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# Ten-year Review and Future Trend of Scientific and Technological Reform

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# Ten-year Review and Future Trend of Scientific and Technological Reform


## Abstract

From the aspects of the macro-governance capability of science and technology (S&T), the mechanism for tackling emerging problems, the life-time career of S&T researchers, the innovation chain of S&T activities, the life cycle of enterprises, innovation players, regional innovation system, and the ecology of S&T innovation, this study systematically reviews the practical exploration and effects of China's S&T reform experience since the 18th National Congress of the Communist Party of China (CPC). It also analyzes the latest S&T reforming characteristics in many other innovative countries, such as stronger strategic coordination, broader government intervention, more concern of disruptive innovation and future technology, greater efforts on talent cultivation and introduction, and better balance between the open science and S&T security. Based on these findings, we discuss the future-oriented S&T reforming trends, and provide some new ideas and prospects for establishing a strong country in S&T, and realizing the country's self-reliance and self-improvement in science and technology.



## Keywords

science and technology reform; science and technology innovation; innovation governance; innovation policy; reform trend



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# Ten-year Review and Future Trend of Scientific and Technological Reform

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**Abstract:** From the aspects of the macro-governance capability of science and technology (S&T), the mechanism for tackling emerging problems, the life-time career of S&T researchers, the innovation chain of S&T activities, the life cycle of enterprises, innovation players, regional innovation system, and the ecology of S&T innovation, this study systematically reviews the practical exploration and effects of China's S&T reform since the 18th National Congress of the Communist Party of China (CPC). It also analyzes the latest S&T reforming characteristics in many other innovative countries, such as stronger strategic coordination, broader government intervention, more concern of disruptive innovation and future technology, greater efforts on talent cultivation and introduction, and better balance between the open science and S&T security. With these findings, we discuss the future-oriented S&T reforming trends, and provide some new ideas and prospects for China to build up the S&T and realize the self-reliance and self-improvement in S&T. **DOI:** 10.16418/j.issn.1000-3045.20220412003-en

**Keywords:** science and technology reform; science and technology innovation; innovation governance; innovation policy; reform trend

Since the 18th National Congress of the Communist Party of China (CPC), China's science and technology (S&T) reform has been expanding and deepening, covering not only S&T but also economic and social development and national security. The CPC Central Committee with Comrade Xi Jinping at its core lays a high emphasis on S&T reform and bolsters both S&T innovation and system innovation to build China into an innovative country and build up China's strength in S&T. It has introduced a top-level design document for implementing the innovation-driven development strategy and formulated an implementation plan for deepening the reform of the S&T system. With the full implementation of all the tasks, a systematic, sound, and effective policy system has been formed. All these reform achievements have been solidified into the *Law of the People's Republic of China on Science and Technology Progress* revised in 2022 and become a state will. This study systematically reviews China's S&T reform experience and achievements since the 18th National Congress of the CPC, analyzes the situation and problems, and discusses the trend of the S&T reform in the future.

## 1 Main achievements of S&T reform in China in the last decade

In the last decade, China has insisted on motivating S&T researchers and enhancing the supporting role of S&T in national development and security in the S&T reform. Following the overall thought of top-level design, framework construction, problem tackling in reform, and policy implementation, China has established a system composed of multiple pillars for the S&T reform and made substantive progress in key fields [1]. With efforts in all aspects, breakthroughs achieved in multiple points, and the deepening of development, the efficiency of the national innovation system has been improved, which are mainly embodied in the following nine aspects.

### 1.1 Improving the macro-governance and enhancing the macro-coordination of S&T

It has become a trend of the times to improve the macro-governance system and capability of S&T [2]. China has taken the improvement of the macro-governance mechanism of S&T as an important part of S&T reform and made efforts to strengthen the coordination of functions, elements, and supervision of S&T innovation and to promote the modernization of the national S&T governance system and capability.

The macro-coordination of S&T was enhanced. The national science and technology advisory committee, the national science and technology leading group, and the national science and technology system reform and innovation system construction leading group were established. The Ministry of Science and Technology (MOST) was re-assembled by integrating functions of the MOST and the former State Bureau of Foreign Experts, and the National Natural Science Foundation of China (NSFC) was changed to be under management of the MOST. With the coordination between S&T innovation and talent introduction, as well as between basic research and applied research, the key of S&T management was transformed from allocating fund and stuff and establishing projects to focusing on strategy, reform, planning, and service. System planning and top-level design were improved, and a 15-year national medium- and long-term S&T

 

development plan and a 5-year S&T innovation plan were dynamically prepared, released, and implemented. Efforts were made to enhance the coordination of innovation elements, integrate the deployment of projects, talents, and bases, optimize the S&T plan financed by the central government, coordinate the resource allocation, and focus on strategic goals of the S&T plan. With the strengthening of the coordination, a great supervision pattern of S&T was formed. The National Science and Technology Ethics Committee was set up, and a hierarchical S&T ethics governance system was established. The national S&T security policy was formulated to bolster the S&T security capability.

### 1.2 Establishing the mechanism for tackling emerging problems and building up China's strength in strategic S&T

S&T has become an important means in coping with major crises and emergencies. Centering on the national strategic needs, China devoted itself to building up the strength in strategic S&T, and established the mechanism for tackling emerging problems, so as to improve the emergency response. For innovation in major fields, China has established national laboratories, reorganized the national key laboratory system, improved the innovation capability of high-level research-oriented universities, national research institutions, and leading S&T enterprises, and enhanced collaborative innovation, forming a systematic layout of national strategic S&T. With the establishment of a new whole-nation system under the socialist market economy, an organization system for key technological breakthroughs, and a mechanism for emergency research in response to COVID-19, a number of significant achievements have been attained.

The research in key fields, such as basic raw materials, high-end chips, industrial software, medical devices, and vaccines, were enhanced. A number of strategic and reserved technological R&D projects were deployed and implemented in cutting-edge fields, such as artificial intelligence and quantum information, which provided strong support for safeguarding the industrial chain, supply chain, and national security. As of April 13, 2022, the first neutralizing antibody for COVID-19 independently developed by China and 99 detection reagents have been put on the market; 29 vaccines have entered clinical trials, 7 of which have been approved for conditional marketing or emergency use, and more than 3.306 billion doses of vaccines have been administrated in China.

### 1.3 Improving the incentive policy for life-time career of S&T researchers to motivate their innovation

The source of innovation is talent. The aim and outcome of the S&T reform are motivating and mobilizing researchers' enthusiasm for innovation and creation, based on which targeted support policies were implemented for researchers at different career stages. Mechanisms such as the discovery, cultivation, employment, introduction, and incentive of S&T talents were reformed, and a talent system with global attractiveness and competitiveness was built.

For the researchers at the early career stage (before 30 years old), a special doctoral and post-doctoral foundation was established to recruit and cultivate doctoral candidates. For the researchers at the growth stage (30–45 years old), the NSFC increased funding for projects supported by the Young Scientists Fund, the National Science Fund for Excellent Young Scholars, and the National Science Fund for Distinguished Young Scholars of China. Up to 21 072 projects were funded by the Young Scientists Fund in 2021. The young scientist projects set up by the National Key R&D Program aimed to support young talents to play the leading role. For researchers at the mature stage (after 45 years old), efforts were made to cultivate them into strategic scientists, leadership scientists, leading talents, and team leaders, and the system of chief scientist responsibility was employed in the national S&T program. Reform of the academician system was deepened to recover the academic honor of the academician title and play the exemplary role of academicians in four aspects (being loyal to the Party, serving the people, taking one's responsibility, and being honest in performing official duties). Classified evaluation of S&T talents was carried out, and a S&T talent evaluation system oriented at S&T innovation capability, quality, performance, and contribution was established. From 2012 to 2020, the full-time equivalent of Chinese researchers increased from 3.246 8 million to 5.234 5 million researchers-years, ranking first in the world for consecutive years (Figure 1).

### 1.4 Formulating the policies supporting the whole chain of research activities to improve organization efficiency of research and quality of research output

To improve the organization efficiency of research and the original innovation capability, the policies supporting the whole chain of research activities were formulated. The formation of a perfect policy toolbox from basic research to applied research and further achievement transformation improved the input-output benefit of research activities in China.

The stable support of financial funds was ensured for research activities. The stable support mechanisms, such as the Fundamental Research Funds, Strategic Priority Research Program of the Chinese Academy of Sciences (CAS), and S&T Innovation Fund were established. The organizational

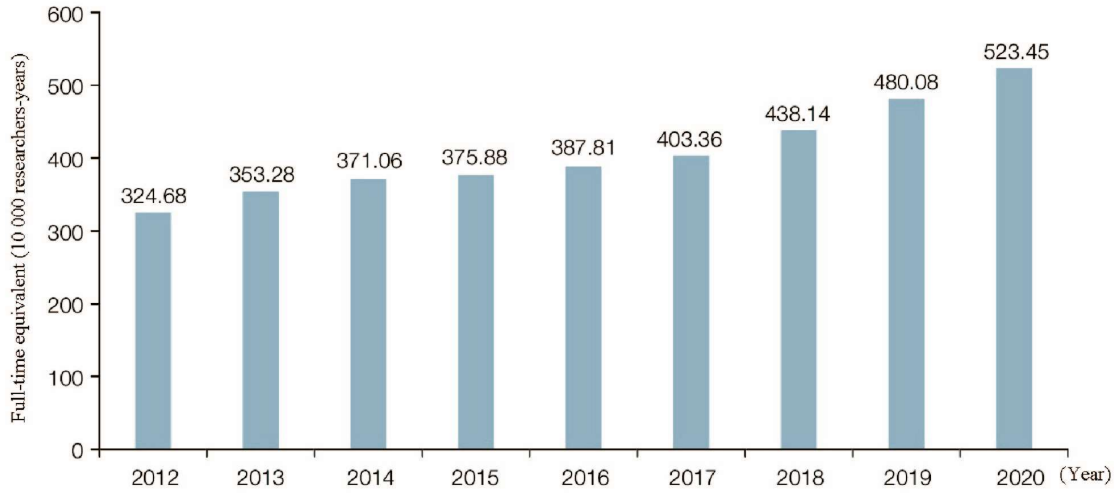


**Figure 1** Full-time equivalent of Chinese researchers from 2012 to 2020

mechanism of research projects was innovated. Specifically, the NSFC was systematically reformed to guide research serving the national strategy, and new project organization modes, such as the open competition mechanism and the horse-racing mechanism, were adopted. The R&D process management system was improved to confer greater research autonomy to leading talents and research institutions. A trust-based fund management method was adopted, which simplified budget-making and adopted an overall rationing system to make funds serve creative activities. A sharing system was adopted for major research infrastructure and instruments. Through incentives for transformation of research achievements, benefits of preferential tax policies, and rights of long-term use and ownership of employee-developed achievements, researchers were encouraged to transform their research achievements. In 2021, up to CNY 169.6 billion was invested in China's basic research, accounting for 6.09% of the R&D investment of the whole society, and the transaction volume of contracts in the national technology market increased to 5.79 times that of 2012 (Figure 2).

### 1.5 Constructing an inclusive innovation policy system covering the life cycle to stimulate the innovation momentum of enterprises

To stimulate enterprises' innovation impetus, the government collaborated industrial policies and innovation policies, optimized enterprise support policies, and enhanced the pre-competition support for enterprise innovation. The country adopted an inclusive policy for all domestic and foreign-funded enterprises of different ownership types. Furthermore, a S&T innovation policy system covering the life cycle of enterprises [3] was established to promote enterprises to become the player of technology innovation decision-making, R&D investment, project organization, and research achievement transformation.


**Figure 2** Number of China national technology contracts and transaction volume from 2012 to 2021

A business incubation system consisting of maker spaces, incubators, and accelerators was constructed for the enterprises at the seed stage. For the start-up enterprises, tax reduction and exemption policies for angel investment and venture capital investment were introduced to guide venture capital to support the early development of enterprises. For the growing and maturing enterprises, the Sci-Tech Innovation Board, the Growth Enterprise Board, and the Beijing Stock Exchange were established to facilitate direct financing for the listing of S&T innovation enterprises. Furthermore, policies such as the preferential income tax for high-tech enterprises, equity incentive for state-owned S&T enterprises, and assessment of R&D investment as profits were adopted for state-owned enterprises to promote high-level R&D and innovation. Inclusive policies, such as additional deduction of R&D expenses and accelerated depreciation of R&D equipment, were adopted for the enterprises in various stages and of various types. The proportion of additional deduction for small- and medium-sized S&T enterprises was increased to 100%, and the final settlement was carried out annually instead of quarterly, so as to benefit enterprises timely. Since 2012, tax deduction and exemption of high-tech enterprises enjoying the additional deduction and the preferential tax policy have exhibited high growth for consecutive years and exceeded the investment of the central finance in S&T, thus becoming an important policy tool to stimulate innovation impetus of enterprises (Figure 3).

## 1.6 Promoting the research system and mechanism reform of universities and research institutions to drive original innovation

Universities and research institutions are important platforms for basic research and gathering highlands of high-level talents. Focusing on the subjective initiative of universities and research institutions, China optimized the research system and mechanism to stimulate the innovation vitality, improve the original innovation capability, and increase the source supply of high-quality research achievements.

Efforts were made to enhance the basic research capacity of universities, and promote the construction of world-class universities and disciplines. The Pilot Program of Top-notch Student Cultivation in Basic Disciplines was implemented to establish basic and cutting-edge research centers and cultivate original research talents. Shouldering national missions, research institutions were encouraged to adopt the management according to constitution, establish a performance management system, and explore a stable performance-oriented support mechanism. The government enhanced target management, reduced macro-intervention, and conferred greater autonomy to legal persons to fully motivate innovation. The original innovation capability of universities and research institutions was improving, and the outputs of international scientific papers and PCT patents ① kept rapid growth for many years. In 2020, the number of China's international scientific papers and PCT patents respectively increased to 3.48 times and 4 times that of 2012 (Figure 4).

## 1.7 Creating regional S&T innovation centers and clusters to form a "wild goose queue" of regional innovation system

The regional agglomeration of innovation activities tended to be more and more outstanding, which was particularly

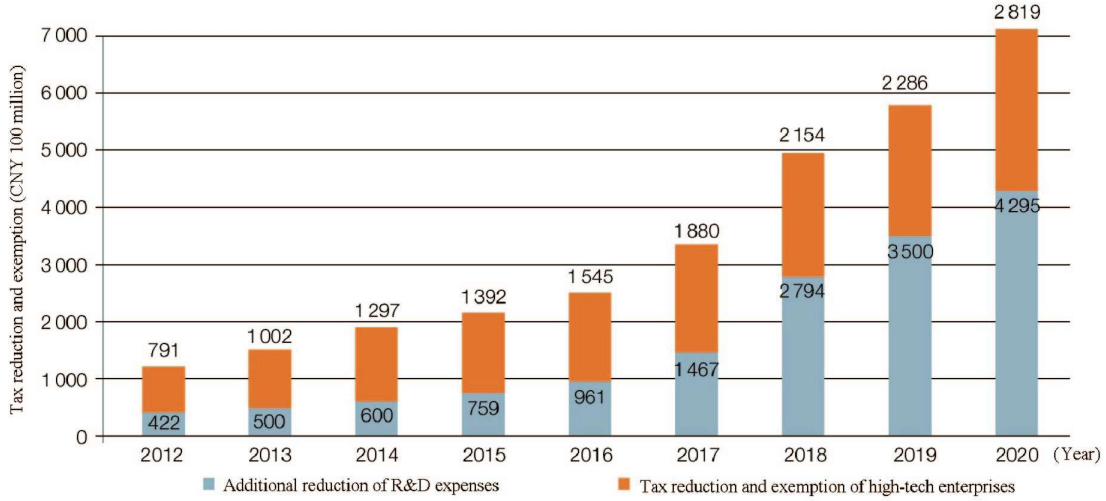


**Figure 3** Additional deduction of China enterprise R&D expenses and tax reduction and exemption of high-tech enterprises from 2012 to 2020

The additional deduction data in 2020 were calculated according to the data released by the State Administration of Taxation in the first 10 months of 2021

① Patent Cooperation Treaty (PCT), an international treaty regarding patent cooperation, was signed in 1970 and took effect in 1978. The Treaty has provided the uniform procedures for applying for patents in state parties. The patent application filed in accordance with PCT is referred to as patent international application or PCT international application.

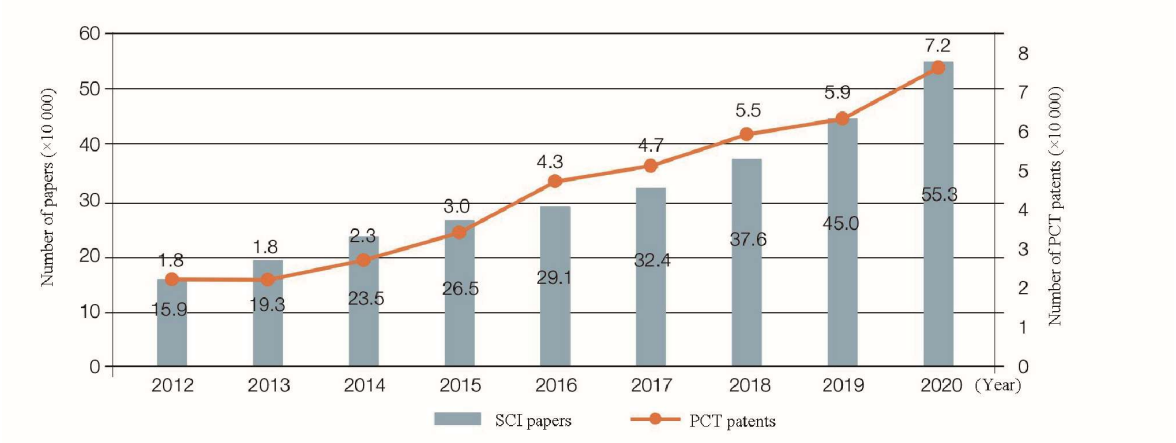


**Figure 4** Number of international scientific papers and PCT patents in China from 2012 to 2020

obvious for knowledge-intensive economy [4]. The regional innovation reform insisted on making breakthroughs in key areas and collaborating innovation-driven development in developed and underdeveloped regions, with different emphases in the eastern, central, and western regions. The construction of the S&T innovation centers, reform highlands, innovation clusters and east-west innovation mechanism was accelerated to promote the collaborative development of regional innovation.

Three international S&T innovation centers in Beijing, Shanghai, and Guangdong–Hong Kong–Macao Greater Bay Area were established to create a source of innovation with global influence. A comprehensive regional innovation reform experiment was performed in eight regions, which achieved a number of important results in system. High-quality development of national innovation demonstration zones and high-tech zones was promoted, on the basis of which an innovation growth pole was created. In 2020, the internal expenditure for research and development (R&D) in national high-tech zones accounted for up to 37.3% of the expenditure for national R&D (Figure 5). Construction of innovative provinces and cities was promoted, and cross-regional collaborative innovation of the Beijing–Tianjin–Hebei Region, the Yangtze River Delta, and the Guangdong–Hong Kong–Macao Greater Bay Area was enhanced. Local governments introduced special laws on S&T innovation and increased local financial investment in S&T to support innovation. In 2021, the local financial investment in S&T accounted for 65.4% of the total central and local investment, which suggested that local financial investment played an increasingly important role in the investment of S&T.

## 1.8 Improving systems and regulations of research integrity and ethics to guide research activities

Research integrity is the cornerstone of S&T innovation; research ethics is the bottom line of research activities; research evaluation is the baton of research activities. System construction in research integrity, ethics, and evaluation was continuously promoted to ensure the orderly operation of research activities.

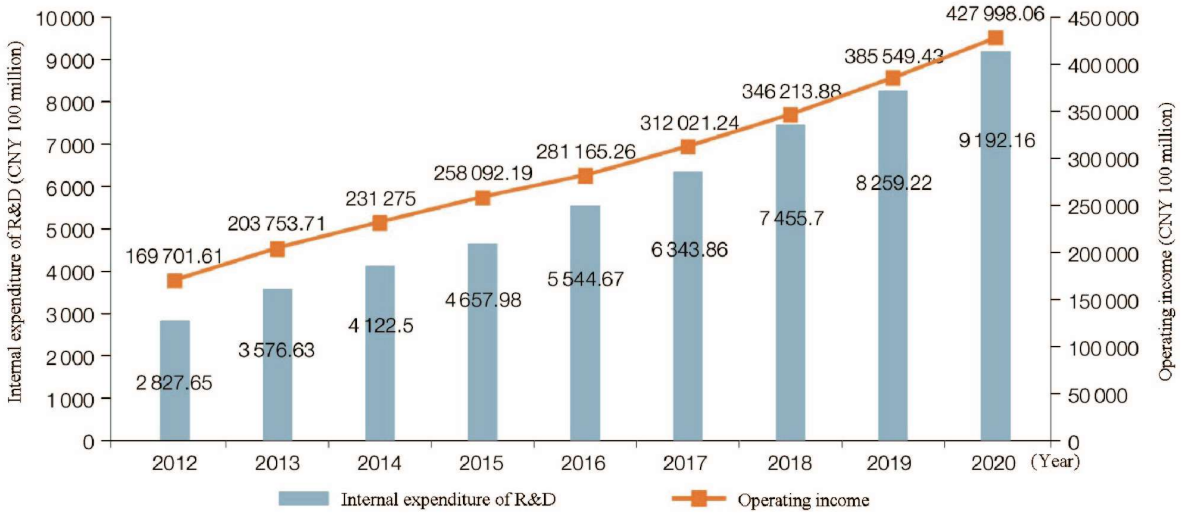


**Figure 5** Growth of internal expenditure and operating income of R&D in national high-tech zones from 2012 to 2020

The scientist spirit was vigorously carried forward, and the work style and study style were greatly improved. A research integrity management system and a joint departmental punishment mechanism covering the whole process of research activities were established. A special chapter of Supervision and Management was set up in the newly revised *Law of the People's Republic of China on Science and Technology Progress* to punish and avoid behaviors violating requirements for research integrity. The governance mechanism of research ethics was improved, and opinions on enhancing the governance of research ethics were introduced. Responsible innovation was promoted and the ethical bottom line was kept to guide research activities. Full play was given to the role of research evaluation as a baton, and reforms in project, talent and institution evaluation were carried out. The tendency of focusing on papers, title, education background, and awards was abolished to avoid the excessive linkage between evaluation results and material interests, and an evaluation system based on the quality, capability, performance, and contribution of S&T innovation was established.

### 1.9 Expanding opening-up and cooperation in S&T and joining the global innovation network

Opening-up and cooperation are the major trends in the new era. Facing the profound changes in the international environment, China has constantly expanded and deepened the opening-up and cooperation in S&T and actively participated in global S&T governance to contribute to solving global difficulties and challenges in S&T.

China strengthened the inter-governmental cooperation in S&T, improved S&T innovation levels, and established an innovation dialogue mechanism with multiple countries. It adopted the research innovation plan along with the Belt and Road innovative and took the four actions of people-to-people exchanges in S&T, co-construction of joint laboratories, cooperation in S&T parks, and technology transfer to expand the governmental and non-governmental cooperation in S&T. The country deeply participated in and took the lead in organizing international big science research plans and projects, opened national S&T plans in an orderly way, and encouraged joint research by scientists from different countries.

### 1.10 Brief summary

With the deepening of S&T reform in the past decade, the national S&T governance system and capability have been enhanced, and the overall efficiency of the national innovation system has been significantly improved. From 2012 to 2021, the expenditure for R&D in China increased from CNY 102 million to CNY 279 million, with its proportion in the gross domestic product (GDP) increasing from 1.98% to 2.44%, which was close to the average level of countries in the Organisation for Economic Co-operation and Development (OECD). With the national innovation capability rising from the 34th to the 12th in global ranking, China has become an innovative country.

## 2 Trends of S&T reform in major innovative countries

The world is experiencing profound changes unseen in a century and the COVID-19 is pandemic. S&T innovation has become the core of strategies and the focus of competition between major countries. Major innovative countries present the following characteristics in the S&T reform.

### 2.1 The innovative countries have built up the macro-governance capability of S&T to strengthen strategic coordination of S&T innovation

With the booming of emerging technologies and the increasingly fierce national competition in S&T, it has become a necessary means to grasp the direction and development opportunities of S&T and promote national economic and social development. Many countries have reformed the top decision-making mechanism of S&T and established a national S&T innovation strategic decision-making (deliberative) organization led by Head of State/Head of Government in person to ensure that uniform S&T innovation strategic planning and policies can be developed for the national interest. For example, the United States reinstated the science adviser to the president in 2021, who also co-acted as the head of the Office of Science and Technology Policy (OSTP), and this position was promoted to the cabinet level for the first time [5]. Japan's Cabinet Office reorganized the Council for Science and Technology Policy (CSIP) as the Council for Science, Technology and Innovation (CSTI), which was led by the cabinet minister (premier) [6], to solidify the role of the decision-making of S&T innovation as a conning tower.

### 2.2 The governments have broadened intervention in S&T innovation activities, guiding the innovation to serve national goals and missions

The innovative countries have recognized the key role of S&T innovation in national competition and the construction of new advantages for national development. While maintaining academic independency, they have taken more powerful measures to guide S&T innovation activities in key fields concerning national goals and public interests and enhanced intervention from strategy, policy, element configuration, and other aspects. (1) States' orientation towards medium- and long-term S&T development has been strengthened. In 2018, the Federal Government of Germany released the *Research and innovation that benefit the people—High-Tech Strategy 2025*, in which several missions and funding schedules were determined in each subject of priority development [7]. (2) Funding and preferential policies for S&T innovation activities have been greatly improved. In

2020–2021, the public financial investment in research exceeded 10 billion pounds for the first time in the UK [8]. According to the Forschungszulagengesetz, enterprises could apply for research allowances based on 60% of expenditures of researchers and entrusted research, 500 000 euros at most for each enterprise [9]. (3) The S&T emergency response capability has been enhanced. To catch up from behind in the competition of COVID-19 vaccines, the United States launched the Operation Warp Speed (OWS) [10], and used a variety of policy tools, such as government procurement, diversified investment for supporting technology, extensive supply chain management and transportation delivery system, to reduce the R&D, production and distribution period of COVID-19 vaccines from 4–10 years to be within 10 months.

### 2.3 Innovative countries have aroused more concern to disruptive innovation and future technology to maintain technological advantages in key fields

With the increasingly intense competition in key technologies, major innovative countries have improved their policies and innovated their organization mechanisms, and have used financial, institutional, industrial and other policy tools to drive the S&T innovation in key fields and future technologies.

The specific measures can be summarized as follows. (1) R&D funding has been increased in key technologies. In 2018, the *National Quantum Initiative Act* of the United States proposed a 10-year National Quantum Initiative, with USD 1.3 billion allocated in the first five years to support the R&D of quantum computation, so as to ensure the leading position of the country in quantum information [11]. (2) The organization mechanism for the R&D of disruptive technologies and future technologies has been innovated. The relevant report of the President's Council of Advisors on Science and Technology (PCAST) in the United States suggested to establish the Industries of the Future Institutes (IotFIs), expecting to bring revolutionary paradigms for the development of future industries via organization innovation [12] and seize the commanding heights of future technologies. In 2021, the UK modeled the Advanced Research Project Agency (ARPA) after the Defense Advanced Research Projects Agency (DARPA) to promote high-risk and high-reward disruptive innovation. (3) Key technologies have been promoted by organizations. On the basis of the *United States Innovation and Competition Act* (USICA) [13] adopted by the Senate in June 2021, the House of Representatives modified and adopted the *America Creating Opportunities for Manufacturing, Pre-eminence in Technology, and Economic Strength* (*COMPETES*) *Act of 2022* (also referred to as *America COMPETES Act of 2022*) in February 2022, proposing to establish the Directorate for Technology, Innovation and Partnership (TIP Directorate), which reinforced support for key technologies, especially information, energy, and biomedicine.①

### 2.4 Innovative countries have made greater efforts in talent cultivation and introduction to attract top talents

In recent years, the competition in the national comprehensive strength with S&T as the core has gradually shifted to basic research [14]. Predicated on the long-term support strategy, the countries have enhanced the support for basic research and the construction of corresponding talent teams. (1) Visa requirements for high-end talents have been relaxed. The UK launched the Global Talent Visa with no upper limit on the number [15], so as to attract the top scientists, researchers, and technicians. (2) Talent inflow management has been simplified and talent outflow has been restricted. In 2022, the U.S. government optimized the procedure for EB-2visa holders to apply for the National Interest Waiver (NIW), so as to provide institutional convenience for the inflow of top talents. In addition, it was stipulated in the *America COMPETES Act of 2022* that any member of science-based federal agencies should be prohibited from participating in any foreign government's talent introduction program [16]. (3) Support for national S&T talents has been further improved. Centering on the Nobel Prize Program, Japan constantly increased research funding for youth researchers, created an independent research environment for youth researchers, cultivated and retained talents who have professional knowledge and creative thinking, and established graduate schools with the highest education and research levels in the world.

### 2.5 Innovative countries have laid greater emphasis on the balance between open science and S&T security to ensure that science development and achievements are controllable

Open science mainly includes open access to science knowledge (e.g., publication, data, software, and source code), open science infrastructure, open participation of social subjects, and open conversation and science exchange with other knowledge systems. In such aspects as knowledge sharing and cross-field exchange and cooperation, the shift of research system to open science has been normal [17]. The European Union (EU) is establishing the European Open Science Cloud (EOSC) to enhance the opening of the results and data of EU-funded projects and is developing the academic appraisal system and personnel incentive mechanism adapting to open science. At the same time, the S&T security management has been strengthened in technology innovation, especially when it involves national development and

① National Science Foundation Establishes New Directorate. [2021-04-13]. https://cgsnet.org/national-science-foundation-establishes-newdirectorate.

 

industrial competition. According to the *America COMPETES Act of 2022*, the state plans to launch a research security action plan to prevent its funded research achievements from being acquired by other countries. In addition, Clarivate, Derwent and other global information service providers keep bolstering the construction and integration of information resources in S&T quotations, patents and other fields, and have gradually developed the ability to control and monopolize scientific data, which may become a restrictive tool under the extreme state.

## 3 Thinking and prospects for deepening S&T reform in the future

To build up the strength in S&T, China still faces the challenges of an unsound innovation system, weak strategic S&T power, and insufficient long-term accumulation of S&T for supporting national security and emergency response. President Xi Jinping has pointed out that S&T requires constant reforms. At present, the S&T innovation is expanding from research to economy and society, changing from mainly "following" to "paralleling" and "leading" in more fields, and from preparing for worst-case scenarios to analyzing problems under extreme conditions. Looking into the future, China needs to focus on the pain points and difficult points restricting the self-reliance and self-improvement in S&T, enhance the comprehensive leadership of the CPC on S&T work, and exert its role as an organizer of major S&T innovation. It needs to further strengthen the macro planning in S&T and the original innovation capability. Further, it needs to grasp the global development trend of S&T, deepen the reform, and make collaborative efforts in practice carriers, institutional arrangement, policy support, and environment construction to improve the overall efficiency of the innovation system, so as to ensure the support for building up China's strength in S&T.

(1) Improving the S&T governance structure and enhancing the coordination of S&T innovation. It is suggested to consolidate the centralized leadership of the CPC Central Committee on S&T innovation, improve the macro management system of S&T, and take advantage of the new whole-nation system under the socialist market conditions. The S&T reform should reflect the new national development pattern, adapt to the changes in S&T innovation, and make more efforts in the coordination of major tasks, innovation players, and input of innovation elements to improve the capacity of systematization and breakthroughs in key fields.

(2) Beefing up the national strategic S&T power and the construction of innovation capability of different players. Systematic deployment, mechanism design, and policy support are needed to speed up the development of the national strategic S&T power led by national laboratories. The universities and research institutions should be encouraged to improve their original innovation and provision of high-quality achievements, and leading S&T enterprises should be cultivated and expanded. In this way, the innovation players with outstanding innovation capability, diverse forms, and clear positioning can be fostered to for reliable national strategic S&T power.

(3) Innovating the organization mechanism for key technologies and future technologies and improving the original research capability. The S&T reform needs to improve the mechanism for making breakthroughs in key core technologies and explore the organization and implementation mechanisms of research for cutting-edge technologies and future technologies. It is suggested to strengthen original basic research in an all-round way, and increase the long-term stable support for unpopular disciplines, basic disciplines, and inter-disciplines. Forward-looking layout should be designed for leading and prospective technologies, and the support mechanism for non-consensus projects and disruptive technologies be constructed.

(4) Perfecting the system and mechanism for the development of S&T talents to cultivate more high-level S&T talents. The S&T reform needs to improve discovery, cultivation, employment, and incentive mechanisms of S&T talents, strengthen the connection of policies in the life-time career of researchers, and combine talent cultivation with the construction of projects and bases. Efforts should be made to give play to the role of strategic scientists and provide more support for the cultivation of young talents so as to foster high-level talent teams in key fields and inspire them to play their role in a better way.

(5) Upgrading the input structure of S&T to improve the input efficiency. It is suggested to establish a diversified S&T input mechanism, steadily increase the central financial input, guide the local S&T input and coordinate their actions, and make use of different policy tools (such as finance, tax, banking, industry, and social organizations) to guide the input of enterprise capital, financial capital, and social capital in S&T innovation. The government should increase the financial input in basic research and generic technology research and establish a long-period stable support mechanism. The decisive role of the market in resource allocation should be given full play, and enterprises be guided to increase input in basic research.

(6) Optimizing the ecology and strengthening the foundation of innovation. The S&T reform should construct the systems for research integrity and ethics, improve the work and study styles, carry forward the spirit of scientists, and coordinate the role of governments, organizations, and academic communities in regulating research activities and self-discipline. Efforts should be made to govern the research ethics, cultivate good research value, and implement responsible innovation. It is essential to improve the S&T talent appraisal system focusing on innovation capability, quality, performance, and contribution, and construct an innovation ecological system that respects creation, tolerates failure, and releases vigor.

 

(7) Improving the openness of innovation system and the cooperation in S&T. China needs to integrate itself into the global innovation system, break through the barriers to international cooperation in S&T innovation, expand intergovernmental cooperation in S&T, and promote openness of the national S&T program. It needs to take the lead in initiating the international big science research plans and projects, and expand the non-governmental cooperation and exchange in S&T. The global-oriented science foundation and visiting scholar program should be established to attract more youths to receive further education in China and cultivate talents for the world. During the openness, China needs to pay attention to S&T security management to cope with risks and challenges.

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