functions to succeed. Should the SOEs be able, however, to overcome these organizational challenges and develop the necessary functional excellence, their scale would represent strength to draw on.

Privately owned enterprises: A drive to professionalize business

Chinese private-sector chemical companies are also on the cusp of an important shift. They are moving from the buccaneering days of China's peak chemical-market growth to ones of more discipline a shift enforced by new financial and environmental constraints and the evolution toward a higher level of maturity in the market. The challenge facing the many companies in this group is to professionalize their operations in all dimensions. Large numbers of these companies are still run by their founders, who are still very much in the driver's seat as executive chairs, even if they have public shareholders. At the biggest of these companies, the founders are now billionaires**.** The differing fortunes of POEs, central SOEs, and provincial SOEs highlight the dynamics that are playing out in the market. A number of POEs and provincial SOEs are continuing to find very-high-growth opportunities, while most of the central SOEs are achieving lower growth rates, at under 10 percent per year.

Leadings players in China's chemical markets fall into two main categories: Fast growers and central giants

Compound annual growth rate (CAGR) compared with revenue



Source: Mc Kinsey and Company: Chemicals
URL:https://www.mckinsey.com/industries/chemicals/our-insights/chinas-chemical-industry-new-strategies-for-a-new-era

International companies: Facing an uphill struggle

It's not easy to find an example of a chemical MNC that has managed to gain a market share in China that is the same as its market share in the global market, a fact that encapsulates the challenges that MNCs have consistently encountered as China's chemical market has ballooned. Historically, MNCs have often entered new geographical markets by making acquisitions, but this has not been feasible in China.

In the first round of large investments by MNCs in China starting 20 years ago, their entry was through joint ventures with Chinese SOEs, allowed on the condition that the MNCs brought chemical-process technologies needed in China. The lack of majority control tended to put a cap on the scale of moves. In addition, where MNCs have been able to own fully their Chinese subsidiaries in more downstream chemicals, MNCs' conservative decision-making processes designed to avoid high-risk moves have made it difficult to make the aggressive capacity expansions typical of the entrepreneurs leading Chinese POEs.

Since the change in rules in 2015, MNCs have been able to make wholly owned investments in upstream petrochemical plants. A further challenge is that some MNCs are failing to undertake product development tailored to the Chinese market's needs. Finally, the shifts under way in China's chemical industry are on a massive scale that mirrors that of the industry itself. Players in the world's largest chemical market must make the adaptations necessary to ensure success at growth rates that are less than half of what they have been seeing in the recent past. At the same time, they must adjust to a world of scarcer financing and tighter environmental regulation. The factors driving success will vary among the different groups of players in the industry, but in all cases, they will need to be informed by a readiness to adapt rapidly and innovate to meet the needs of the market.[1356]

Chemical and Engineering News titled **"Chemists benefit from changes to China's R&D policies" dated May 2, 2016,** mentioned that **Chemistry** research in China is set to get a boost from a raft of recently announced central government policies and goals. Chemists working in China's universities and research institutes can expect to see increased overall funding. They are also set to benefit from a new policy that liberalizes the transfer of technology from universities and institutes to companies and shifts from basic research to practical applications. The new technology transfer policy could have a greater impact on **chemistry** in China than the expected funding increase, observers say. The changes come after the conclusion in March of China's annual parliament, the National People's Congress (NPC), in Beijing. This is a transitional year for China as it moves from the 12th to the 13th five-year plan, which covers 2016–20. In these five-year plans, the Chinese government maps out how it will develop the country socially and economically, an approach China adopted from the Soviet Union in the 1950s. The newest plan includes a push for major breakthroughs in basic research, applied research, big data, and what the government calls "exploring frontiers," which involves disciplines such as marine science.

Speaking at NPC, Wang Yuanhong, senior economist from the State Information Center, explained how the government is increasing the ratio of deficit to gross domestic product to provide an additional $72 billion to spend on pro-growth measures. This includes setting up national-level efforts to boost research and innovation as China looks to science to fuel its slowing economy. The government estimates that scientific research will account for 60% of economic growth by 2020.

[1356] Excerpts from Mc Kinsey and Company: Chemicals published article titled "China's chemical industry: New strategies for a new era" dated March 2019, written by Sheng Hong, Yifan Jie, Xiaosong Li, and Nathan Liu, available online at URL: **https://www.mckinsey.com/industries/chemicals/our-insights/chinas-chemical-industry-new-strategies-for-a-new-era**

During a news conference at NPC, Minister for Science & Technology Wan Gang confirmed that China will continue to increase research funding. Spending on R&D has increased by an annual average of 11.4% from 2012 to 2015 and will reach 2.5% of gross domestic product by 2020, up from 2.1% in 2015.

Wan said overall R&D expenditure in China in 2015 amounted to $215 billion, 77% of which came from companies. Of that figure, $10.3 billion went to basic science, according to a summary from China's National Bureau of Statistics that was released in advance of the full figures, which have not yet been made public. Yu Biao, vice director of Shanghai Institute of Organic **Chemistry** and director of State Key Laboratory of Bioorganic & Natural Products Chemistry, tells C&EN that work to address issues of health, energy, and climate change are important and reflect the Chinese government's support of applied chemistry research. But he predicts that "it will be difficult to secure support for pure **chemistry** research and publishing papers."

Jay Siegel, dean of Tianjin University's School of Pharmaceutical Science & Technology, agrees. "China is not a country that at this moment places a heavy importance on very basic research," he says. "It wants to move toward basic science, but it's a country that sees technology as a way to drive its economy in the next five years." Yu foresees a strengthening of the relationship between basic and applied research in China. "The inherent mode of research is going to undergo a transformation," he says. "Interdisciplinary and practical research will receive encouragement and vigorous support." **Chemists** will need to consider focusing on problems in these areas of science.

China's government wants to make research outcomes more easily available to small businesses as well as big enterprises as part of its "Made in China 2025" policies aimed at boosting the economy. National research institutes and universities will be able to sell their intellectual property to businesses without needing national-level approval, which has previously involved lengthy waits. All profits earned on the sales will now be kept by the institutes where the research was conducted. New incentives aimed at researchers themselves may further speed up the commercialization of scientific research in China. At least 50% of the proceeds from the sale of findings will go to the researchers themselves. They will be able to work for the companies that buy their research for up to three years while maintaining their positions at the institute where they did the research. It is hoped that this will encourage greater productivity.

Gao Xudong, deputy director of the Research Center for Technological Innovation at Tsinghua University, told *People's Daily,* the official newspaper of the Chinese Communist Party, that this change should also resolve a fundamental issue: "Some enterprises who bought scientific research findings could not fully use them due to a lack of understanding of the findings." In light of the increasing push to transfer technology to industry, Tianjin University in 2013 opened China's first national center for patent and intellectual property. The Tianjin University Technology Transfer Center now has 18 full-time patent brokers who work on moving technology from the university to industry.

Removing the need for central approval for the sale of intellectual property will, in turn, grant China's universities and institutes greater autonomy in what they research."Passing greater autonomy to universities and cutting the red tape on the reporting for grants involving science and technology is a very big thing because, in general, funds have been very controlled. So if we see policies that allow for more entrepreneurial ventures within the university your degree programs, new directions for research that the university can control, then we get bottom-up control. This will have a big impact on research in general, and **chemistry** is poised to benefit enormously," Siegel says. Or, as Yu summarizes, China's new policies "will encourage **chemists** to get involved in 'useful' research."[1357]

Excerpts from article titled **"Impact of tightened environmental regulation on China´s chemical industry"** written by Kai Pflug, mentioned that key regulatory changes within the last two years include a massive program of shifting chemical production to chemical parks, restrictions on the location of chemical production near the Yangtze river, the tightening of rules for many individual substances and substance classes and the introduction of an environmental tax, all overseen by a strengthened and renamed ministry.

The goal of shifting chemical production to chemical parks was first outlined in the 13th Five-Year Plan for the Chemical Industry (Petroleum and Chemical Industry of China, 2016), in which it is stated that during the period of the plan "the rate of new established chemical industrial enterprises entering the park will reach 100%, and the relocation of the enterprises outside the parks shall be accelerated". These high-level guidelines were later specified in more detail, providing a timeline for the different sizes of chemical companies. In addition, the guidelines were transferred from a central level to the provincial level. For example, Fujian province in 2018 enacted the "Implementation Plan for the Relocation and Renovation of Dangerous Chemicals Production Enterprises in Urban Densely Populated Areas", which states that small and medium-sized enterprises and large enterprises with major potential risks will start relocation and reconstruction before the end of 2018 and be completed before the end of 2020 while other large-scale and extra-large enterprises will start relocation and reconstruction before the end of 2020 and will be completed before the end of 2025. Other provinces including Anhui, Gansu, Guangdong, Heilongjiang, Henan, Jiangsu, Jilin, Shaanxi, Shanghai, Sichuan, Tianjin and Zhejiang have enacted similar guidelines. Some provinces even indicate target figures for the share of chemical enterprises to be located in chemical parks by 2025, aiming to reach 90% or higher from the current nationwide 45%.

At the same time, there is the objective of regulating or even reducing the number of chemical parks. The 13th Five-Year Plan for the Chemical Industry states that "in principle, no new chemical industrial parks will be established". Indeed, some Chinese provinces have initiated the process to close or revoke chemical industrial parks, with some industry participants expecting the number of chemical parks to go down to about 480 by the end of 2018 from the 601 chemical parks existing at the end of 2017. However, given the fact that the number of chemical parks increased by almost 100 from the end of 2016 (502 parks) to the end of 2017 despite the objective of not increasing the number of chemical parks, this is a somewhat risky prediction.

Certainly, there are such developments on the level of individual provinces. Shandong province has announced the goal of halving the number of chemical parks in the province to 100 (ICIS, 2018). A first step towards this goal was the certification of 31 chemical

[1357] Chemical and Engineering News titled "Chemists benefit from changes to China's R&D policies": Push for technology transfer may have larger effect than funding boost by Frank Hersey, Volume 94 Issue 18, pp. 22-23 Issue Date: May 2, 2016, available online at URL: https://cen.acs.org/articles/94/i18/Chemists-benefit-changes-Chinas-RD.html parks as qualified. A second and third list of qualified chemical parks in Shandong is expected to be announced by the end of September and December. Shandong may serve as a model as it is reported to both have a low share of chemical companies located in chemical parks (37%) and a high share of GDP depending on the chemical industry (20%).

In any case, the goal of controlling the number of chemical parks indicates that the objective of the relocation is not only to avoid chemical production being located close to population centers, but also to allow for a better control of the individual chemical companies therein, in particular with regard to their environmental efforts. Even within some chemical parks, limitations have been imposed with regard to the location of chemical production, particularly in the Yangtze area. Chemical industry projects have been prohibited within one kilometer of the Yangtze and its major tributaries, a regulation that also applies within chemical parks near the river.[1358]

8.7.3.2 Materials Science

An article titled **"Materials science is helping to transform China into a high-tech economy: Researchers are reaping the benefits of carefully built programs and a surge in funding"** dated **March 27, 2019** published by **Nature Research Journal,** mentioned the following details:

Hard Data

1980s: Chinese universities and research institutes develop 23 small-scale materials databases with financial support from the national government. They are used and updated infrequently.

2000: China launches two national, centralized materials databases involving 18 research institutes. For the first time, data are collected and entered in a standardized format (see http://www.materdata.cn).

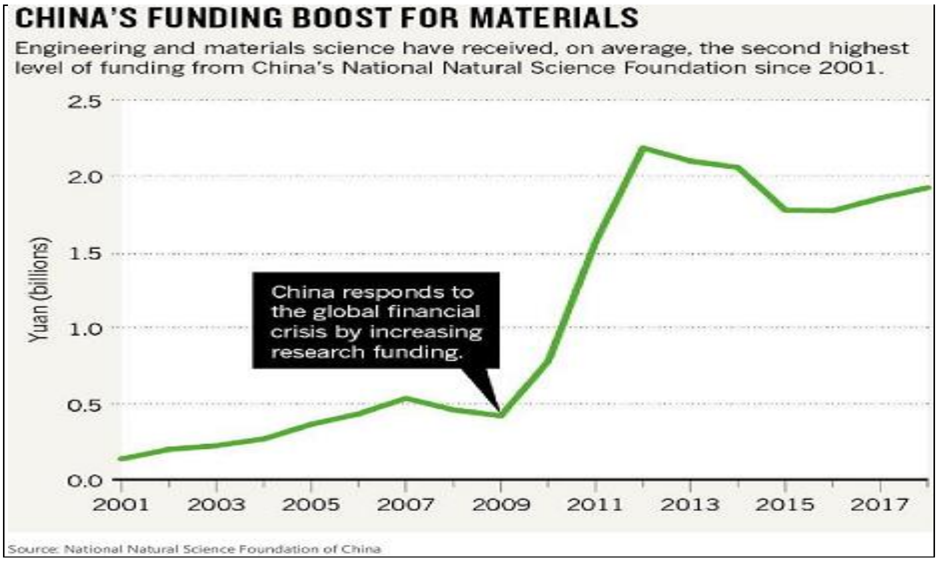
2016: Policymakers invest in developing databases and big-data technology for China's Materials Genome Engineering project, which echoes the Materials Genome Initiative launched by then-US president Barack Obama in 2011.

A clear funding plan

Funding for materials science in China has quadrupled since 2008, and the field receives the second highest level of funding from the National Natural Science Foundation of China (NSFC), behind only medical sciences (see 'China's funding boost for materials'). The volume of China's materials-science research has grown correspondingly. According to data from the Web of Science, the number of papers on the topic more than tripled between 2006 and 2017, to around 40,000, and around one in every nine papers published by a Chinese researcher in 2015 was in materials science.

[1358] Excerpts from Practitioner's Section article titled "Impact of tightened environmental regulation on China´s chemical industry" written by Kai Pflug, published by Journal of Business Chemistry available online at URL: https://businesschemistry.org/article/?article=305

China Funding Boost for Materials



Source: China Funding Boost for Materials
URL: https://www.nature.com/articles/d41586-019-00885-5

Since 2006, China's scientific research and development (R&D) funding has been guided by a national plan to improve the country's level of innovation by 2020. The plan includes the realization of ambitious research and development projects, such as Moon exploration and the development of China's first domestically designed passenger aircraft. These goals are designed to spur technological breakthroughs and improve the country's economic prospects, and materials science is crucial to their success.
In 2018, the NSFC pumped more than 2 billion yuan into 701 projects, including the MGE and work on nanotechnology and advanced electronic materials. In the same year, the Ministry of Science and Technology announced total funding of more than 1.6 billion yuan for six special projects, which also covered nanotechnology.

China now publishes more high-impact research papers than any other country in 23 fields with clear technological applications, including batteries, semiconductors, new materials and biotechnology (see go.nature.com/2xuboa9). And in November, a start-up called Qing Tao Energy Development, begun in 2014 by PhD graduates from Tsinghua University, Beijing, announced that it had developed the country's first solid-state battery production line.[1359]

8.7.3.3 Nanotechnology

The National Center for Nanoscience and Technology (NCNST) of China is co-founded by Chinese Academy of Sciences (CAS) and Ministry of Education. It is a subsidiary non-profit organization of CAS which enjoys full financial allocations with a status of independent non-profit legal entity. It will have 314 formal employees. The center was

[1359] Excerpts from article titled "Materials science is helping to transform China into a high-tech economy: Researchers are reaping the benefits of carefully built programs and a surge in funding" written by Sarah O'Meara dated March 27, 2019 published by Nature Research Journal, available online at URL: https://www.nature.com/articles/d41586-019-00885-5 officially founded on December 31, 2003, with CAS, Peking University and Tsinghua University as its initiators and co-founders.[1360]

Introduction to NCNST

National Center for Nanoscience and Technology, China (NCNST), established in December 2003, is co-founded by the Chinese Academy of Sciences (CAS) and the Ministry of Education as an institution dedicated to fundamental and applied researches in the field of nanoscience and technology, especially those with important potential applications. NCNST is operated under the supervision of the Governing Board and aims to become a world-class research center, as well as public technological platform and young talents training center in the field, and to act as an important bridge for international academic exchange and collaboration.

The NCNST currently has three CAS Key Laboratories: the CAS Key Laboratory for Biological Effects of Nanomaterials & Nano safety, the CAS Key Laboratory for Standardization & Measurement for Nanotechnology and the CAS Key Laboratory for Nano system and Hierarchical Fabrication. Besides, there are Division of Nanotechnology Development, Nano Processing Laboratory and Theoretical Laboratory. The NCNST has co-founded 19 collaborative laboratories with Tsinghua University, Peking University, and Chinese Academy of Sciences. Management departments of NCNST consist of General Administration Office, Science and Technology Management, Human Resource Management, Education department, S&T development and promotion Management, Finance Management, Administration Management and Assets Equipment Management. The National Technical Committee 279 of Standardization Administration of China (SAC/TC279) on Nanotechnology, the Special Committee on Nanotechnology of China National Accreditation Service for Conformity Assessment, the Chinese Society of Nanoscience and Technology, and Secretariat of National Steering Committee for Nanoscience and Nanotechnology are affiliated to the Center. The high impact academic journal on nanoscience and nanotechnology, Nanoscale, is co-hosted by the Center and the Royal Society of Chemistry Publishing Group.

The NCNST has doctor and postdoctoral education programs in condensed matter physics, physical chemistry, materials science, nanoscience and technology. In 2014 the International Evaluation Committee highly applauded the significant achievements and outstanding contributions in nanoscience, and remarked that NCNST had risen to a position of “by far the best in China”. In 2018 the Nature Index showed that NCNST had been one of the “Top 5 Institute of CAS”. According to the latest data of Clarivate Analytics in 2018, five researchers in NCNST were included in the "Highly-Cited Researchers” around the world in recent 10 years, a total of 216 highly cited papers.

In November 2013, the NCNST initiated one of the Strategic Priority Research Program of CAS, entitled "Industrial Nanomanufacturing Focus". The innovation teams from 25 institutes of CAS joined forces to focus on the main R&D targets of the nanotechnology-related new product development and Nano systems integration, which will finally raise the technical level of the traditional industry. In December 2018, the program "Industrial Nano-manufacturing Focus" has passed the test. In October 2015, the CAS set up the

[1360] National Center for Nanoscience and Technology (NCNST): History, available online at URL: http://english.nanoctr.cas.cn/au/hy/

"Center for Excellence in Nanoscience" (CAS-CENano) to speed up the establishment of a new model for scientific research. The CAS-CENano's tasks are to accumulate innovative talent, focus on the fore frontier of nanoscience, achieve a major breakthrough and become an internationally renowned organization.[1361]

Excerpts from news article dated **March 5, 2012** titled **"China 'soaring ahead' in nanotechnology research"** written by **T.V. Padma** mentioned that China has emerged as a major nanotechnology player. China's share of published nanotechnology papers soared from less than 10 per cent of the global total in 2000, to nearly a quarter by 2009 overtaking the United States. By contrast, India was occupying seventh place. However, neither was well-represented in the top three nanotechnology research journals, and although Chinese representation in high-quality journals was rising, its researchers were well behind the European Union and the United States in attracting citations. In terms of patent applications received, China was second to only the US, and accounted for a fifth of international patenting activity. By contrast, India represented just four per cent of such activity.[1362]

8.7.4 Deep sea exploration

Chapter 15 captioned "China's Domestic Law on the Exploration and Development of Resources in Deep Seabed Areas", of the book "The Law of Seabed" written by Chelsea Zhaoxi Chen, highlights that the "Law of the People's Republic of China on Exploration for and Exploitation of Resources in the Deep Seabed Area", adopted on February 26, 2016, came into force on 1 May 2016. This represents China's first special law dealing with the exploration for and exploitation of deep seabed resources. "Resources" here however was not defined. It is speculated that currently the definition only refers to non-living resources such as minerals but is intentionally silent regarding living seabed resources. This limitation to non-living resources in China's Deep Seabed Law is inferred from the limitation of the 1982 United Nations Convention on the Law of the Sea (UNCLOS, or the Convention), and the definition given there under for the term "resources".

In addition, the law applies to activities conducted by Chinese entities in the Area. Pursuant to Article 1(1) of the UNCLOS, "Area" means the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction. In other words, the applicable area of the Deep Seabed Law is not the traditional "within the territory of the People's Republic of China and other sea areas under the jurisdiction of China". Instead, it aims to effectively govern the behaviour of Chinese citizens, legal persons or organizations from territories outside the jurisdiction of China and other countries, i.e. a law governing extraterritorial issues. Prior to the adoption of the Deep Seabed Law, China had already adopted laws, rules and regulations regarding the exploration for, and development of, oceanic mineral resources located within marine areas under its national jurisdiction:

[1361] National Center for Nanoscience and Technology (NCNST): Introduction, available online at URL: http://english.nanoctr.cas.cn/au/bi/

[1362] Excerpts from scidev.net news article dated March 5, 2012 titled "China 'soaring ahead' in nanotechnology research" written by T.V. Padma, available online at URL: https://www.scidev.net/global/water/news/china-soaring-ahead-in-nanotechnology-research.html