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Asia and Pacific Research Center

Study on the mechanism of discovery and promotion of the excellence in China's R&D system

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Japan Science and Technology Agency

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This report is compiled as part of a research that surveyed and analyzed science and technology innovation policies, research and development trends, and associated economic and social circumstances in the Asia-Pacific region. It is being made public on the APRC website and portal site to enable wide use by policymakers, associated researchers, and people with a strong interest in collaborating with the Asia-Pacific region; please see the websites below for more details.

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Executive Summary

Considering that it is indispensable for the economic and social development of the country, China is making a national effort to promote science and technology, including generous investment of national funds and training of high-level human resources through industry-academia-research institute collaboration. The results are clearly reflected in the international indicators and the remarkable increase in the number of influential papers.

This study clarifies the trends and future prospects of R & D system reform in China, especially the mechanism and actual conditions of excellence and promotion in R & D systems, and further deepens the research and analysis of science and technology policies so far. The purpose is to provide basic information that will be useful in cooperation between Japanese research institutes and researchers and Chinese counterparts.

This study consists of the following six chapters, a questionnaire survey, and analysis by Japanese experts.

Chapter 1: Science and Technology Policy making Processes in China

Chapter 2: Important Science and Technology Policies in China

Chapter 3: National Medium- and Long-Term Program for Science and Technology Development (2021-2035)

Chapter 4: National Key Research and Development Project of China

Chapter 5: R & D system in China

Chapter 6: R & D funding in China

Questionnaire surveys of researchers at universities, research institutes, and companies have highlighted the characteristics of China's R & D system. According to it, (1) simplification of administration, delegation of authority to researchers, and optimization of government services will be the principles of future research activities, and (2) emphasis on basic research is an important guiding direction for the future development of scientific research in China. Women and young science and technology personnel are regarded as important, from the government to companies and R & D institutions. A classification and evaluation system for scientific and technological achievements is being constructed with the participation of the government, markets, third-party institutions, financial investment institutions, etc.

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Introduction

On September 20, 2021, the World Intellectual Property Organization (WIPO) released its Global Innovation Index (GII) 2021.[1] The index, published annually since 2007, evaluates and ranks about 130 countries and regions based on 80 innovation indicators, including R&D spending and patent activity.

China moved up from 14th to 12th place in the 2021 index. In regional rankings, it ranked third in Southeast Asia, East Asia, and Oceania, behind South Korea and Singapore. China first overtook Japan in 2019, ranking 14th while Japan was placed at the 15th position. The following year, China maintained its position while Japan slipped to 16th place. Switzerland topped the 2021 global rankings, followed by Sweden, the United States, the United Kingdom, and South Korea, with Japan ranking 13th, one spot behind China. China's rise has been steady: from 29th place in 2015, it climbed to 25th in 2016, 22nd in 2017, and 17th in 2018, thus reaching within striking distance of the top 10.

China has now surpassed the United States as the world leader in influential research papers. According to the Science Research Benchmarking 2021 report released by Japan's National Institute of Science and Technology Policy (NISTEP) on August 10, 2021[2], China produced more highly cited papers than the United States for the first time. The study looked at natural science papers published between 2017 and 2019, focusing on those ranking in the top 10% by citation count. China produced 40,219 highly cited papers compared to the United States' 37,124. Japan's output was notably lower at 3,787 papers—less than a tenth of China's total. NISTEP attributes China's dramatic progress primarily to substantial increases in both its researcher population and research funding. Meanwhile, Japanese universities face two significant challenges: chronic research funding shortages and faculty members who struggle to dedicate time to research owing to their heavy administrative workloads.

Comparing Japan and China in the GII rankings, in 2015, Japan ranked 19th while China was 29th. China's steady climb in the rankings aligned with its 13th Five-Year Plan period (2016–2020). Considering that achievements in science and technology cannot be obtained overnight, it may be necessary to take a broader view of the timespan of China's current progress.

The "National Medium and Long-term Science and Technology Development Plan Outline (2006–2020)" [in Chinese], published by the State Council in February 2006, is considered a fundamental and extremely important policy in China's science and technology strategy. Looking at recent achievements in the field of science and technology, it would not be an overstatement to say that this policy has led to China's current advancement.

The outline detailed 16 National Major Science and Technology Projects. These projects encompassed a wide range of initiatives, including core electronic components, high-end general purpose chips and basic software; VLSI manufacturing equipment and complete process technology; new generation broadband wireless mobile communications; high-end CNC machine tools and basic manufacturing equipment; large oil & gas fields and coalbed methane development; advanced pressurized water reactors and high-temperature gas-cooled reactors; water body

1 "Global Innovation Index 2021: Innovation Investments Resilient Despite COVID-19 Pandemic;Switzerland, Sweden, U.S., U.K. and the Republic of Korea Lead Ranking; China Edges Closer to Top 10" (https://www.wipo.int/pressroom/en/articles/2021/article_0008.html)

2 "Regarding the Publication of 'Science Research Benchmarking 2021'" [in Japanese] (https://www.nistep.go.jp/wp/wp-content/uploads/NISTEP-RM312_PressJ.pdf)

pollution control and treatment; development of new transgenic varieties; major new drug innovation; prevention and treatment of major infectious diseases including AIDS and viral hepatitis; large aircraft; high-resolution earth observation system; and the manned space program and lunar exploration project.

Each of these projects has delivered results that meet their initial expectations. In lunar exploration, China achieved several milestones with its Chang'e-5 mission: the successful launch via Long March 5 rocket on November 24, 2020, placing the probe into its planned orbit; the automated collection of lunar surface samples on December 2; the proper packaging and storage of these samples in the ascender module's storage devices; and finally, the safe return of the Chang'e-5 capsule to Inner Mongolia on December 17.

In terms of nuclear power development, China has established itself as the world's third-largest nuclear power nation after the United States and France. Its domestically developed third-generation reactor, Hualong One, is being actively deployed both domestically and in international markets. The high-temperature gas-cooled demonstration reactor, classified as a fourth-generation system, commenced power generation in December 2021. China's nuclear ambitions extend further. The country is strengthening its position as a nuclear power through the construction of two demonstration fast reactors while simultaneously developing next-generation technologies, including floating nuclear power plants, advanced heavy water reactors, lead-bismuth fast reactors, and thorium molten salt reactors.

However, China still faces various challenges. A survey conducted among Chinese experts has highlighted how the country has pursued national scientific and technological advancement for economic and social development while confronting numerous obstacles.

While the "National Medium and Long-term Science and Technology Development Plan Outline (2006–2020)" served as the master blueprint for China's remarkable scientific and technological advancement, attention is now focused on the forthcoming "National Medium and Long-term Science and Technology Development Plan Outline (2021–2035)," which will chart the country's future direction in science and technology. However, some observers suggest that given the intensifying international competition in scientific and technological fields, China should withhold publication to avoid revealing its strategic intentions.

China has made the advancement of science and technology a national priority, viewing it as essential for the country's economic and social development. This commitment is demonstrated through substantial government funding and nationwide efforts to cultivate high-level talent across industry, academia, and research institutions. China's next target is strengthening basic research to generate original scientific and technological achievements.

This report introduces some aspects of the trial-and-error process undertaken by Chinese stakeholders over the past 15 years that has led to today's results, as well as the direction of efforts for the coming 15 years. We hope this report will serve as a reference for Japanese research institutions and researchers in their future cooperation with China.

1 China's Science and Technology Policy Decision-Making Process

1.1 China's Science and Technology Policy Decision-Making Process

Professor Xue Lan of Tsinghua University, a member of the Standing Committee of the China Association for Science and Technology who has been involved in formulating many science and technology policies, provided an explanation of China's science and technology policy making process.

According to the "Regulations on the Functional Organization, Internal Structure and Staffing of the Ministry of Science and Technology"[3] [in Chinese], the Ministry of Science and Technology holds a primary position in establishing science and technology policies and is responsible for formulating and organizationally implementing the National Innovation-Driven Development Strategy guidelines and science and technology development, as well as introducing and implementing related policies including foreign intelligence plans.

The formulation of science and technology policy is a dynamic process that cannot be simplified as either purely top–down or bottom–up. Under China's socialist market economy framework, policy development follows a bidirectional approach that combines top–down and bottom–up processes, with final decisions made by top political leaders. The policy formation process follows relatively standardized procedures. The Department of Strategic Planning at the Ministry of Science and Technology generally bases its work on the Five-Year Plans and science and technology laws (such as the "Law on Scientific and Technological Progress") approved by the Standing Committee of the National People's Congress. The Department of Strategic Planning identifies and determines issues that must be addressed in the science and technology field. When developing science and technology policies, it seeks input from experts and the general public and ultimately coordinates with other divisions, such as the Department of Policy, Regulations and Innovation System Construction, to arrange for policy legitimization. Each step involves specific key points and participation from relevant organizations and departments.

During this process, socially prominent issues are considered in policy formation. For instance, cases that have attracted public attention—such as the mass resignation of 90 researchers from the Nuclear Safety Technology Research Institute of the Hefei Institutes of Physical Science, Chinese Academy of Sciences, and China's first major case of suspected mathematical paper fraud (with 65 papers suspected of plagiarism, fabrication, and ghost-writing)—are examined through expert and public consultation and incorporated into policy considerations. Additionally, multiple factors shape the identification of public policy issues, including input from political leaders, political parties, stakeholder organizations, public opinion representatives, mass media, policy research institutions, government agencies, and responses to occasional crises or special events.

[3] "Provisions on the Functions, Internal Organizations and Staffing of the Ministry of Science and Technology" [in Chinese] (http://www.gov.cn/zhengce/2018-09/10/content_5320819.htm)

(1) Policy Issue Identification and Specification

The Department of Strategic Planning at the Ministry of Science and Technology coordinates research discussions with experts from various institutions: the Chinese Academy of Science and Technology for Development, the Chinese Academy of Sciences[4], the China Association for Science and Technology, and universities participating in the "985" and "211" projects[5]. Based on scientific and technological goals specified in China's social development plans, these discussions focus on both identifying policy issues and determining problems that need to be addressed in the national medium and long-term science and technology development plan.

(2) Science and Technology Policy Planning

"Planning" in science and technology policy refers to a series of directional proposals and plans put forward by the Department of Strategic Planning, the policy making body of the Ministry of Science and Technology, to address specific issues. This process involves making preliminary judgments and decisions about specific policies based on comparative evaluation.

The Department of Strategic Planning publicly announces policy goals and directions (themes) and key research points for each policy component that have been discussed and formulated in expert meetings. Organizations then submit proposals with specific research content designed to achieve these policy goals. The most outstanding proposals are selected by an expert committee established by the Ministry of Science and Technology. All alternative policy options undergo comprehensive evaluation, from which the highest priority or most effective proposal, or combination of proposals, is chosen as the final policy action. Multiple criteria guide policy evaluation and selection. For policy effectiveness, evaluators consider criteria such as efficacy, efficiency, and equity. Feasibility is assessed through political, social, and economic acceptability, as well as technical viability. Policy options are also evaluated and selected based on criteria such as potential external impacts and associated risks.

In the submission process for specific research proposals aimed at achieving these policy goals, universities and R&D institutions have been increasingly selected. For instance, in the "Major Research Issues in the 2021–2035 National Medium and Long-term Science and Technology Development Plan," universities accounted for 11 of the 20 selected institutions. Selected institutions may submit their own solution plans and implementation proposals for the consideration of the Department of Strategic Planning.

4 The institute originated as the "China Science and Technology Development Promotion Research Center," established in October 1982 with State Council approval. On December 28, 2007, it was reorganized as the "Chinese Academy of Science and Technology for Development (CASTED)." Wan Gang, Vice Chairman of the Chinese People's Political Consultative Conference and Minister of Science and Technology, served concurrently as its president. The academy, operating directly under the Ministry of Science and Technology, conducts research on national science and technology development strategies, policies, systems, management, forecasting, evaluation, and the promotion of economic and social development through science and technology. It also provides consulting and recommendations for national macro-policies related to science, technology, economic, and social development. The current president is Hu Zhijian.

5 The "211" Project and "985" Project: The Chinese government implemented two initiatives aimed at building world-class universities. The "211 Project" designated 116 key universities and 1,000 key disciplines. The "985 Project" selected 39 universities from among the 116 "211 Project" institutions to accelerate the development of advanced new disciplines. Both projects have been succeeded by the "Double First-Class" project (i.e., the construction of world-class universities and first-class disciplines), which selected 42 universities for world-class university construction and 140 universities (including the aforementioned 42) for world-class discipline construction.

(3) Collecting Public Opinion

Following the planning phase, the Department of Strategic Planning convenes additional expert meetings to discuss issues and publishes the results as a "draft for comments," welcoming proposals from the general public.

(4) Policy Publication and Implementation

Throughout this process, the Ministry of Science and Technology invites personnel from the strategic planning and legal affairs departments of the Ministries of Justice, Finance, Education, and other ministries to oversee the entire implementation process and review the legality of policy content and procedures. At the final stage, the draft policy document is submitted to the State Council for approval. Upon receiving State Council approval, the Ministry of Science and Technology publishes and implements the policy, either independently or in conjunction with other departments.

The above process applies to departmental regulations within the Ministry of Science and Technology's authority. However, for State Council decrees or matters elevated to the level of law, participation and approval from governing bodies such as the State Council and the Standing Committee of the National People's Congress become necessary.

1.2 Tasks and Roles of Policy-Making Institutions at Various Levels

(1) The National People's Congress and the Central Committee of the Communist Party

Articles 1 and 57 of the Chinese Constitution stipulate that "the National People's Congress is China's highest organ of state power, the socialist system is the fundamental system of the People's Republic of China, and the Communist Party of China is both the ruling party and its leadership represents the most essential characteristic of socialism with Chinese characteristics." From the perspective of the essential characteristics of the socialist system, the Constitution explains the Party's power and position in exercising overall leadership in domestic affairs. The Party's National Congress serves as its highest leadership body, responsible for discussing and deciding major Party issues. During its term, the Central Committee convenes plenary sessions known as Party Central meetings. When the National Congress is not in session, the Central Committee implements National Congress resolutions and leads all Party activities. The Party Central Committee determines fundamental policies, strategies, and programmatic plans for development—including science, technology, culture, and health—and submits these to the Party Congress. Since the Party Congress convenes only once every five years, many important national policies are determined through discussions in the Party Central Committee or Standing Committee. Party Central Committee decisions are published as "communiques" through central media outlets such as Xinhua News Agency, providing guidance and direction for activities and decision-making across various fields. The National People's Congress, as the highest organ of state power, formulates national social development goals and plans in accordance with state guidelines and strategic plans submitted by the Party Congress or Party Central Committee. Specific guidelines and policies are then codified in the form of legislation. Therefore, laws, policies, and regulations in the science and technology field are based on these communiques' content. Their fundamental concepts, objectives, and specific measures must both reflect the spirit of relevant communiques and the Party Congress while remaining consistent with the spirit of Party Central Committee communiques.

(2) The State Council

The State Council of the People's Republic of China, or the Central People's Government, serves as both the highest state executive organ and the highest state administrative organ. According to Article 89 of the Constitution, the State Council's roles [as they relate to science and technology] include the following:

(1) Stipulating administrative measures, formulating administrative regulations and issuing decisions and orders [including those in the science and technology field] in accordance with the Constitution and the law

(2) Submitting proposals [related to science and technology development] to the National People's Congress or its Standing Committee

(3) Stipulating the missions and responsibilities [of all departments within the Ministry of Science and Technology], exercising unified leadership over their work [including various departments and committees]

(4) Drawing up and implementing plans for national economic and social development and state budgets [including the science and technology sector]

(5) Directing and managing [science work as part of its broader mandate over] education, science, culture, health, sports and family planning work.

The State Council has two primary responsibilities in science and technology:

(1) Formulate and effectively implement science and technology development plans, along with strategies and policies for scientific and technological innovation and building China into a science and technology power. This includes taking strategic actions and handling specific matters during the planning period, directing the allocation of public resources in the science and technology field, and compiling the five-year development plan outline for science and technology. This outline is then submitted to the National People's Congress and its Standing Committee for deliberation and implemented after approval.

(2) Based on the Constitution, laws, or authority delegated by the Standing Committee of the National People's Congress, formulate and issue normative documents (such as announcements and notices) for administrative management in relevant science and technology fields, following statutory authority and procedures. Within China's legislative system, administrative regulations hold a significant position, ranking second only to laws in the legislative hierarchy.

(3) Ministry of Science and Technology

According to the "Decision of the CPC Central Committee on Deepening the Reform of the Party and State Institutions" [in Chinese] adopted at the Third Plenary Session (Third Plenum) of the 19th CPC Central Committee and the "State Council Institutional Reform Proposal" [in Chinese] and approved at the First Session of the 13th National People's Congress, the Ministry of Science and Technology is an institution constituting the State Council. Its main functions are ① to research and propose macro-level strategies for scientific and technological development, as well as guidelines, policies, and regulations that promote economic and social development; ② to study major scientific and technological issues that affect economic and social development; ③ to research and determine key arrangements and priority areas for scientific and technological development; ④ to advance the construction of a national scientific and technological innovation system and enhance the nation's scientific and technological innovation capabilities; ⑤ to research and propose guidelines, policies, and measures for reforming the scientific and technological system; ⑥ to promote the construction of scientific and technological innovation systems and new initiatives in accordance with socialist market economy principles and the laws of scientific and technological development; and ⑦ to guide scientific and technological system reform across various departments and regions.

Following the "Notice by the General Office of the State Council of Issuing the Plan for the Allocation of the Key Tasks Determined at the National Video Teleconference on Deepening the Reforms[6] to 'Streamline Administration and Delegate Power, Improve Regulation, and Upgrade Services' (Fang-Guan-Fu) and Endeavoring to Foster and Stimulate the Vitality of Market Entities," the Ministry of Science and Technology needs to transition from a management role to a service role. Specifically, the details are as follows:

(1) Transform the management and service functions of government science and technology while improving the systems and organizational structures for scientific and technological innovation. Furthermore, strengthen macro-management and overall coordination, reduce micro-management and specific review requirements, and enhance both interim and post-implementation supervision management as well as scientific research integrity.

(2) Transform from research and development management to innovation services and work to deepen reform of scientific and technological program management. Furthermore, build an open and unified national science and technology management platform to reduce such phenomena as duplication, dispersion, isolation, inefficiency, and fragmentation in the allocation of resources for science and technology program projects.

(3) Government departments will not directly manage specific research and development projects but will delegate specific tasks such as project acceptance, review, planning, process management, and acceptance inspection to specialized project management agencies.

(4) General training programs, including overseas training programs, are exempt from approval and review requirements, with each department making adjustments based on industry and field conditions.

(5) The establishment and adjustment of research institutions are exempt from review requirements, with emphasis placed on planning arrangement and performance evaluation.

(4) Local Authorities

According to the "Organic Law of Local People's Congresses and Local People's Governments of the People's Republic of China" and constitutional provisions, referring to regulations established by local People's Congresses, the science and technology departments of local governments are responsible for implementing the Communist Party of China (CPC) Central Committee's policies regarding science and technology innovation activities. They implement relevant decisions and agreements of regional Party committees and, under the Party's centralized and unified leadership, carry out the following main tasks in the course of performing their duties:

(1) Macro-management and overall coordination of science and technology progress in their administrative regions: ① Thoroughly implement national science and technology laws, regulations, guidelines, and policies, ② Lead the formulation of regional science and technology development plans and determine strategic layout and priority development areas, ③ Draft regional regulations and rules, formulate related policies, and supervise their implementation, and ④ Participate in the demonstration and policy-making of interdepartmental and interdisciplinary projects that have significant impact on economic and social development.

6 Fang-Guan-Fu (放管服): Refers to streamlining administration and delegating power, improving regulation, and upgrading services

(2) Organizational implementation of local special science and technology projects:
① Formulate relevant policies, ② Organize plan demonstration, review and approval, tracking management, evaluation, and acceptance inspection in the implementation of major special science and technology projects, and ③ Coordinate the filing and organizational implementation of national special science and technology projects, as well as the linkage and integration of regional special science and technology projects with national science and technology projects.

(3)Implementation of provincial-level science and technology planning activities:
① Formulate and implement provincial-level science and technology plans and major science and technology projects, including basic research plans, science and technology support plans, and science and technology innovation environment construction plans, ② Be responsible for the filing, recommendation, and management of related national science and technology plans (projects), and ③ Take the lead in addressing key technologies in fields crucial to the province's overall economic and social development.

(4) Leading science and technology advancement activities in rural and social development areas in their administrative regions:
Formulate science and technology plans and policies to promote rural and social development, breakthrough and demonstrate key technical issues in agriculture and social development fields, and promote rural construction and social construction with a focus on improving People's lives.

(5) Leading the coordination and promotion of industry–academia–research cooperation activities in their administrative regions:
① Work with relevant departments to formulate policies promoting industry–academia–research cooperation; ② Organize the application and demonstration of major scientific and technological achievements, strengthen the transformation and dissemination of scientific and technological achievements, and promote the construction of enterprises' technological innovation capabilities; and ③ Formulate policies to promote the development of technology markets and science and technology intermediary organizations, assign responsibility for the construction and management of local technology market systems, and promote the development of science and technology service systems.

(6) Primary responsibility for high-tech research and development, results transformation, and industrialization activities in their administrative regions:
① Work with relevant departments to formulate high-tech development and industrialization plans and policies and organize the implementation of major high-tech industrialization projects at the provincial level, ② Integrated management, guidance, and coordination of high-tech industrial development zones and other science and technology parks and specialized industrial bases, ③ Organize certification activities for high-tech enterprises, technology-advanced service enterprises, and independently innovative products, iv) Participate in high-tech venture capital activities.

(7) Propose policy measures for science and technology system reform in their administrative regions together with relevant departments and promote the construction of local innovation systems. Review the establishment and coordination of related research and development institutions.

(8) Take responsibility for budget and final accounts of science and technology funds at the departmental level and provincial level under unified management and supervise the use of funds. Work with relevant departments to establish policy measures for expanding science and technology investment through multiple channels. Formulate

plans and related policies to ensure research and development conditions in their administrative regions. Work with relevant departments to formulate and implement research and development infrastructure construction plans in their administrative regions and promote joint construction and sharing of infrastructure. Work with relevant departments to propose policies for rational allocation of science and technology resources.

(9) Formulate international science and technology cooperation and exchange plans and policies in their administrative regions. Take responsibility for review and decision-making activities for international science and technology cooperation projects.

(10) Science and technology popularization activities in their administrative regions:
① Formulate science and technology popularization plans and related policies for their administrative regions, organize the implementation of science popularization plans, and be responsible for certifying provincial-level science popularization bases and demonstration bases, ② Conduct integrated coordination, supervision, and inspection of local science popularization activities.

(11) Activities related to science and technology personnel in their administrative regions:
① Work with relevant departments to formulate plans and propose policies for building science and technology talent teams, ② Take charge of activities related to building science and technology talent teams and science and technology innovation teams in their administrative regions.

(12) Formulate basic research plans and policies in their administrative regions and take responsibility for local natural science foundation activities.

(13) Take responsibility in their administrative regions for activities including science and technology awards, management of laboratory animals for research and development, science and technology confidentiality, science and technology evaluation, science and technology statistics, science and technology information, and science and technology periodicals.

1.3 Tasks and Roles of the Ministry of Finance in Formulating Policies Related to Fiscal Expenditure

According to the "State Council Institutional Reform Plan" [in Chinese] approved at the First Session of the 13th National People's Congress, the "Provisions on the Functional Configuration Internal Organizations and Staffing of the Ministry of Finance" [in Chinese], established by the State Council in 2019, and regulatory systems including the "Plan on Deepening Reform of Central Fiscal Science and Technology Program (Special Projects, Funds, etc.) Management" [in Chinese], "Standards for Performance Assessment of Central Fiscal Science and Technology Programs (Special Projects, Funds, etc.)" [in Chinese], and "Interim Measures for the Administration of National Key Research and Development Programs" [in Chinese], jointly established by the Ministry of Finance and Ministry of Science and Technology, the tasks and roles of the Ministry of Finance in policies related to fiscal expenditure are as follows:

(1) Formulate relevant financial support policies based on development strategies, guidelines and policies, medium and long-term plans, laws and regulations, reform plans, and departmental rules established by institutions at various levels in the science and technology field. During the formulation of macro-level plans and micro-level policies in the science and technology field, participate in relevant advisory meetings, implement macro-level control, and present proposals for fiscal and taxation policies aimed at achieving a balanced allocation of financial resources across society.

(2) Participate in compiling the Ministry of Science and Technology's annual budget and final accounts and provide expert proposals. Submit these to the State Council for review and approval, with the understanding that the budget and final accounts require joint approval by the Ministry of Science and Technology and Ministry of Finance. In this process, the Ministry of Finance provides support to the Ministry of Science and Technology on matters relating to financial systems for budgets and final accounts, taking into consideration both the national fiscal situation and the policies and budget scale set by higher authorities for the science and technology field.

(3) Determine fiscal and tax collection plans in line with the Ministry of Science and Technology's budget formulation. Submit proposals for tax increases or decreases, adjustments to applicable tax rates, tax reductions and exemptions, and temporary special tax exemptions that would have a relatively significant impact on central finances.

(4) Cooperate with the Ministry of Science and Technology in compiling national debt issuance plans in accordance with the guidelines, policies, regulations, and management methods for debt management within jurisdictional projects as submitted by the Ministry of Science and Technology. Additionally, assist the Ministry of Science and Technology in coordinating procedures for various government financing and financial support from international organizations for science and technology, and in reporting and recording these with the State Council. Verify economic transactions arising from foreign aid and cooperation projects conducted under the Ministry of Science and Technology's name and complete related procedures.

In summary, regarding the Ministry of Finance's formulation of policies related to fiscal expenditure, the authority to make decisions on relevant matters and projects rests with the Ministry of Science and Technology, which leads the planning and establishment of major projects. The Ministry of Finance implements proposals and supervision activities regarding macro-level policies and comprehensive management to ensure the Ministry of Science and Technology implements relevant projects in compliance with the law. The authority and initiative for fund allocation at the micro level lies with the Ministry of Science and Technology.

1.4 Policy Decision Process for Expenditure Allocation between Basic Research and Applied Research

The allocation process primarily consists of budget proposal submission and formulation, and expenditure distribution is carried out according to the approved budget plan. Therefore, decisions on expenditure allocation are primarily determined through the process of formulating and approving budget requests.

According to the 2021 departmental final accounts materials published by the Ministry of Science and Technology, basic research expenditure comprises spending by institutions engaged in basic research and applied research requiring longer periods for practical application, special scientific research expenditure[7], and key laboratory expenditure.

According to data released by the Ministry of Science and Technology at the 2021 Two Sessions (National People's Congress and Chinese People's Political Consultative Conference), China's basic research funding doubled during

[7] Special scientific research expenditure: Refers to dedicated project funds within basic research funds, including "National Key Basic Research Development Plan Special Project Funds," "National Science and Technology Support Plan Special Projects," and "National High-Tech Research Development Plan Special Project Funds."

the ""13th Five-Year Plan"" period (2016–2020), achieving a growth rate of 16.9% and reaching CNY 133.6 billion in 2019. This was the first time that this proportion accounted for 6% of total research and development. According to data released by the National Bureau of Statistics, basic research funding in 2020 was CNY 150.4 billion. In his report on the activities of the two meetings in 2021, Premier Li Keqiang stressed the need to significantly expand investment in basic research. In his activity report at the 2021 Two Sessions, Premier Li Keqiang emphasized the need to significantly expand investment in basic research. He indicated that basic research expenditure from central fiscal funds would show a 10.6% increase in 2021.

Resource allocation for basic research is primarily concentrated in the Ministry of Science and Technology, where its affiliated departments organize budget formulation and funding requests, and the Ministry of Science and Technology also coordinates related resource distribution.

The basic principles for allocating basic research expenditures according to the "Administrative Measures for Special Project Funds under the National Key Basic Research Development Plan" are as follows: (1) Concentrate financial resources for breakthrough achievements, ensure funding needs while avoiding dispersed usage, arrange scientifically and allocate rationally, strictly align with project goals and tasks for scientific and rational budget planning and allocation, and eliminate arbitrariness and (2) Separate accounting and dedicated expenditure. The specific process is as follows:

The Ministry of Science and Technology has 24 independent budget accounting departments. Since the Department of Basic Research is not an independent accounting department, related budget reports must be submitted under the name of the Ministry of Science and Technology General Office. In addition to the budget and allocation of basic research funds related to the Department of Basic Research (an internal department of the Ministry of Science and Technology), the other 23 operational organizations under its jurisdiction that maintain independent accounting systems outside of internal departments must also separately submit requests for expenses related to basic research projects. According to the financial function classification code requirements, the unified internal application code for the Department of Basic Research and other accounting departments is 20602. This mainly includes expenditures for basic research, expenditures for applied research institutions that cannot obtain practical value in the near future, special scientific research expenditures, and key laboratory expenditures. Basic research funds must be separately accounted for and can only be used for their designated purpose.

(2) To illustrate this process, the Department of Basic Research prepares expenditure estimates around October of each fiscal year (in China, the fiscal year runs January to December). These estimates must align with Ministry of Science and Technology and national policies and cover national basic research plans, policies, and major tasks for the upcoming budget year. These estimates must provide detailed explanations of the main purposes and rationale for each expenditure. The project estimates are based on the comprehensive past performance of major basic research projects and research project selection outcomes. The Budget Division of the Department of Resource Allocation Management within the Ministry of Science and Technology, along with experts from the scientific community and Ministry of Finance, are invited to conduct independent deliberations and evaluations, which form the basis for budget compilation.

(3) The General Office of the Ministry of Science and Technology compiles a specialized budget for basic research expenses by combining the basic research budgets submitted by the Department of Basic Research and other independent accounting units under the Ministry's jurisdiction.

(4) The Ministry of Science and Technology and Ministry of Finance either organize experts or commission

intermediary agencies to review and evaluate the budget and then announce it according to established procedures. If there are major objections to the budget, it must go through a formal reconsideration process. The Ministry of Science and Technology maintains an expert database specifically for budget review.

(5) According to the annual budgeting process, the Ministry of Science and Technology submits the budget to the Ministry of Finance in accordance with departmental budget formulation requirements. After receiving a response from the Ministry of Finance, the Ministry of Science and Technology compiles the response and budget application materials for submission to the State Council and awaits the State Council's response. After approval by the State Council and the National People's Congress, the program takes legal effect and funds are allocated to the Ministry of Science and Technology through the Ministry of Finance according to the budget plan.

The above represents the process for applying for and allocating basic research funds primarily supported by the central government budget. Additionally, according to the "Interim Measures for Management of Special Project Funds for Applied Technology Research and Development" [in Chinese], issued by the Ministry of Finance and Ministry of Science and Technology, applied technology research and development funds are intended to support scientific and technological innovation and development; strengthen the connection between science, technology and the economy; and promote sustainable development of the national economy and society. These funds primarily support the following:

(1) Scientific and Technological Breakthrough Programs

These provide technical support for industrial structure adjustment; improvement of People's quality of life; and sustainable social development by supporting research and development activities for major, fundamental, and public interest technologies that address common issues in national economic and social development.

(2) Building Science and Technology Industrialization Infrastructure and Transfer/Diffusion of Scientific and Technological Achievements

This creates an environment for technological innovation and industrialization of scientific and technological achievements through supporting the development of technological innovation capabilities at science and technology industrialization bases, research and development of science and technology industrialization demonstration projects, and related scientific and technological training.

(3) Project Costs and Program Management Fees are Included in Applied Technology Research and Development Fund Expenditures

Applied research and basic research are treated as distinct, dedicated financial request items. Consequently, the Ministry of Science and Technology's internal institutions, the Department of Achievement Transformation and Regional Innovation, jointly handle the request and allocation procedures with the Department of Resource Allocation Management. The allocation decision process is the same as for basic research.

1.5 Policy Recommendation Process and Achievements of the China Association for Science and Technology

The China Association for Science and Technology (CAST) leverages its unique organizational advantages and academic influence to unite numerous scientific and technological workers. It actively conducts consulting activities for policy decisions related to scientific and technological innovation, supports party and government scientific policy formulation, and serves as a think tank for scientific and technological innovation.

According to regulations such as "Opinions on Strengthening the China Association for Science and Technology's Policy Decision Consulting Activities and Promoting the Construction of National Science and Technology Think Tanks" [in Chinese] and "Administrative Measures for the China Association for Science and Technology's Collection of Suggestions from Scientific and Technical Personnel (Trial)" [in Chinese], CAST holds its first standing committee meeting each year. At this meeting, the Policy Decision Advisory Committee affiliated with the association's representative assembly focuses discussions on major issues of central government interest. Through these discussions, they determine the major issues and topics to recommend to the Secretariat of the CPC Central Committee and the State Council and compile meeting resolutions.

Within one month after these resolutions, the Strategy Development Department and General Office (internal organizations of the Standing Committee) lead the establishment of relevant project working groups together with the CAST Policy Decision Advisory Committee and the Innovation Strategy Research Institute, which is directly subordinated to the association. The working groups are divided into task groups based on criteria such as function and regional focus, with each group working on separate issues. Each task group must assemble personnel to complete project research and recommendations within three months for each project, drawing from experts at local science and technology associations and the branch institutes and offices of CAST's think tank network.

The project working groups submit their project reports at the second standing committee meeting held within the year. They also submit these reports to third-party institutions and experts, including relevant committee members of the CAST Academic Committee, academicians from the Chinese Academy of Sciences (CAS) and Chinese Academy of Engineering (CAE), and experts from the Ministry of Science and Technology's Strategy Research Institute, as reference material for standing committee discussions. Through standing committee discussions, they determine the content for comprehensive reporting to the Secretariat of the CPC Central Committee and State Council. The Policy Decision Advisory Committee and the leadership of CAST report recommendations and opinions on major national themes and projects to the Party Central Secretariat and State Council at appropriate times. Zou Xiaodong, Deputy Secretary of the Central Committee and State Organs Work Committee of the CPC Central Committee, currently serves as the liaison to the CAST. Having previously served as Communist Party Secretary of Zhejiang University, he has extensive experience in research and development operations. On the State Council, Vice Premier Wang Yang acts as the liaison to CAST.

In January 2021, CAST established the Kechuang China Consultation Committee. This committee functions as a platform organization to promote the practical implementation of research results through industry–academia–government collaboration, with two chairs serving at the top, one representing industry and the other representing the science and technology sector. Its purpose is to incorporate industry perspectives into R&D activities, enhance both the economic and industrial value of technological achievements, and improve the efficiency of industry–academia–government collaboration. It should be noted that CAST does not currently have any channels for accepting proposals from individual researchers.

CAST conducts specialized research on topics commissioned by the Party, government, and related departments. Specifically, it organizes experts to conduct strategic research on major issues focused on science, technology, and socioeconomic development. Furthermore, members of the Chinese People's Political Consultative Conference (CPPCC) and CAST participate in state affairs by providing recommendations and proposals to support research initiatives. For evaluation and science-technology related tasks directly mandated by the CPC Central Committee, State Council, or National People's Congress, certain evaluation reports may be submitted directly to the CPC Central Committee and State Council.

CAST monitors innovative trends in international scientific and technological development, leverages the professional strengths of its affiliated science and technology groups, makes timely assessments of major scientific and technological development opportunities and directions, provides high-level consultation for China's science and technology strategy planning, and supplies reference materials for policy formulation.

The academic societies within CAST select and forecast technologies that are considered "make-or-break" core technologies. These societies also implement in-depth projects to guide academic field development and integrate resources, while tracking and evaluating global science and technology frontiers. Furthermore, they organize groups of academicians to evaluate development trends and innovation capabilities in key fields. They systematically examine and assess the opportunities and challenges that new phases of scientific, technological, and industrial transformation present to China's development. Through these activities, they collaborated with departments including the Ministry of Science and Technology of the State Council to establish the "Guiding Opinions on Improving the Evaluation Mechanism for Scientific and Technological Achievements" [in Chinese], which led to appropriate positioning of both basic and applied research. Market-based evaluation and other systems guide the allocation of innovation resources, and these reforms are considered advantageous for achieving breakthroughs in core fundamental technologies. Based on research studies and expert opinions, CAST's Policy Advisory Committee assisted the Chinese Academy of Engineering, a direct subordinate of the State Council, in completing the "Strategic Research on Emerging Industry Development (2035)" [in Chinese] project and made recommendations regarding the development vision, key objectives, and measures for the "14th Five-Year Plan" and medium to long-term strategic emerging industries.

The Academic Committee, acting under CAST's name, organized experts to participate in feasibility studies for major projects including the Three Gorges Project and the Tibet Railway. The Policy Advisory Committee organized internal experts to participate in drafting important documents including the "Outline of the National Action Plan for Scientific Literacy (2006–2010–2020)" [in Chinese], "Law of the People's Republic of China on Popular Science" [in Chinese], "Outline of the Medium and Long-term Science and Technology Development Plan (2006–2020)" [in Chinese], "Opinion on Further Promoting Scientific Spirit and Strengthening Work Style and Academic Style" [in Chinese], and "Outline of the Medium and Long-term Science and Technology Development Plan (2021–2035)" [in Chinese].

2 Important Science and Technology Policies of China

China's scientific and technological advances in recent years have been remarkable. In China, significant policies have been announced and implemented at key junctures in response to changing domestic and international situations. The following five experts introduced policies that have significantly contributed to China's progress in science and technology, as well as recently formulated policies expected to make important contributions to China's scientific and technological advancement.

Name	Affiliation
ZHU Hongyong	Vice President, China Institute of Atomic Energy
LIU Huijuan	Distinguished Professor, School of Environment, Tsinghua University (Researcher, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences (CAS); Deputy Director, State Key Laboratory)
WANG Chengwen	Professor, School of Environment, Tsinghua University (Director, Environmental Assessment Office, Tsinghua University)
XUE Lan	Professor, School of Environment, Tsinghua University (Director, Environmental Assessment Office, Tsinghua University)
Jin Changqing	Researcher, Institute of Physics, CAS (Chief Scientist, National Key R&D Program Project; Leader of Innovation Research Group, National Science Fund for Distinguished Young Scholars, National Natural Science Foundation of China (NSFC))

2.1 Policies That Made Major Contributions to Scientific and Technological Development

The following is a chronological list of policies and their main points. (Note that some policies may be listed more than once.)

Policy Name (Issuing Organization, Date of Issue)	Key Policy Points
"National Medium and Long-term Science and Technology Development Plan Outline (2006–2020)[8]" [in Chinese] (State Council, February 2006)	· A macro-level science and technology strategy and policy toward 2020, serving as a framework for innovation-oriented national strategy · Achieve breakthroughs in several critical core technologies and comprehensively enhance science and technology support capabilities based on national conditions and needs · Implement multiple major special projects targeting national objectives, achieve breakthrough development, and fill gaps · Make advance strategic preparations in frontier technologies and basic research to enhance sustainable innovation capabilities · Deepen institutional reform, improve policy measures, expand investment in science and technology, and strengthen talent team building (Listed by three experts)
"Law of the People's Republic of China on Promoting the Transformation of Scientific and Technological Achievements[9]" [in Chinese] (Standing Committee of the National People's Congress, August 2015)	· Plays a normative and guiding role in encouraging the transformation of scientific and technological achievements and improving economic quality and upgrading, while serving as a crucial reference for transforming scientific and technological achievements at state-established R&D institutions and universities
"The '13th Five-Year' National Science and Technology Innovation Program" [10](State Council, July 2016)	· A key special plan in the field of science and technology innovation that outlines the overall vision, development goals, main tasks, and major measures for science and technology innovation during the 13th Five-Year period (2016–2020), serving as an action guide for building an innovation-oriented nation · Established overall objectives for building China into a world science and technology power · (Listed by two experts)
"Notice on Completing Stock Ownership and Dividend Activities of Central Science and Technology Enterprises under the State-owned Assets Supervision and Administration Commission of the State Council[11]" [in Chinese] (State-owned Assets Supervision and Administration Commission of the State Council, October 2016)	· Carefully implement stock ownership incentives; for the same incentive recipient, adopt one incentive method and provide one incentive based on the same job's scientific and technological achievements or industrialization projects · When implementing dividend incentives, annual performance evaluation indicators must be clearly defined

8 "国家中长期科学和技术发展规划纲要 (2006–2020)" [in Chinese] (http://www.gov.cn/gongbao/content/2006/content_240244.htm)

9 "中华人民共和国促进科技成果转化法" (https://www.jetro.go.jp/ext_images/world/asia/cn/ip/law/pdf/regulation/regulation20151001.pdf)

10 "十三五'国家科技创新规划" (http://www.gov.cn/zhengce/content/2016-08/08/content_5098072.htm)

11 "关于做好中央科技型企业股权和分红激励工作的通知" (http://www.sasac.gov.cn/n2588035/n2588320/n2588335/c4258387/content.html)

"National Strategic Emerging Industries Development Plan for the 13th Five-Year Period[12]" [in Chinese] (State Council, December 2016)	· Provided strong planning support for developing five major areas and eight major industries in strategic emerging industries by detailing strategic emerging industries for priority development during the 13th Five-Year period, incorporating overall objectives, innovation environment guarantees, and specific development measures
"Guiding Opinions on Supporting and Encouraging Professional Technical Personnel in Public Institutions for Innovation and Entrepreneurship[13]" [in Chinese] (Ministry of Human Resources and Social Security, March 2017)	· Public institutions select and dispatch technical personnel to enterprises or participate in project cooperation · Professional technical personnel in public institutions engage in innovation through part-time work or start businesses during their tenure · Public institutions establish innovation-oriented positions · Professional technical personnel in public institutions may leave their positions to pursue innovation and entrepreneurship
"National Technology Innovation Project Plan for the 13th Five-Year Period[14]" [in Chinese] (15 departments, including the Ministry of Science and Technology, April 2017)	· Rely on market mechanisms Improve market-oriented mechanisms for technological innovation and strengthen enterprises' primary role in technological innovation · Strengthen cooperation: Enhance industrial joint innovation and fully mobilize the initiative and creativity of various innovation entities including enterprises, universities, and R&D institutions · Deepen reforms: Fully exercise government's guiding role in technological innovation, drive innovation through reform, promote the transformation of government functions from R&D management to innovation services, and unleash scientific and technological innovation potential · Open cooperation Grasp new trends in global innovation element mobility, and concentration; fully utilize domestic and international innovation resources; and effectively allocate innovation resources
"Opinions of the State Council on Comprehensively Strengthening Basic Scientific Research" [in Chinese] [15](State Council, January 2018)	· Improve the organization of basic research and promote the construction of major national scientific infrastructure · Build high-level research centers Strengthen the construction of innovation centers such as State Key Laboratories · Expand basic research talent teams · Raise the level of internationalization in basic research; Organize and implement international big science plans and projects Implement the Belt and Road Science and Technology Innovation Action Plan · Optimize mechanisms and environment for basic research development Establish diversified investment mechanisms for basic research and deepen reform of R&D project and funding management · (Listed by two experts)

12 "十三五' 国家战略性新兴产业发展规划" (http://www.gov.cn/zhengce/content/2016-12/19/content_5150090.htm)

13 "关于支持和鼓励事业单位专业技术人员创新创业的指导意见" (http://www.mohrss.gov.cn/rydwrsgls/SYDWRSGLSzhengcewenjian/201703/t20170318_268143.html)

14 "十三五'国家技术创新工程规划" (http://www.most.gov.cn/xxgk/xinxifenlei/fdzdgknr/fgzc/gfxwj/gfxwj2017/201705/t20170503_ 132603.html)

15 "国务院关于全面加强基础科学研究的若干意见"(http://www.gov.cn/zhengce/content/2018-01/31/content_5262539.htm)

"Opinions on Further Strengthening Research Integrity[16]" [in Chinese] (General Office of the CPC Central Committee, General Office of the State Council, May 2018)	· Establish a national database of misconduct, a blacklist of "low-quality" journals, and government agencies responsible for regulating academic misconduct, elevating and improving research integrity to the level of national policy · (Listed by two experts)
"Opinions on Deepening the Reform of Project Review, Talent Evaluation, and Organization Assessment[17]" [in Chinese] (General Office of the CPC Central Committee, General Office of the State Council, July 2018)	· Establish classification evaluation indicator systems and standardize evaluation processes; For basic frontier research, make originality the highest priority as the core of peer review · For public welfare research, prioritize needs and focus on industrial user and social evaluation · For applied technology development and achievement transformation evaluation, prioritize enterprise leadership and market orientation, centering on user evaluation, third-party assessment, and market performance · (Listed by two experts)
"Notice on Several Measures to Optimize Scientific Research Management and Improve Scientific Research Performance[18]" [in Chinese] (State Council, July 2018)	· Implement a pilot program to expand autonomy in the use of scientific research funds. · Host organizations are encouraged to independently determine the scope and standards for fund usage within their total performance and wage allocations and to publicize these internally within the organization[19].
"Notice on Further Optimizing National Key R&D Program Project and Fund Management[20]" [in Chinese] (Ministry of Science and Technology, Ministry of Finance, January 2019)	· Consolidate and simplify various reports and further improve and streamline budget preparation · Items exceeding 10% should be categorized and explained but do not need to be calculated for each conference or research trip Furthermore, enable innovation teams and top talent to exercise strong management over human, financial, and material resources and make decisions regarding technical approaches.
"Guiding Opinions on Promoting the Development of New Types of R&D Institutions[21]" [in Chinese] (Ministry of Science and Technology, September 2019)	· New types of R&D institutions should focus on scientific and technological innovation needs, primarily engaging in scientific research, technological innovation, and research services. They are independent legal entities with diversified investment bodies, market-oriented operational mechanisms, and flexible employment mechanisms and can be registered as private non-enterprise scientific organizations, institutional organizations, or enterprises according to law.

16 "关于进一步加强科研诚信建设的若干意见" (http://www.xinhuanet.com/politics/2018-05/30/c_1122913789.htm)

17 "关于深化项目评审、人才评价、机构评估改革的意见" (http://www.gov.cn/zhengce/2018-07/03/content_5303251.htm)

18 "国务院关于优化科研管理提升科研绩效若干措施的通知" (http://www.gov.cn/zhengce/content/2018-07/24/content_5308787.htm)

19 Note on Host Organizations: According to the "General Program Management Measures of the National Natural Science Foundation of China" and the "Management Measures for Host Organizations of the National Natural Science Foundation of China," individual applications are not permitted. Host organizations must be registered with the NSFC. Proposals must be submitted under the name of the organization to which one belongs or through another qualifying organization. Even if one's own organization does not qualify to submit a proposal, it is possible to submit through another organization if it offers a better match in expertise or provides an advantage in the application process.

20 "科技部 财政部关于进一步优化国家重点研发计划项目和资金管理的通知" (http://www.most.gov.cn/xxgk/xinxifenlei/fdzdgknr/fgzc/gfxwj/gfxwj2019/201901/t20190130_144943.html)

21 "科技部印发《关于促进新型研发机构发展的指导意见》的通知" (http://www.gov.cn/gongbao/content/2020/content_5469722.htm)

"Notice on Issuing the Rules for Investigation and Handling of Scientific Research Integrity Cases[22] (Trial)" [in Chinese] (Ministry of Science and Technology, September 2019)	· Competent departments shall establish a sound information reporting mechanism for major scientific research integrity cases and independently investigate major scientific research integrity cases within the system. · For credibility violations in paper publications, the first author or the first author's primary affiliated organization shall be responsible for leading the investigation and handling. Organizations of other authors shall actively participate in the investigation and handling of their authors and report the status to the leading organization as appropriate. · For suspected misconduct in degree theses, the degree-granting organization shall be responsible for investigation and handling. Journal editorial departments or publishers of published papers have an obligation to cooperate with investigations.
"Plan for Strengthening '0 to 1' Basic Research Activities[23]" [in Chinese] (Ministry of Science and Technology et al., January 2020)	The plan presented specific measures related to optimizing the environment for original innovation, strengthening original orientation in national science and technology programs, enhancing the cultivation of basic research talent, innovating scientific research methods and means, strengthening original innovation in State Key Laboratories, elevating enterprises' independent innovation capabilities, and strengthening management services.
Notice of the Ministry of Science and Technology on the Issuance of "Measures for Eliminating the Undesirable Trend of 'Relying Solely on Papers' in Science and Technology Evaluation (Trial Implementation)[24]" [in Chinese] (Ministry of Science and Technology, February 2020)	A transition from initial publication metric-based evaluation to multi-faceted evaluation. The first priority is strengthening the orientation toward classified review and evaluation, and the second is establishing classification of evaluation points and requirements for scientific and technological activities. The third is avoiding simplistic connections between publications and resource allocation and benefits.
"Direction for Implementing Pilot Projects to Grant Scientific Research Personnel Ownership or Long-Term Use Rights to Scientific and Technological Results" [25](9 divisions of the Ministry of Science and Technology, etc., May 2020)	· Implementation organizations for the pilot project can grant rights to use scientific and technological achievements for periods exceeding 10 years. This deepens the reform of rights to use, dispose of, and benefit from scientific and technological achievements; further, it is an important measure to stimulate researchers' enthusiasm for innovation and promote the transformation of scientific and technological achievements.

22 "关于印发《科研诚信案件调查处理规则（试行）》的通知"
(http://www.nhc.gov.cn/qjjys/ycgfxwj/202106/54568b3e915244a4ae4fc44109db700a.shtml)

23 "加强'从0到1'基础研究工作方案" (http://www.cac.gov.cn/2020-03/04/c_1584872637385792.htm)

24 "科技部印发《关于破除科技评价中"唯论文"不良导向的若干措施(试行)》的通知"
(http://www.most.gov.cn/xxgk/xinxifenlei/fdzdgknr/fgzc/gfxwj/gfxwj2020/202002/W020200716318617342543.pdf)

25 "赋予科研人员职务科技成果所有权或长期使用权试点权实施方案"
(http://www.gov.cn/zhengce/zhengceku/2020-05/19/content_5512908.htm)

2.2 Policies Considered to Make Significant Contributions to Scientific and Technological Development

The following is a chronological list of policies and their main points. (Note that some policies may be listed more than once.)

Policy Names (Issuing Agency, Publication Date)	Key Policy Points
"Guiding Opinions on Promoting the Development of New Types of R&D Institutions" (Ministry of Science and Technology, September 2019)	(Op. cit. Listed by a total of three experts)
"Several Measures to Eliminate the Over-Reliance on Publication Metrics in Science and Technology Evaluation (Trial)" (Ministry of Science and Technology, February 2020)	(Op. cit. Listed by a total of three experts)
"Notice on Implementing the Collection of Major Research and Development Needs for the National Key R&D Program During the 14th Five-Year Plan Period (Supplementary Explanation)[26]" [in Chinese] (Ministry of Science and Technology, February 2020)	· Further deepen the reform of project formation mechanisms. Major research and development needs during the 14th Five-Year Plan period are directed toward basic frontiers, energy, transportation, information technology, manufacturing, materials, space technology, agriculture, resources environment and marine, biomedicine and life health, social programs and public safety, and other fields.
"Several Key Measures to Strengthen Basic Research Under New Circumstances[27]" [in Chinese] (Ministry of Science and Technology et al., April 2020)	· Presents specific measures to strengthen basic research to implement the "Opinions of the State Council on Comprehensively Strengthening Basic Scientific Research" (see above.

26 "科技部关于开展国家重点研发计'十四五'重大研发需求征集工作的通知" (http://www.most.gov.cn/xxgk/xinxifenlei/fdzdgknr/qtwj/qtwj2020/202001/t20200106_150952.html)

27 "新形势下加强基础研究若干重点举措" (https://www.cas.cn/zcjd/202005/t20200512_4745744.shtml)

Local (Shanghai, Guangdong, Beijing, Shenzhen, etc.) "14th Five-Year Plans for Science and Technology Innovation" (Various Local Governments, 2021–2022) [in Chinese][28,29]	· Accelerate breakthroughs in basic research originality and enhance original innovation capabilities. (Shanghai) · Achieve international advanced levels in major innovation indicators and preliminarily establish a science, technology, and industrial innovation highland with global influence in the Guangdong-Hong Kong-Macao Greater Bay Area[30]. (Guangdong Province) · Accelerate the cultivation and construction of national laboratories, promote the systematization of Beijing's State Key Laboratories, and accelerate the construction of comprehensive national science centers. Also foster new types of R&D institutions in priority areas. (Beijing) · Listed seven strategic emerging industries (20 industrial clusters) and eight future industries as areas for technological breakthroughs. (Shenzhen)
"Interim Provisions on Handling Violations in Scientific and Technological Activities[31]" [in Chinese] (Ministry of Science and Technology, July 2020)	· Standardize the handling of violations in scientific and technological activities and create a positive scientific research atmosphere.
"Outline of the 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035[32]" [in Chinese] (National People's Congress, March 2021) (http://www.gov.cn/xinwen/2021-03/13/content_5592681.htm)	· Strengthen originality-driven scientific and technological breakthroughs. · Formulate and implement strategic scientific plans and projects in core basic fields that affect national security and overall development. · Implement forward-looking strategic national major science and technology projects targeting frontier fields including artificial intelligence (AI), quantum information, integrated circuits, life and health, brain science, biological breeding, space science and technology, deep earth and deep sea. · Foster world-class basic research talent teams and promote interdisciplinary and cross-disciplinary research. · Guide enterprises and financial institutions to expand support through appropriate methods and encourage society to invest through multiple channels such as donations and fund establishment. · Reform the evaluation mechanisms for basic research, topic selection, and incentive systems and strengthen the guiding role of basic research's originality orientation and scientific support for applied sciences. (Listed by three experts)

28 "多地公布科技创新'十四五'规划，瞄准这些领域" (https://www.chinanews.com.cn/cj/2021/10-26/9594890.shtml)

29 "深圳科技创新十四五规划：明确7大战略性新兴产业和8大未来产业" (https://www.thepaper.cn/newsDetail_forward_16301776)

30 Note: A regional development plan that aims to integrate Hong Kong, Macao, and nine cities in the Pearl River Delta of Guangdong Province (including Guangzhou, Shenzhen, Dongguan, Huizhou, Foshan, Jiangmen, Zhongshan, Zhuhai, and Zhaoqing) into a Greater Bay Area.

31 "科学技术活动违规行为处理暂行规定" (http://www.gov.cn/zhengce/zhengceku/2020-08/09/content_5533566.htm)

32 "中华人民共和国国民经济和社会发展第十四个五年规划和2035年远景目标纲要" (http://www.gov.cn/xinwen/2021-03/13/content_5592681.htm)

"Notice on Further Promoting Comprehensive Innovation Reform[33]" [in Chinese] (National Development and Reform Commission, Ministry of Science and Technology, April 2021)	· Plan and promote the "Xiaogang Village[34]"-style reforms in science and technology innovation and resolve the problems and obstacles that innovators acutely experience. · Build a scientific research system capable of operating with high efficiency. Steadily implement the "Fang-Guan-Fu[35]" reforms (to "streamline administration and delegate power, improve regulation, and upgrade services") for scientific funding and grant research and development institutions greater autonomy in personnel matters. · Reform the launch and organizational management methods for major science and technology projects. Implement systems such as Strategic Open Recruitment[36] and Competitive Project Selection[37] for core fundamental technologies and promote the technical director system. · Grant R&D personnel ownership and long-term usage rights to scientific and technological achievements obtained through their work duties. Establish exception lists for assessing the value and risks of scientific and technological achievement transformation, as well as tolerance mechanisms for failures. · Establish a unified market access system that prohibits exceptions for new technologies, new industries, new business formats, and new models. (Listed by two experts)
"Outline of the National Action Plan for Scientific Literacy (2021–2035)[38]" [in Chinese] (State Council, June 2021)	· Sets a long-term goal for 2035 to increase the proportion of citizens with scientific literacy to 25%, while significantly reducing the gap in scientific literacy development between urban and rural areas and regions. Additionally, aims to fundamentally achieve equalization of public services for science popularization.
"Data Security Law[39]" [in Chinese] (Standing Committee of the National People's Congress, June 2021)	· Explores models for balancing technological advancement and social benefits in frontier sciences and technologies and establishes legal baselines that will affect future scientific and technological development.

33 "国家发展改革委 科技部关于深入推进全面创新改革工作的通知" (https://www.ndrc.gov.cn/xxgk/zcfb/tz/202104/t20210409_1272028.html?code=&state=123)

34 Note: China's reform and opening up started in rural areas, with Xiaogang Village in Fengyang County, Anhui Province serving as its starting point.

35 Fang-Guan-Fu (放管服): Refers to streamlining administration and delegating power, improving regulation, and upgrading services

36 4.4 See the National Key Research and Development Program's Strategic Open Recruitment system.

37 Competitive Project Selection (Ch. *sai ma*; 賽馬; literally "Horse Racing") In exploring the Strategic Open Recruitment system, this term refers to a new method of project organization designed to optimize the research structure for core technologies. Under this approach, multiple entities tackling the same challenges are selected at the project planning stage and undergo a prioritization process. Throughout the implementation, they are subject to phased evaluations and a competitive selection process, which ensures that only the most capable and superior entities prevail. This competitive framework significantly enhances both the quality and efficiency of the research efforts.

38 "国务院关于印发全民科学素质行动规划纲要(2021—2035年)的通知" (http://www.gov.cn/zhengce/content/2021-06/25/content_5620813.htm)

39 "中华人民共和国数据安全法" (http://www.npc.gov.cn/npc/c30834/202106/7c9af12f51334a73b56d7938f99a788a.shtml)

"Several Measures to Support Women Scientists and Engineers to Play a Greater Role in Scientific and Technological Innovation[40]" [in Chinese] (13 departments including the Ministry of Science and Technology, July 2021)	· Improves evaluation and incentive mechanisms for women in science and technology; Supports women in science and technology to engage in R&D activities during pregnancy and nursing periods; Strengthens the development of backup female science and technology personnel; Enhances foundational activities for women in science and technology
"Opinions on Improving the Management Reform of Central Government Scientific Research Funds[41]" [in Chinese] (General Office of the State Council, August 2021)	· Grants research and development institutions greater autonomy while giving scientists more authority in determining technical directions and control over the use of funds. (Listed by two experts)
"Guiding Opinions on Improving the Evaluation Mechanism for Scientific and Technological Achievements[42]" [in Chinese] (General Office of the State Council, August 2021)	· Makes quality, achievements, and contributions the core direction for evaluation of scientific and technological innovation · Introduces third-party evaluation and establishes a diversified evaluation system with joint participation from government, social organizations, enterprises, and investment and financing institutions, in addition to building technology markets (Listed by two experts)
Science and Technology Policy[43] Explanation at the 2021 Central Economic Work Conference [in Chinese]	· Formulates and implements a three-year action plan for science and technology system reform and a 10-year plan for basic research · Promotes strengthening of national strategic scientific and technological capabilities, utilization of national laboratory functions, reorganization of National Key Laboratories, and reform of research and development institutions · Strengthens enterprises' position as primary innovation entities and deepen industry–academia–research integration · Improves the science and technology innovation ecosystem and establishes sound scientific research practices; Continues international scientific and technological cooperation.

40 "科技部等十三部门印发《关于支持女性科技人才在科技创新中发挥更大作用的若干措施》的通知" (http://www.most.gov.cn/xxgk/xinxifenlei/fdzdgknr/fgzc/gfxwj/gfxwj2021/202107/t20210719_175960.html)

41 "国务院办公厅关于改革完善中央财政科研经费管理的若干意见" (http://www.gov.cn/zhengce/content/2021-08/13/content_5631102.htm)

42 "国务院办公厅关于完善科技成果评价机制的指导意见" (http://www.gov.cn/zhengce/content/2021-08/02/content_5628987.htm)

43 https://www.xinhuanet.com/politics/ldzt/2021zyjjgzhy/index.htm

"Law of the People's Republic of China on Scientific and Technological Progress[44]" [in Chinese] (Standing Committee of the National People's Congress, December 2021)	· Strengthens basic research and national strategic scientific and technological capabilities and improves the national innovation system; Additionally, promotes breakthroughs in core fundamental technologies and optimizes regional innovation layout · Improves management systems for scientific and technological personnel, enhances service awareness and support capabilities, and simplifies management processes; Avoids duplicate inspections and evaluations and reduces the burden on scientific and technological personnel in areas such as project reviews · Develops new types of innovation entities such as new research and development institutions and improves models for investment diversification, management system modernization, operational mechanism marketization, and employment system flexibility · Raises incentive levels for scientific and technological personnel, resolves financing challenges for science and technology enterprises, and strengthens regional scientific and technological innovation (Listed by three experts)
Notice on Issuing the Overall Plan for Comprehensive Reform Pilot Program of Market-Based Allocation of Factors of Production [45](State Council Office, January 6, 2022)	· The market-oriented direction of various reforms, including those to the science and technology system, remains unchanged. With the advancement of pilot programs, science and technology reform is transitioning from conventional management models to one of scientific management and service.

44 "中华人民共和国科学技术进步法" (http://www.npc.gov.cn/npc/c30834/202112/1f4abe22e8ba49198acdf239889f822c.shtml)

45 "国务院办公厅关于印发要素市场化配置综合改革试点总体方案的通知" (http://www.gov.cn/zhengce/content/2022-01/06/content_5666681.htm)

3 National Medium and Long-term Science and Technology Development Plan Outline (2021–2035)

Compilation work is underway on the "National Medium and Long-term Science and Technology Development Plan Outline (2021–2035)" [in Chinese], which is positioned as the foundation of China's science and technology policy. This outline represents China's highest-level national policy in the field of science and technology, where China's presence continues to grow stronger, and it is drawing worldwide attention. Mr. Zhu Hongyong (Vice President of the China Institute of Atomic Energy) provided an analysis of the outline's prospects.

3.1 Basic Policies of the Development Plan Outline

(1) Integration and Optimization of Science and Technology Resource Allocation

Strategic scientific and technological capabilities, led by national key laboratories, will be established based on strategic needs for national medium- and long-term economic and social development. State-class laboratories will be constructed in fields including quantum information, photonic/micro/nanoelectronics, internet communications, artificial intelligence (AI), biomedicine, and modern energy systems. Existing State Key Laboratories will be restructured to create a laboratory system with rational structure and high operational efficiency. Research capabilities and resources will be optimally allocated and shared among research institutes, universities, and enterprises. New innovation entities, including new types of research universities, will be developed, while reforms promoting market-oriented operational mechanisms and flexible employment systems will be steadily implemented.

(2) Enhancing Original and Advanced Scientific and Technological Research

Strategic scientific plans and projects will be implemented in core fields fundamental to national security and overall development. Recent international circumstances have created situations where supply chains have been driven into difficulties. Implementation of strategic major national science and technology projects with future potential requires careful consideration, given the US-led blockade of Western technology.

Moreover, in the context of the prolonged coronavirus pandemic, it is essential to focus resources on core fundamental technologies to prevent and control new infectious diseases and biosecurity risks in the public health sector.

(3) Strengthening Basic Research

Research and development bases in basic fields will be strategically positioned. Fiscal investment in basic research will be expanded, and investment funding for basic research will be diversified through economic measures such as tax exemptions. Long-term evaluation will be conducted for basic research, and its proportion will be increased in the evaluation of research and development institutions. A favorable research environment will be created that benefits basic research.

(4) Improving the Market-Oriented Mechanism for Technological Innovation and the Technological Innovation Service System

The shift of government functions from managing to servicing scientific and technological activities continues, with an emphasis on enhancing guidance through planning and policies and fostering an environment conducive to innovation. Furthermore, the direct involvement in projects, such as fund allocation, is reduced. More autonomy is granted to research and development institutions and personnel, advancing the chief technology officer system. Systems such as Strategic Open Recruitment[46] and Competitive Project Selection will be implemented, and fiscal support mechanisms combining compensation and subsidies will be strengthened. Science and technology evaluation mechanisms will be enhanced, the classification evaluation system for both exploratory and mission-oriented science and technology projects will be improved, an evaluation system for "non-consensus science and technology projects"[47] will be established, and science and technology incentive projects will be optimized.''

The role of enterprises as the primary drivers of innovation is strengthened, and the concentration of various innovation elements within enterprises is promoted. Moreover, a technology innovation system will be built with enterprises at the core, oriented towards the market, and featuring a strong integration of industry, academia, and research. The opening of national research and development platforms, scientific and technological reports, and scientific research data to enterprises will be promoted. The system for transforming scientific and technological achievements will be updated, and small and medium-sized enterprises will be encouraged to utilize scientific and technological achievements that meet the necessary conditions and have secured financial support.

(5) Cultivating High-Level Talent Teams

Following the patterns of talent growth and research and development activities, a greater number of world-class strategic scientific and technological personnel, scientific and technological leaders, and innovation teams will be fostered. In addition, a reserve of young scientific and technological talent with international competitiveness will be cultivated. Emphasis will be placed on cultivating and identifying talent through major scientific and technological tasks and significant innovation bases, and support will be provided for the establishment of postdoctoral innovation positions.

The training of outstanding students in basic disciplines will be strengthened, and bases and frontier science centers will be established in foundational fields such as mathematics, physics, chemistry, and biology.

An increasingly open talent policy will be implemented, creating an advantageous environment for scientific and technological innovation that attracts outstanding talent from both within China and abroad. Policies related to the invitation, research and development, exchange, and residence of high-level and specialized foreign talent will be improved, as will the permanent residence system for foreigners in China. Furthermore, the establishment of a technology immigration system will be explored, and the domestic environment and institutional framework for high-level overseas scientific and technological talent will be further enhanced.

The "green channel" (streamlined procedures) for research and development management will be expanded.

46 4.4 See the National Key Research and Development Program's Strategic Open Recruitment system.

47 "Non-consensus" scientific and technological projects refer to those that encounter significant disagreements during peer review, making consensus difficult to achieve and often leading to these projects not passing the review.

The granting of ownership or long-term use rights of scientific and technological achievements to research and development personnel based on their duties will be considered, and the proportion of income shared with research and development personnel will be increased. Research and development personnel will be granted greater authority over research and development and the use of funds. The initiative of research and development personnel will be fully mobilized to encourage their active engagement in research and development activities.

(6) Improve the Operating Mechanism for Intellectual Property Protection

The intellectual property powerhouse strategy will be implemented, and a strict intellectual property protection system will be enforced. Furthermore, laws and regulations related to intellectual property will be improved, and legislation on intellectual property in new fields and new business types will be expedited.

(7) Expand Opening Up and Cooperation

An international scientific and technological cooperation strategy focused on further opening up, inclusivity, mutual benefit, and sharing will be implemented, along with active integration with the global innovation network. International scientific and technological cooperation in areas such as global infection prevention and control and public health will be actively promoted. A focus will be placed on issues like climate change and human health, and joint research and development efforts by researchers from various countries will be strengthened. China will actively conceive and lead the launch of major international scientific programs and projects and play a unique role in science funding. The opening of national science and technology plans to other countries will be expanded, and a series of major scientific and technological cooperation projects will be initiated. Additionally, the establishment of a global scientific research fund will be considered, and a scientist exchange program will be implemented.

3.2 Key Areas, Major Projects, and Cutting-Edge Technologies and Basic Research in the Development Plan Outline

In terms of the basic core areas related to the overall aspects of national security and development, there are eight key frontier areas, including artificial intelligence (AI), quantum information, integrated circuits, life and health, brain science, bio-breeding, space science and technology, and deep geological strata and the deep sea, and a series of promising and strategic national major science and technology projects will be implemented. The following are the key technologies and related projects covered in priority areas:

(1) Artificial Intelligence (AI)

Breakthroughs in cutting-edge basic theory, research and development of specialized chips, building open-source algorithmic platforms such as deep learning frameworks, and development of projects and technologies in learning and inference, decision-making, image graphics, speech and video, and natural language processing.

(2) Quantum Information

Research and development of quantum communication technologies for metropolitan areas, inter-city connections, and free space; research and manufacturing of general-purpose quantum computing prototypes and practical quantum simulators; breakthroughs in quantum precision measurement technology.

(3) Integrated Circuits

Research and development of integrated circuit design tools and core materials including key equipment and highpurity target materials; breakthroughs in advanced integrated circuit processes and special processes such as insulated-grid bipolar transistors and MEMS (Micro Electro Mechanical Systems); upgrading of advanced storage technologies; development of integrated brain-inspired computing and brain-computer technologies.

(4) Genetic and Biotechnology

Research and application of genomics; technological innovation in genetic cells and genetic breeding, synthetic biology, and biopharmaceuticals; research and development of innovative vaccines, in vitro diagnostics, and antibody drugs; innovation in major new varieties of crops, livestock/poultry/aquaculture, and agricultural microorganisms; research of core biosafety technologies.

(5) Brain Science and Brain-Inspired Intelligence Research

Analysis of brain cognitive principles, brain mesoscopic nerve connection atlas, research on major brain diseases, child and adolescent brain development, research and development of brain-inspired computing and computer integration technologies.

(6) Clinical Medicine and Health

Basic research on disease mechanisms for cancer, cardiovascular and cerebrovascular diseases, respiratory diseases, and metabolic disorders; research and development of proactive health intervention technologies; research and development of innovative technologies including regenerative medicine, microbiome, and new treatments; research on prevention and treatment technologies for major infectious diseases and major chronic non-communicable diseases.

(7) Deep Earth, Deep Sea, and Polar Exploration

Basic research on the origin and evolution of the universe and Earth imaging; research and manufacturing of deep Earth exploration equipment, deep-sea exploration operation and maintenance support and equipment testing vessels, polar three-dimensional observation monitoring platforms and large icebreakers; construction of the Phase IV Lunar Exploration Project, Phase II "Jiaolong" Ocean Exploration Project, and Phase II "Xuelong" Polar Exploration Project.

(8) Space Science and Technology

Interplanetary exploration including Mars orbital missions and asteroid imaging; next-generation large carrier rockets and reusable space transportation systems; construction of space environment ground monitoring networks and high-precision ground time signal systems, large low-speed wind tunnels, and ground simulation facilities for space environments.

Moreover, basic research is the foundation of scientific knowledge and forms the core of all technological issues. The medium- to long-term plan strengthens basic research and enhances basic research and scientific and technological innovation capabilities through respecting the laws of scientific development, emphasizing directional goals, supporting free inquiry, optimizing overall arrangements, and deepening systemic and mechanism reforms. This will achieve breakthroughs in forward-looking basic research and pioneering original results, strongly supporting the development of an innovative nation and world scientific and technological power.

(1) Optimizing the Overall Structure of Basic Research

Maintain comprehensive thinking in basic research, understand the trend toward integration of basic and applied research, and focus on solving practical problems. Additionally, guide basic research through applied research, strengthen the development of major science-oriented and application-oriented basic research projects, resolve common fundamental problems in industrial development and production practice, and support major national technological innovations.

(2) Stimulate the Vitality of Innovation Entities and Support Enterprises and New Types of R&D Institutions to Strengthen Basic Research

Guide enterprises to actively conduct basic research for long-term development and enhancement of competitiveness. Remove institutional barriers to talent mobility between universities, research institutions, and enterprises. Support for new types of research and development institutions in building innovation platforms and undertaking national R&D tasks. Additionally, promotion of industry–academia–research collaboration to create a new environment for scientific and technological innovation that integrates basic research, applied research, and technological innovation.

(3) Deepening Project Management Reform

Improvement of the basic research topic collection mechanism, organization of industrial sectors, enterprises, strategic research institutions, and scientists to jointly research and assess scientific frontiers and strategic development directions, and compilation of major scientific issues at the forefront of economic and social development and production. For highly original research, consideration of replacing guidelines with directional guidance. A system of reviewer accountability is being promoted, with enhanced peer review by specialists in closely related fields (*xiaotongxing*),[48] and an increase in the number of applied and industry experts for reviewing application-targeted basic research.

(4) Creating an Innovation Environment Conducive to Basic Research and Development

Improvement and advancement of basic research evaluation. Basic research evaluation must align with scientific development principles and reflect the characteristics of basic research, implementing categorized and long-term evaluations, and promoting evaluation of representative achievements. Emphasis on in-depth research following the publication of basic research papers, medium and long-term innovation performance evaluation, and post-transformation outcome evaluation. Establishment of an evaluation system combining regular and flexible evaluations, with no mid-term evaluations for projects under three years. Establishment of dynamic project adjustment mechanisms and strengthening of full-process tracking. Making public outreach for science a required criterion in the review of basic research projects.

(5) Promoting Open Access and Sharing of Scientific and Technological Resources

Strengthening of the construction of national network management platforms for research and development facilities and equipment, promotion of the construction of national scientific and technological resource sharing service platforms, and construction of a series of national scientific data centers and national scientific and technological resource banks. Strengthening of the research, development, and application of experimental animal resources and research and development reagents. Establishment of a comprehensive national scientific and technological literature information security service system.

(6) Improving Support Systems

Expansion of stable support for basic research. Improvement of investment mechanisms for basic research, expanding stable support for long-term key basic research projects, key teams, and research and development centers. To support excellent young scientists so that they can conduct basic research stably over a long period of time and to promote their training in Japan and acceptance from overseas in parallel. Support for outstanding young scientists to conduct stable long-term basic research, pursuing both domestic development and international recruitment in parallel. Expansion

[48] *Xiaotongxing refers to professionals in fields that are relatively similar in specialization.*

of basic research funding channels, steadily increasing the proportion of basic research within overall research and development investment. Continued expansion of central government fiscal support for basic research. Promotion of increased local investment in basic research through departments and provinces jointly organizing and implementing major national scientific and technological tasks and jointly building research and development centers, strengthening local fiscal support for basic research applications. Promotion of industry establishment of joint funds to resolve deep-rooted scientific problems constraining industrial development. Guidance and encouragement for enterprises to increase investment in basic research and its applications. Encouragement of social capital[49] investment in basic research and support for various sectors of society to establish basic research endowment funds.

3.3 Strategic Working Group Discussion

According to the action plan designated by the Department of Strategic Planning of the Ministry of Science and Technology in June 2019, the Ministry was required to publish a "draft opinion" of the "National Medium and Long-term Science and Technology Development Plan Outline (2021–2035)" before November 2020, with the specific plan outline to be published before March 2021. However, due to the impact of COVID-19, the research and development institutions responsible for preparing this outline had to prioritize COVID-19-related issues. Additionally, the positioning and resolution of public health issues were elevated and required renewed detailed examination and response. According to the Department (Bureau) of Strategic Planning of the Ministry of Science and Technology, related specific regulatory development activities are still in progress. The outline draft has been distributed as an internal document to provincial science and technology departments, some state-owned central enterprises, central research and development institutions, and universities, with the specific planning content to be published as an official document from the Ministry of Science and Technology by the end of 2022. With the expectation of prolonged competition with the United States and the possibility that Western countries including the US may implement science and technology countermeasures, some experts are suggesting that publication should be postponed or avoided where possible.

When the "National Medium- and Long-Term Science and Technology Development Plan Outline (2006–2020)" [in Chinese] was being formulated, the country was undergoing administrative reform and was at a critical juncture in rebuilding its innovation system. As a result, there were marked differences in perspectives regarding concepts such as indigenous innovation, the role of enterprises as primary drivers of technological innovation, and the development of innovation systems. Some issues evolved into ideological disputes, ultimately requiring the central government to make final decisions. The debates during the previous plan's formulation process proved more intense than expected. Nevertheless, the previous plan outline established proper consensus on a series of crucial issues, successfully guided science and technology development activities through 2020, and facilitated major scientific and technological advances. Therefore, whether or not the Ministry of Science and Technology, State Council, or Party Central Committee engages in discussions when formulating strategic plans, it remains crucial to maximize input from stakeholders across the scientific, educational, economic, and governmental sectors.

49 Social capital: A collective term for public capital (government agencies, state-owned enterprises, public R&D institutions, etc.) and private capital (private enterprises, private investment institutions, private financial institutions, private research and development institutions, etc.).

On June 24, 2019, the "Launch Meeting for Research and Compilation of the 2021–2035 National Medium- and Long-Term Science and Technology Development Plan" was held at the Ministry of Science and Technology. The meeting's primary objective was to thoroughly implement General Secretary Xi Jinping's key statements and directives on scientific and technological innovation, and to advance the research and compilation work for the 2021–2035 National Medium- and Long-Term Science and Technology Development Plan. During the meeting, the Ministry of Science and Technology invited over 60 experts from various State Council departments, local governments, industries, universities, research and development institutions, and key enterprises. Hu Zhijian, Director of the Chinese Academy of Science and Technology for Development, presented research on the overall strategic direction and target indicators for national medium- and long-term science and technology development. Zhao Zhiyun, Party Committee Secretary of the Institute of Scientific and Technical Information of China, outlined scientific assessments of global science and technology innovation trends and methods for mitigating potential risks. The discussions were organized into three specific themes.

Following the launch meeting, the Ministry of Science and Technology held two strategic research discussions attended by both domestic and international experts.

First, on July 28, 2019, a research discussion meeting was held on the major theme of medium- and long-term science and technology development planning in high-tech fields. Fifteen academicians and over 40 experts and scholars from 7 high-tech sectors participated and presented at the discussion meeting, representing energy, transportation, information, advanced manufacturing, materials, space technology, and modern service industry. Academicians WU Jiangxing, WU Chaohui, and other leaders of the seven strategic research special projects reported on their respective mid-to-long-term science and technology development plans for 2021–2035. Vigorous discussions were held with participating experts, resulting in the presentation of major assessments, concepts, tasks, and measures for science and technology development in the new era, and initial drafts of research reports were prepared for each special theme. Through intensive exchange, research, and discussion, each thematic group was tasked with making preliminary assessments of development trends in their respective fields, presenting development concept goals, and specifying development tasks and measures.

On September 27, 2019, the Ministry of Science and Technology held a high-level expert symposium on national medium- and long-term science and technology development planning strategy, inviting distinguished experts from science and technology, economics, and industry fields. The group comprises 11 experts: YANG Zhenning, Professor at Tsinghua University (Member of Chinese Academy of Sciences); YAO Qizhi, Professor at Tsinghua University (Member of Chinese Academy of Sciences); CHEN Zuoning, Vice President of Chinese Academy of Engineering; XUE Qikun, Vice President of Tsinghua University (Member of Chinese Academy of Sciences); GAO Song, President of South China University of Technology (Member of Chinese Academy of Sciences); WU Manqing, General Manager of China Electronics Technology Group Corporation (Member of Chinese Academy of Engineering); ZHOU Qi, Director of Institute of Zoology, Chinese Academy of Sciences (Member of Chinese Academy of Sciences); LEI Fanpei, Party Secretary and Chairman of China State Shipbuilding Corporation Limited; YIN Zhiyao, Chairman and General Manager of Advanced Micro-Fabrication Equipment Inc. China; XU Wenwei, Director and President of Strategy Research Institute at Huawei; and YE Tianchun, Director of Institute of Microelectronics, Chinese Academy of Sciences. The experts shared insights from the perspective of the country's future development, addressing the international situation, domestic development, the state of science and technology, and planning objectives, priorities, and methods. The experts indicated that the medium- and long-term science and technology development plan must be based on long-term and future assumptions and must be both advanced and pioneering in nature. Specifically, interdisciplinary science is becoming a major trend in future science and technology development. Whether in quantum computing, nanomaterials, biopharmaceuticals, autonomous driving, or financial technology development, all rely on the close integration of multiple fields, and interdisciplinary science must be emphasized in the country's medium- and long-term science and technology development. Furthermore, while it is necessary to strengthen scientific and technological capabilities as a national strategy, the country must also build an innovation-oriented nation and establish a complete talent development chain with human resources as the foremost priority. Moreover, there is a need to systematically nurture a series of high-quality personnel for the nation, ranging from undergraduate students to graduate students to leadership talent. A distinctive characteristic of this strategic planning process was the active seeking of foreign experts' opinions, with two symposiums being held.

On July 12, 2019, the Ministry of Science and Technology held a foreign experts' symposium on national medium- and long-term science and technology development planning research and compilation at the Beijing Friendship Hotel in Beijing. Fourteen experts attended from countries including the United States, Belarus, Germany, Cuba, Poland, and Japan.

The second symposium was held on September 29, 2019, attended by numerous experts, including Nobel Prize laureates, from the United States, Norway, Ukraine, France, Russia, Switzerland, and Germany, who provided recommendations. The specific recommendations addressed academic evaluation mechanisms, inter-university competition and cooperation, the importance of basic science, international exchange and cooperation, scientific and technological fields that could significantly impact human society, applications of digital technology, and the International Thermonuclear Experimental Reactor project.

3.4 Funding and Budget Arrangements for Implementation of the Development Plan Outline

China's total research and development expenditure in 2020 reached CNY 2.44 trillion, accounting for 2.4% of the gross domestic product (GDP), and the proportion of basic research in R&D investment exceeded 6% for the first time. The medium- and long-term planning outline does not specify figures for overall growth in research and development investment or its proportion of GDP, stating only that the average annual growth rate of overall research and development investment should exceed 7%. This was done to avoid the effects of GDP fluctuations.

Furthermore, the proportion of GDP varies by region according to local economic and research and development levels and cannot be standardized. The outline states that the aspirational target ratio of 2.8% cannot be reduced before 2035. However, in coastal provinces where science and technology investment is relatively high, this ratio could potentially exceed 4%.

Regarding capital provisions, to address issues of insufficient research and development funding and investment institutional imbalances, the outline clearly defines four aspects: market access, financial support, fiscal and tax support, and market services. It establishes and optimizes pathways for social capital participation in science and technology research and development.

Additionally, the outline presents methods for support through robust science and technology financing, including establishing a credit guarantee system, developing science and technology insurance systems, completing a multi-tiered capital market, and refining an investment-financing linkage model to ensure social and private capital support for science and technology. At the same time, the need to support financial institutions to establish specialized science and technology financial institutions and to expand financial support for the conversion of scientific research results and innovation and entrepreneurial human resources has been identified.

(The above explanation is a compilation of the contents of the "National Medium- and Long-Term Science and Technology Development Plan Outline (2020–2035)" [in Chinese] provided by the China Association for Science and Technology and opinions from some experts at the Chinese Academy of Sciences.)

4 National Key Research and Development Program

Dr. Jin Changqing (Researcher at the Institute of Physics, Chinese Academy of Sciences) explained the background and results of consolidating previous national research and development programs that had been implemented within frameworks such as the "973 Program," "863 Program," and National Science and Technology Support Program, as well as the Strategic Open Recruitment system in the National Key Research and Development Program.

4.1 Background of the Consolidation into the "National Key Research and Development Program"

The "National Key Research and Development Program" is a new science and technology program implemented following the 2014 reform of the science program management system. It consolidated various previous programs including the "National Key Basic Research Development Program" ("973 Program"), "National High-tech Research Development Program" ("863 Program"), "National Science and Technology Support Program," International Science and Technology Cooperation and Exchange Special Projects, Industrial Technology Research and Development Funds, and Public Industry Scientific Research Special Projects.

Since China's first national science and technology program— "The Sixth Five-Year (1981–1985) Science and Technology Breakthrough Program"—various national-level science and technology programs were successively established, including the "Spark Program," National Natural Science Foundation, "863 Program," "Torch Program," "973 Program," and Industrial Scientific Research Special Projects. These were macro-level top-down designs that comprehensively enhanced China's overall scientific and technological innovation capabilities and supported China's reform and development process. Each science and technology program (special projects, funds, etc.) was established at different times, lacked top-level design and unified attention, and was not sufficient for the output and national development requirements. Many critical fields faced pressure to resolve vital scientific and technological problems that were constraining development.

These problems were concentrated in the following areas:

(1) The fragmentation of science and technology programs prevented concentration of effort on achieving strategic goals

In the science and technology program field, the large number of management departments resulted in complicated administration, and the continuous overlap and expansion of plans among various departments and committees created a chaotic system. As a result, project initiatives pursued either "comprehensive large-scale implementation" or "comprehensive moderate-scale implementation," leading to dispersed allocation of scientific and technological resources, divergent program objectives, and fragmentation of science and technology programs. This resulted in ineffective utilization of China's central government science and technology funds.

(2) Dispersed Objectives Led to Unfocused Research Projects

The distribution of science and technology programs, various special projects, and funds lacked rationality. Operating under independent management systems, these programs suffered from insufficient top-level design and macro-level coordination. This made strategic science and technology planning impossible, as they were unable to respond to new scientific and technological revolutions and industrial changes or collaborate effectively to address major national challenges. An indirect effect that is noted is that research and development personnel have been submitting proposals for multiple aspects of projects and diverting their efforts towards managing departments, projects, and expenses unrelated to the core nature of research and development. However, the support from any single department was typically limited and could only meet research and development funding needs at specific stages.

(3) Inflexible Management and Operating Systems

In scientific projects, administrative departments exercised excessive control over project operations, from initiation through operation and completion to the industrial application of scientific and technological results. Administrative procedures were complicated, there was little respect for researchers' academic freedom and expertise, and strict limitations were placed on funding authority. The focus was placed on management rather than guidance or service, which ironically resulted in poor efficiency in fund utilization. While research and development personnel had their own views on research and development activities, they were unable to fully express their enthusiasm for dedicated scientific research work.

(4) Basic Research Was Inadequate, with a Predominance of Task-Oriented Projects Focused on Short-Term Benefits in Applied and Practical Research, and a Lack of Comprehensive Oversight across the Entire Chain from Basic Research to Industrialization

Research and development activities were not open to the public, and third-party oversight and participation were insufficient. This was especially evident in the transition from basic to applied research. Additionally, the evaluation system covering all phases of industrial application was inadequate, and research and development activities were not connected to needs-oriented and industrialization directions. Consequently, many research projects could not be maintained stably over long periods, and scientific achievements failed to benefit society.

To address these issues, as part of implementing the new innovation-driven development strategy, reforming the management of central science and technology programs (special projects, funds, etc.) became the most urgent task to ensure science and technology would play a beneficial role in economic and social development. At the beginning of 2014, the Ministry of Science and Technology and the Ministry of Finance submitted a report and proposal to the State Council titled "Opinions on Improving and Strengthening the Management of Central Government-Funded Scientific Research Projects and Budgets." The proposal recommended the optimization, reorganization, and integration of scientific and technological programs (including special projects, funds, etc.) managed by various central government departments. To this end, the Ministry of Science and Technology and the Ministry of Finance established a joint working mechanism, examining and identifying nearly 100 science and technology programs individually, investigating their backgrounds, and determining the scope for optimization and consolidation. They studied policies from advanced nations such as France and Germany regarding the adjustment of science and technology innovation strategies and strengthening the integration of scientific research resources, after which they proposed reform ideas and measures.

Subsequently, the Ministry of Science and Technology and the Ministry of Finance held numerous consultation meetings and sought written opinions from 50 departments (organizations), including the Ministry of Education and Ministry of Agriculture. On April 22, 2014, Vice Premier Liu Yandong, who was in charge of science and technology, was also asked to lay the groundwork. Following deliberations by the National Science and Technology System

Reform and Innovation System Construction Leading Group, the State Council Executive Meeting, the Central Comprehensively Deepening Reform Leading Group Meeting, and the Central Political Bureau Standing Committee, and incorporating central leadership's opinions, continuous revisions and improvements were made. Finally, the "Plan for Deepening the Management Reform of Central Fiscal Science and Technology Programs (Special Projects, Funds, etc.)[50]" was promulgated and implemented in January 2015.

This plan goes beyond simply checking for project duplication or "combining similar items"; it instead establishes a new arrangement for science and technology programs (special projects, funds, etc.). This plan holds the key to optimization and consolidation. The plan proposes building a unified and open national science and technology management platform and requires various government departments to establish a new management system through this unified science and technology management platform, with clear responsibilities and effective coordination in areas such as policy-making, consulting, implementation, evaluation, and supervision/management. Specific components include a joint conference system (policy-making platform), expert organizations and strategic advisory/ comprehensive review committees, a unified evaluation and management system (three operational pillars), and a national science and technology management information system (management system).

Furthermore, it categorizes the existing diverse central fiscal science and technology programs into five categories and proposes a new science and technology program system. Among these, the newly established "National Key Research and Development Program" addresses major, core, and key scientific and technological issues in various key areas of national economic and social development. Through focused special project methods, it aims to design the entire chain from basic frontier and major common core technologies to application and demonstration. Through integrated organization and implementation, basic frontier research and development activities gain clearer needs-oriented and industrialization directions, accelerating the penetration and introduction of the latest basic frontier achievements into downstream innovation.

4.2 Achievements of the National Key Research and Development Program During the 13th Five-Year Plan Period

During the 13th Five-Year Plan period (2016–2020), the National Key Research and Development Program supported approximately 1,500 organizations with total funding exceeding CNY 100 billion. Individual project funding varied considerably from CNY 500,000 to CNY 400 million, with an average of about CNY 20 million per project. Following the principle of combining top-down high-level design with bottom-up needs collection, the National Key Research and Development Program proposed technically progressive and adaptable solutions for the conversion and industrialization of scientific and technological achievements, using technical guidelines and related evaluation criteria as policy direction to improve the evaluation and incentive system across the entire industrial chain. During the five years of the 13th Five-Year Plan, 60 key special projects were independently organized, approved by the State Council, and implemented, including "Stem Cell and Translation Research," "New Energy Vehicles," "Seven Major Crop Breeding," and "Digital Medical Equipment Research and Development." These played an important leading

50 Notice on the State Council's Issuance of the Plan for Deepening the Management Reform of Central Fiscal Science and Technology Programs (Special Projects, Funds, etc.) [国务院印发关于深化中央财政科技计划(专项、基金等)管理改革方案的通知] (http://www.most.gov.cn/ztzl/shzyczkjjhglgg/wjfb/201501/t20150107_117294.html)

role in scientific, technological, economic, and social development during the 13th Five-Year Plan period. In particular, the key special project for new energy vehicles not only provided technical standards and equipment for industrial development but also contributed to further industrial development and achieving a first-mover position in global competition.

Looking ahead, amid intensifying global competition, especially in frontier and interdisciplinary fields, the strategic planning and implementation of the National Key Research and Development Program during the 13th Five-Year Plan period may guide the basic competition pattern for the next five years by combining with the internet and artificial intelligence, based on technological integration and phased progress, and under the premise of establishing the basic framework for new energy vehicle technology and standards. Considering the inherent disadvantage of insufficient basic research, the progress of related technologies has built a solid foundation for narrowing the gap with advanced countries and eventually surpassing and leading them. Naturally, further improvements are needed in the grade evaluation of these specific projects, and the Ministry of Science and Technology began performance evaluations in 2020 for 42 key special projects that started during the 13th Five-Year Plan period. For this evaluation, experts from eight institutions, including the High-Tech Research Development Center, Chinese Academy of Sciences, and Chinese Academy of Engineering, were invited to conduct project performance evaluations. The evaluation primarily focused on the completion status of task objectives and indicators, the level and innovativeness of research results, demonstration and prospects of achievements, contributions to overall project objectives, and talent development and organizational management. The key feature of the evaluation was not only to identify results but also to analyze major problems and strictly verify the authenticity of project outcomes.

4.3 Decision-Making Process for the National Key Research and Development Program

The National Key Research and Development Program encompasses a series of processes including the formation of key special projects, the planning and evaluation of specific projects, and their implementation. The first step is to establish and clarify these components, while the second step involves listing and systematically implementing the specific projects that make up the special projects based on this foundation. The mechanism for forming key special projects follows these steps:

(1) The Department of Strategic Planning of the Ministry of Science and Technology compiles research and development needs from various departments, regions, and industries using a combined top-down and bottom-up approach, based on major national development strategies, the National Medium and Long-term Science and Technology Development Plan Outline [in Chinese], and the Science and Technology Innovation Plan.

(2) Through national science and technology programs (special projects, funds, etc.), the Ministry of Science and Technology manages the inter-ministerial joint conference system. In collaboration with relevant departments such as the Ministry of Finance and following the major strategic deployments of the CPC Central Committee and the State Council, they conduct comprehensive and detailed analysis of the needs compiled from various sectors and research and propose key task arrangements. These are then submitted to the general meeting of the inter-ministerial joint conference for deliberation after consulting with the Strategic Advisory and Comprehensive Evaluation Committee.

(3) Following the approval of key task arrangements by the inter-ministerial joint conference, the Ministry of Science and Technology works with relevant departments and local authorities to develop major special project

proposals and systematically formulate implementation plans for key special projects. Each key special implementation plan must develop primary tasks for different research and development stages.

(4) The Strategic Advisory and Comprehensive Evaluation Committee convenes special topic meetings to review and deliberate on the implementation plans for key special projects. They submit comprehensive opinions and provide recommendations ranked by field, based on the urgency of special deployment and the maturity of implementation plans.

(5) The inter-ministerial joint conference holds special topic meetings to examine and discuss the opinions and rankings from the Strategic Advisory and Comprehensive Evaluation Committee and consolidates these opinions. The findings from these special topic meetings are reported to the general meeting of the inter-ministerial joint conference. If the inter-ministerial joint conference raises major objections, the matter returns to the Strategic Advisory and Comprehensive Evaluation Committee for consultation and verification, followed by another deliberation at the general meeting of the inter-ministerial joint conference.

(6) After the key special projects submitted by the inter-ministerial joint conference undergo review by the National Science and Technology System Reform and Innovation System Construction Leading Group, they are reported to the State Council following established procedures. Particularly significant special projects are reported to the CPC Central Committee.

(7) In accordance with the relevant provisions of the Professional Institution Management Measures, professional institutions are selected to oversee specific projects within the key special projects. The Ministry of Science and Technology, representing the inter-ministerial joint conference, enters into project management delegation contracts for key special projects with these professional institutions. The professional institutions formulate and establish management activity plans based on the characteristics and implementation plans of the key special projects they are entrusted to manage. These plans are attached to the delegation contract along with the key special project implementation plans.

On this basis, specific research and development projects are initiated and implemented under the key special projects.

(1) Professional institutions compile budget estimates based on key special implementation plans, in accordance with the Notice Regarding Issues Related to Central Financial Science and Technology Plan Management Reform Transition Period Fund Management [in Chinese] and other related documents. The Ministry of Finance, in conjunction with the Ministry of Science and Technology, conducts budget estimate evaluations for key special projects and seeks guidance on the estimates according to procedures.

(2) The Ministry of Science and Technology works with departments involved in implementation plan development and professional institutions to assemble experts and create annual project guidelines. The guidelines propose more detailed and clear primary technical indicators but do not restrict specific technical approaches or research plans. The guidelines further suggest detailed and clear key technical indicators, but do not limit specific technical routes or research plans. They specify the selection method for project contractors (either open priority recruitment or targeted priority recruitment), and for targeted priority recruitment, they clearly state the qualifications and capability requirements for contracting institutions. An expert list is published alongside the annual guidelines. For confidential projects, a targeted non-disclosure method must be used when determining contracting institutions. Guidelines are compiled according to project requirements. The annual budget estimates for major special projects are announced

upon the issuance of the guidelines but do not precede the establishment of project budget management allocations.

(3) Specialized agencies are responsible for receiving project proposals through the National Science and Technology Management Information System. They handle tasks such as responding to proposal-related inquiries, checking for project duplication, and conducting formal reviews of proposal documents.

(4) Professional institutions carry out project evaluation and review in accordance with the relevant requirements. Experts involved in project evaluation and review are selected from a unified National Science and Technology Management Expert Database.

(5) Upon completion of the review process, professional institutions propose project arrangement plans, total budget, and annual budget arrangement plans, publishing them in accordance with relevant requirements. The project adjustment plan is submitted to the Ministry of Science and Technology in accordance with the relevant requirements, while the budget adjustment plan is submitted to the Ministry of Finance through the budget proposal channels.

(6)The Ministry of Science and Technology provides its opinions on key special project initiation procedure regulations, project conditions, and alignment with task objectives and guidelines, sending this feedback to professional institutions with copies forwarded to the Ministry of Finance. The Ministry of Finance, in accordance with budget review procedures and requirements and considering the Ministry of Science and Technology's opinions, issues the budget for key special projects and circulates copies of the documents to the Ministry of Science and Technology.

(7) Professional institutions issue project initiation notices according to projects and budget arrangements that have passed compliance review and conclude project task agreements (budget agreements) with the projects' managing institutions.

4.4 The Strategic Open Recruitment System in the National Key Research and Development Program

General Secretary Xi Jinping mentioned the Strategic Open Recruitment system (open competition mechanism to select the best candidate) at the Internet Security and Information Technology Work Forum on April 19, 2016. This was the first instance of proposing this system for research and development projects. The 14th Five-Year Plan Outline in 2021 proposed reforming the planning and organizational management methods of major science and technology projects, giving research and development institutions and personnel greater autonomy, implementing the "Strategic Open Recruitment" and "Competitive Project Selection" systems, and improving the funding support system that combines rewards and subsidies. Currently, the "Strategic Open Recruitment" system has been widely implemented in more than 20 provinces nationwide, with standardization and unification of this model progressing. Meanwhile, many regions remain in the exploratory phase, primarily engaging in preliminary planning, list collection, and list publication.

This issue has drawn high attention due to deep-rooted reasons including insufficient basic research, technical weaknesses in core technologies and industrial chain technologies, the emergence of critical problems, and disadvantages in international competition. The reason for the lack of basic scientific research can be traced back to the scientific research evaluation system that began in the 1990s based on the "Four-Only" evaluation criteria (which restricted assessment to papers, positions, academic credentials, and honors alone).

In the 1990s, the so-called "SCI Impact Factor" emerged in the scientific community. This meant that scholars gained more recognition, the more their journal papers were cited. However, this was merely a simple quantitative indicator, not an objective and comprehensive evaluation of research activities and scholars by professional evaluation institutions. These evaluation criteria directly led to problems such as distorted pursuit of value, exaggerated impulsive research styles, and shortsighted enthusiasm for scientific and technological innovation success. Subsequently, rather than paper quantity, a different set of evaluation indicators emerged—specifically, the level of journal in which papers could be published—and this evaluation system has gradually influenced the national science and technology evaluation system. While this evaluation mechanism still discusses excellence based on personnel titles, professional designations, and paper numbers, risks related to subjectivity and personal relationships remain fundamentally unresolved in project review methods such as "peer review," "project evaluation," and "expert voting." This evaluation system not only fails to evaluate projects scientifically but also diminishes the quality of scientific research results, cannot support basic research projects requiring long-term and stable support to produce results, and may even lead to the expansion of projects pursuing short-term benefits. This issue seriously affects academic authority; prevents projects from being assigned to those who truly want to do them, can do them, and can succeed at them; and reduces young People's enthusiasm for actively engaging in scientific research and innovation frontiers. To resolve these issues, while it is necessary to improve policies and systems such as the Opinions on Deepening the Reform of Project Evaluation and Review, Personnel Evaluation, and Organizational Evaluation[51] [in Chinese], we must also comprehensively utilize innovative mechanisms such as "competition systems" and "milestone evaluation" to supplement and improve the current scientific research management mechanism and achieve a virtuous cycle from entry-stage to exit-stage competition.

Additionally, the Strategic Open Recruitment system and mechanism reflects a problem-oriented approach to scientific and technological R&D while also indicating future directions for scientific research development. The Strategic Open Recruitment system concentrates on core fundamental technologies, is driven by major needs, uses problem-solving effectiveness as its evaluation criteria, clearly defines tasks for addressing important issues, effectively connects innovation chains with industrial chains, and enables applicants to direct their efforts precisely toward collaboratively addressing important problems. Indeed, Strategic Open Recruitment system has played a vital role in the fight against COVID-19. In COVID-19 vaccine R&D, numerous teams have participated, accelerating research along five technical pathways and currently, many domestic COVID-19 vaccines have entered phase 3 clinical trials. China is providing support within its capabilities to countries and regions vulnerable to infectious diseases, offering robust scientific and technical support for achieving a global victory over the COVID-19 pandemic. The Strategic Open Recruitment system employs demonstration effects to deepen reform of the science and technology system; clarifies directions for application; defines end-user tasks; effectively unleashes enormous innovation potential; maintains control over key technologies related to the national economy, People's livelihood, and national economic lifelines; leverages innovation strengths in advantageous fields; guides the formation of a positive cycle through the national innovation environment chain; and promotes the achievement of high-level self-reliance and self-improvement.

This model exploration provides direct career advancement paths for training and promotion of young scientific

51 "中共中央办公厅 国务院办公厅印发《关于深化项目评审、人才评价、机构评估改革的意见》"
(http://www.gov.cn/zhengce/2018-07/03/content_5303251.htm)

and technological talent, particularly outstanding young scientific and technological talent within the system. Some business organizations have relatively limited channels for R&D personnel mobility, with relatively low career ceilings. When submitting project proposals, recommendations are sometimes influenced by internal relationships or conservative achievements, indicating that robust mechanisms for nurturing outstanding researchers have yet to be fully established.

Several researchers made the following detailed recommendations for improvement:

① Post-subsidy funding support methods are incompatible with traditional budgeting systems. Under the Strategic Open Recruitment post-subsidy system, research teams must invest a predetermined amount of R&D funds upfront. For new R&D institutions, including universities, research institutes, and business organizations, project personnel costs constitute the majority of R&D staff income. Since staff must be supported through project funding, making upfront investments becomes difficult.

② The practice of evaluating researchers based on success or failure is incompatible with traditional title-based evaluation systems. Research teams at universities and research institutes face strict annual evaluation metrics, and they cannot accept outcomes where time and effort are expended without securing funding or producing academic achievements.

③ Poor scientific design of application processes directly impacts R&D teams' willingness to participate. While universities and R&D institutions have been establishing policies for situations such as taking leaves of absence for paid concurrent positions or entrepreneurship, implementation has been less than ideal. Given that R&D personnel currently hold stable positions, there are concerns about the new system, such as potential position changes after leaving for entrepreneurship and the need to consider improvements to these aspects of personnel management models.

4.5 Doctoral Student and Postdoctoral Researcher Participation in the National Key Research and Development Program

While participation of doctoral students and postdoctoral researchers in the National Key Research and Development Program is not regulated at the national level, some local governments, universities, and R&D institutions have implemented effective measures. As policies and conditions mature, these are expected to be elevated to the policy level and implemented nationwide. The following measures have been implemented by Guangdong Province, Zhejiang Province, the Chinese Academy of Sciences, Peking University, and Nanjing University to encourage active participation of doctoral students and postdoctoral researchers in projects:

(1) Special funds have been established using revenue from university and research institution technology transfers to provide supplementary support for those with master's degrees or higher who lack research funding. This addresses funding shortages while considering the inclusion of highly educated personnel in Strategic Open Recruitment projects. Some organizations are also considering partnerships with external upstream and downstream companies interested in Strategic Open Recruitment projects through internal intermediaries, both to improve research efficiency and reduce R&D costs through collaborative research.

(2) Universities and R&D institutions have incorporated Strategic Open Recruitment project reviews and evaluations into their assessment systems, applying various weightings across different evaluation types.

(3) For technology transfer projects, technology transfer departments support highly educated personnel in Strategic

Open Recruitment project announcements and corporate partnerships, viewing Strategic Open Recruitment as an opportunity for technology transfer.

(4) Given that doctoral students and postdoctoral researchers have organizational and position-based cooperation mechanisms, universities and R&D institutions have systems allowing highly educated personnel to take leave for paid concurrent positions and entrepreneurship. They fully utilize the Strategic Open Recruitment system's flexible talent deployment mechanisms, allowing doctoral students and postdoctoral researchers to continue participating in title evaluations after leaving their positions. Additionally, leave periods and technology transfer achievements related to their original organizations are incorporated into evaluations and included in graduation or selection assessment criteria.

(5) The Strategic Open Recruitment system extends beyond project management to include competition, platform, and career approaches, similar to the National Postdoctoral Innovation and Entrepreneurship Competition launched by the Guangdong Provincial Government in 2021. This competition, co-hosted by the government and leading domestic companies, centers on doctoral students and postdoctoral researchers using the Strategic Open Recruitment approach. It aims to facilitate postdoctoral research transfer based on needs and problems, enhance industry–academia–research integration, and enable postdoctoral talents and teams to address technical challenges limiting industrial development. The project focuses on eight major industrial sectors, including next-generation information technology, high-end equipment manufacturing, new materials, and new energy. It targets critical frontier technologies and common issues constraining development in these fields, with competition platforms to be established annually.

5 China's Research and Development System

Professor Liu Huijuan of Tsinghua University explained the role distribution between central and local governments in the R&D system, the current status of various research institutions, inter-institutional cooperation, and the status and prospects of National Key Laboratories that have significantly contributed to China's R&D.

5.1 Division of Roles between Central and Local Governments

Central and local governments maintain distinct fiscal and administrative authorities. The central government traditionally invests in strategic science and technology fields, public interest science and technology fields, and basic frontier fields. Local governments focus their investments on consolidating innovation elements and developing regional and industrial core competencies.

Regulations govern the classification and budget management of basic and applied research between central and local governments, with specific implementation methods and divisions determined project-by-project by the Ministry of Science and Technology and Ministry of Finance.

The Notice on Reform Plan for Dividing Central and Local Fiscal Authority and Expenditure Responsibilities in Science and Technology Fields[52], issued and implemented by the State Council in May 2019, clearly separates fiscal and administrative authorities for specific research fields within basic research. The fundamental principle establishes central government decision-making authority in fiscal resource allocation and division, based on enhanced central decision-making and local implementation mechanisms. It also systematically divides central and local fiscal authorities and expenditure responsibilities in science and technology fields according to the public nature of scientific issues and the scope of scientific achievements and benefits. Central finance handles major scientific and technological tasks primarily in areas affecting the overall situation, fundamental fields, long-term activities, science and technology frontiers, major national needs, and the national economy. The central government fulfills its role of supporting local governments while encouraging local government initiative and autonomy. Local fiscal expenditures support technological development and the transformation/application of results, with each region developing innovation according to its unique characteristics. Science and technology plans (special projects, funds, etc.) established with fiscal funds to support basic research, applied research, and technological R&D are considered shared fiscal responsibilities between central and local governments, with both levels bearing expenditure responsibilities according to specific circumstances.

52 Notice of the General Office of the State Council on Issuing the Reform Plan for the Division of Financial Powers and Expenditure Responsibilities between Central and Local Governments in the Science and Technology Field [in Chinese; 国务院办公厅关于印发科技领域中央与地方财政事权和支出责任划分改革方案的通知]
(http://www.gov.cn/zhengce/content/2019-05/31/content_5396370.htm)

(1) Basic Research

Basic research through free inquiry must focus on exploring unknown scientific problems. The central government bears the primary expenditure responsibility and plays an important role in supporting innovation through the National Natural Science Foundation, strengthening basic research and exploration of scientific frontiers. For science and technology programs (special projects, funds, etc.) independently established by local governments in relation to basic research area deployment, local fiscal expenditures cover the spending responsibilities, while the funding source is central fiscal appropriations.

(2) Applied Research and Technological Development

For matters requiring integrated, coordinated research within set timeframes that focus on nationally significant strategic products and major industrialization goals, leveraging the advantages of the whole-nation system, the central government bears primary expenditure responsibility and provides support through major special science and technology projects.

The central government bears primary expenditure responsibility and provides support through the National Key Research and Development Program and other means for public interest research crucial for long-term evolution in fields related to the national economy and People's livelihood, such as agriculture, energy resources, ecological environment, and health, and research and development of major scientific issues related to industrial core competitiveness, overall independent innovation capability and national security, as well as common and major core technologies and products. Local governments assume corresponding financial responsibilities in accordance with relevant scientific research objectives, taking into account local conditions.

(3) Construction of Science and Technology Innovation Bases

Support for the construction and development of science and technology innovation bases is recognized as a shared fiscal power between central and local governments, with central and local finances bearing expenditure and management responsibilities according to various circumstances. The central government bears primary responsibility for funds related to the construction and development of science and technology innovation bases that need to be built based on national objectives, scientific frontier development, national strategic needs, and industrial innovation development. Local governments bear corresponding financial responsibilities within their jurisdictions based on relevant construction and development plans. Additionally, for science and technology innovation bases independently constructed by local governments based on their regional plans, while local finances bear primary expenditure responsibility, funding comes from the central government.

(4) Building Teams of Scientific and Technical Personnel

The development of high-level science and technology personnel teams is governed by special projects that are organized and implemented according to relevant plans. These projects fall under either central or local fiscal jurisdiction, with the corresponding level of fiscal authority bearing responsibility for expenditures. For projects under central jurisdiction, the central government implements special personnel initiatives supporting the recruitment and development of science and technology talent. These are recognized as central fiscal responsibilities, with expenditure obligations borne by central fiscal authorities. Local governments independently implement their own special personnel projects, including recruitment and development support for science and technology talent, in accordance with relevant plans. These projects fall under local fiscal jurisdiction, with expenditure responsibilities borne by local fiscal authorities.

(5) Transfer and Transformation of Scientific and Technological Achievements

The transfer and transformation of scientific and technological achievements—supported through fiscal measures such as risk compensation, post-project subsidies, and venture capital guidance—are recognized as shared fiscal responsibilities between central and local governments. Both central and local fiscal authorities bear expenditure responsibilities according to their respective circumstances. Central fiscal authorities primarily serve to guide and leverage national-level funds through market mechanisms. This involves mobilizing social capital to promote the transfer, transformation, capitalization, and industrialization of scientific and technological achievements related to national economic and industrial development. Local fiscal authorities operate based on regional conditions, independently guiding social capital to increase investment and supporting the transfer and transformation of scientific and technological achievements in key regional industries. The central fiscal authorities provide additional support through unified planning of payment transfers.

(6) Promotion of Science and Technology Outreach

The nationwide dissemination of scientific and technological knowledge, promotion of scientific methods, spread of scientific ideas, cultivation of scientific spirit, and enhancement of scientific literacy across the population are recognized as shared fiscal responsibilities between central and local authorities. Both central and local fiscal bodies bear expenditure responsibilities according to their respective situations. At the central level, fiscal authorities hold primary expenditure responsibility for implementing science dissemination activities. At the local level, local fiscal authorities hold primary expenditure responsibility for ensuring science dissemination activities. In such cases, central fiscal authorities provide support through unified planning of payment transfers.

(7) Reform and Development of R&D Institutions

Subsidies for the reform, development, and establishment of fiscally funded scientific research institutions are recognized as either central or local fiscal responsibilities based on their affiliation, with fiscal bodies at the corresponding level bearing expenditure responsibilities. For central-level research and development institutions, subsidies for their reform, development, and establishment are confirmed as central fiscal responsibilities, with central fiscal authorities bearing expenditure responsibilities. When commissioned by local governments, central-level research and development institutions receive appropriate subsidies through local finances. For local research and development institutions, subsidies for their reform, development, and establishment are confirmed as local fiscal responsibilities, with local fiscal authorities bearing expenditure responsibilities.

5.2 Current Status of National/Public Research Institutions, Corporate R&D Institutions, and University Research Institutions

According to the *China Science and Technology Statistical Yearbook 2021* [in Chinese] published by China Science and Technology Press, as of December 2020, mainland China (excluding Hong Kong, Macau, and Taiwan) had 3,109 national and public research and development institutions, with 731 directly under central administration and 2,378 under local administration. In 2020, expenditures by national and public research and development institutions totaled CNY 340.8 billion, including CNY 57.3 billion for basic research, CNY 108.4 billion for applied research, and CNY 175.0 billion for various experimental development costs. It should be noted that the Chinese Academy of Sciences maintains a significant presence, with expenditures reaching CNY 6.7 billion in 2020, placing it decisively at the top among public research institutions. Government grants constitute the majority of R&D institutions' income, reaching CNY 284.7 billion when combining central and local funding. Corporate investment in public research institutions amounts to CNY 13.5 billion, foreign funding totals CNY 370 million, and self-raised and other income by research institutions reaches CNY 42.2 billion. As of the end of 2020, research and development personnel numbered 519,355, with 395,036 affiliated with central institutions and 124,319 with local institutions.

As of the end of December 2020, there were 2,738 universities in mainland China (excluding Hong Kong, Macau, and Taiwan), with university research and development institutions reaching 19,988. University research and development institutions employ 1,273,926 research and development personnel, of whom 503,834 are women. The number of individuals holding doctoral degrees or higher has reached 470,000. In 2020, total expenditure by university research and development institutions reached CNY 188.2 billion, with CNY 72.4 billion allocated to basic research, CNY 96.4 billion to applied research, and CNY 19.3 billion to experimental development. Government funding comprises a significant portion of income, with central and local government funding totaling CNY 112.8 billion, enterprise funding at CNY 66.6 billion, foreign funding at CNY 650 million, and funding from other sources at CNY 8.1 billion. As of 2020, 1,288,633 research projects were completed, with total expenses reaching CNY 120.2 billion.

By the end of 2020, mainland China (excluding Hong Kong, Macau, and Taiwan) had 162,394 companies engaged in research and development as their primary business, while 104,003 companies maintained R&D departments. There are 117,710 enterprise-involved R&D institutions[53], employing 4.69 million R&D personnel. Total R&D expenditure amounts to CNY 1.7592 trillion. Enterprises are implementing relevant government policies, with R&D deductions and tax reductions reaching CNY 242.1 billion. Additionally, tax reductions and exemptions for high-tech enterprises reached CNY 216.1 billion, promoting corporate R&D activities. Among expenditures, enterprises above a designated size (those with main business income exceeding CNY 20 million) spent CNY 46 billion on foreign technology acquisition, showing a decrease compared to 2018 and 2019. This decline is primarily attributed to the COVID-19 pandemic and international circumstances. Furthermore, spending on domestic technology purchases was CNY 45.6 billion, lower than CNY 53.7 billion in 2019 but higher than CNY 44 billion in 2018.

5.3 Cooperation between R&D Institutions (Joint Research and Personnel Exchange)

In the global science era, scientific issues are increasingly interdisciplinary and complex, with scientific and technological activities characterized by closer cooperation between scientific and technological communities.

[53] Enterprise-involved R&D institutions: These are R&D institutions either fully funded by enterprises or jointly funded with other organizations, operating independently from enterprises (though not necessarily in corporate form, they maintain independent accounting). Establishing such R&D institutions requires certification from local science and technology management authorities. Possessing such R&D institutions enables enterprises to demonstrate their scientific and technological capabilities and provides advantages in project applications.

Cooperation between research institutions is a natural outcome of the complexity of scientific development, and only through such cooperation can scientific and technological challenges be resolved.

In China's scientific and technological sectors, the greatest need for cooperation lies in major science and technology project areas, which significantly impact research and development projects. These currently fall into five types: the National Natural Science Foundation, National Major Science and Technology Projects, National Key Research and Development Program, Special Projects (Funds) for Technology Innovation Guidance, and Base and Talent Special Projects. Cooperation represents an inevitable outcome of scientific development's complexity, and scientific and technological challenges can only be resolved better and faster through cooperation.

Typically, major special projects have a host (coordinator) responsible for the overall project framework design who bears responsibility for the entire project framework design. Several subprojects are then established to realize the original intentions of the project design. Scientific research teams are generally categorized into strong–strong alliance models and strong–weak alliance models, based on reputation, standing, and academic level of research and development. Strong–strong alliances incorporate high-level researchers and experts with reputation and standing in their respective fields. Such individuals command significant influence in their respective fields, making it relatively easy for them to submit and coordinate project proposals. The Chinese Academy of Sciences Institute of Environmental Sciences has actively implemented this model while strengthening research cooperation with major universities. However, in such cooperation, a contradiction arose where project research efficiency remained low and core research subprojects could not be allocated, since most partners were themselves conducting numerous scientific research projects. Another form of cooperation is the strong–weak alliance, where research and development institutions of high prestige collaborate with ordinary research and development institutions of lower standing. The advantage of this method lies in the clear distinction between the host and subproject leaders, which prompts subproject teams to actively cooperate with the host's various ideas and arrangements, resulting in high execution efficiency and more appropriate implementation of designated cooperative tasks.

Beyond the aforementioned cooperation methods, cooperation in the industrialization of scientific and technological achievements is occurring between various research and development institutions within the industry–academia–research framework.

The decision of the Fourth Plenary Session of the 19th Central Committee of the Chinese Communist Party presented an overall requirement to build a technology innovation system with enterprises as the main body, market orientation, and deeper integration of industry, academia, and research. This represents a key element in the system and mechanism of scientific and technological innovation. Currently, under the industry–academia–research cooperation framework, a new system of cooperation among research and development institutions is emerging. In this system, state-owned research and development institutions take the lead, enterprise research and development institutions serve as the main body, and university research and development institutions provide the foundation. By making the transformation of scientific and technological achievements a breakthrough point in a market-oriented direction, this system aims to create innovation mechanisms and enhance economic effectiveness and benefits.

(1) Strategic Alliances among R&D Institutions

Strategic alliances between research and development institutions represent a high-level model of cooperation that crosses industrial sectors. For example, under the coordination of the Industry–Academia–Research Cooperation Promotion Activity Coordination Steering Group, which was established by six ministries and committees with the

Ministry of Science and Technology serving as the secretariat, four major industrial technology innovation strategic alliances were formed. These alliances brought together 26 corporate research institutes, 18 leading universities, and 9 major research and development institutions to create a comprehensive technology innovation chain that closely integrates scientific research, design, engineering, production, and market applications. This has effectively addressed China's challenges of dispersed industrial concentration, lack of originality in technological fields, insufficient supply of general-purpose technologies, and core competitiveness constraints due to human resources. Through joint organization of upstream and downstream components of the industrial chain, these alliances have effectively promoted comprehensive cooperation among various research institutions in areas such as industry-oriented basic research, applied research, validation and sharing of specific scientific research outcomes, and patent utilization cooperation. Currently, the most prominent alliances are the Shanghai University Technology Innovation Cluster, Enterprise Cluster, and Industry Cluster, which have jointly established industry–academia–research alliances. Five universities, including Shanghai Jiao Tong University and Tongji University, have established industry cluster-style strategic alliances with seven groups, including research institutions under Shanghai Electric and Shanghai Automotive Industry (Group). The Ministry of Science and Technology and the Ministry of Industry and Information Technology are jointly supporting organizations such as the China Automotive Chip Industry Innovation Strategic Alliance, which was established with the Beijing Automotive Group Research Institute serving as the secretariat.

(2) 1+1+1 Joint Innovation Platform

The 1+1+1 Joint Innovation Platform is a government-led model of industry–academia–research cooperation. It comprises technology innovation institutions such as research institutes, research and development centers, key laboratories, and engineering centers jointly established by three parties: government, universities or research institutions, and local enterprises. This model has attracted significant attention from governments at all levels. For example, since 2006, the Guangdong Provincial Government has maintained long-term cooperation with 50 universities and research institutions nationwide, establishing 20 technology innovation platforms including research institutes, research and development centers, branch organizations of national key laboratories, and engineering centers. Additionally, 21 universities have established offices, and 18 universities have established research institutes. The Taizhou Municipal Government in Zhejiang Province has actively recruited renowned universities to establish research institutes and enterprise alliances in Jiaojiang District, with over 30 platforms currently in place.

(3) University Science and Technology Parks Jointly Established by Universities, Enterprises, and State-owned Research Institutions

Based on high-tech industrial development needs and utilizing research and development institutions from universities designated under the 985 Project and 211 Project, this model integrates research and development resources from universities, enterprises, and major research institutions. It adopts a university science and technology park model where multiple universities participate in a single park, promoting the establishment of research and development platforms, incubation platforms, and industrialization bases for research outcome transformation. For example, 48 renowned domestic and international universities, including the University of Hong Kong and Wuhan University, have jointly established the Shenzhen Virtual University Park with enterprise research institutes such as Huawei and Xiaomi, and the Chinese Academy of Sciences (Shenzhen). Based on Shenzhen's high-tech industry development needs, they have established high-level talent training and university outcome transformation and industrialization bases. To date, they have trained personnel, incubated 304 companies, transformed 236 research outcomes, undertaken 97 science and technology projects, and obtained 136 patents. The research institutions within the University Science and Technology Park have attracted and maintain 78 national key laboratories.

(4) National Collaborative Innovation Centers

In May 2012, the University Innovation Capacity Enhancement Plan was launched with the Ministry of Education as the secretariat and participation from the Ministry of Science and Technology and the Ministry of Industry and Information Technology. National Collaborative Innovation Centers were an important pillar of this plan. The key focus of these centers is to promote high-tech industry talent development, scientific and technological innovation, outcome transformation, and social services through various cooperation methods including university–university, university–enterprise, university–research institution, and university–local government collaboration. The Collaborative Innovation Centers address four categories: scientific frontiers, cultural inheritance and innovation, industrial development, and regional development. Based on significant national needs, these centers position institutional and systemic reform as their core focus, promoting close cooperation among university research institutes, research institutions, enterprise research institutes, local governments, and foreign research institutions. They explore collaborative innovation models for different needs and foster an environment and atmosphere conducive to collaborative innovation. The centers operate under a director system (responsible for the entire organization) with corresponding organizational and management departments. Additionally, they establish professional science and technology advisory committees responsible for academic oversight, talent development guidance, personnel selection participation, and promotion of domestic and international cooperation.

5.4 State Key Laboratories

(1) Current Status of State Key Laboratories

In order to raise the level of basic research in China, efforts were made to explore systems and institutions that would align with the development of China's basic research. In 1984, under the leadership of what was then the State Planning Commission, State Key Laboratories were established through joint coordination between the State Science Commission (as it was known at the time), Education Commission (as it was known at the time), Chinese Academy of Sciences, and other departments. These laboratories serve as China's scientific and technological innovation centers in the fields of basic and applied research, bringing together and cultivating outstanding scientists. As of the end of 2020, there were 522 operational State Key Laboratories, with expenditures reaching CNY 4.552 billion. The Ministry of Science and Technology and the Ministry of Finance jointly issued "Opinions from Two Ministries on Strengthening the Construction and Development of State Key Laboratories" [in Chinese][54], which clarified the need for optimizing and adjusting existing laboratories while establishing new ones, with the goal of steadily increasing their number to maintain a total of approximately 700.

Looking at the organizations supporting these laboratories, the institutions entrusted with establishing State Key

54 两部门关于加强国家重点实验室建设发展的若干意见 (http://www.gov.cn/xinwen/2018-06/27/content_5301344.htm)

Laboratories are classified into six categories based on property rights and administrative management. Specifically, universities represent the largest category with 234 laboratories, accounting for 42.62% of the total. Corporate State Key Laboratories number 174, comprising 31.69% of the total, with 137 being state-owned enterprises and 37 private enterprises. The Chinese Academy of Sciences operates 92 State Key Laboratories, representing 16.76% of the total. Research institutes under various ministries and committees (local) account for 31 laboratories or 5.65%, while military organizations maintain 18 laboratories, representing 3.28% of the total, among others. As of the end of 2020, State Key Laboratories were distributed across 25 provinces, autonomous regions, and municipalities. Beijing had the highest concentration with 136 laboratories, followed by Shanghai with 44, Jiangsu Province with 39, Hubei Province with 29, and Shaanxi Province with 26, reflecting the regional distribution of China's basic research capabilities.

(2) Financial Support for State Key Laboratories (Central Government, Local Government, Enterprises, etc.)

The central government has established special funding for State Key Laboratories. These special funds are primarily used for operating State Key Laboratories established under the "Administrative Measures for the Construction and Operation of State Key Laboratories" [in Chinese][55], supporting independent innovation research and updating and modifying instruments and equipment. Additionally, the "Administrative Measures for Special Funds of State Key Laboratories" [in Chinese][56] was established to standardize and strengthen special funds management and improve the efficiency and benefits of fund utilization. The special funds employ different budget management methods based on usage classification, with corresponding performance and effectiveness evaluation systems in place to improve fund utilization efficiency. Regular evaluations and adjustments are conducted for the operation and management of key laboratories. Expenses related to State Key Laboratories are designated as separate special expenditures. Special funding for State Key Laboratories has steadily increased from an initial CNY 1.4 billion annually to CNY 4.55 billion in 2020, accelerating the construction of State Key Laboratories and establishing a research platform with advanced equipment and excellent research environments.

Following the annual plan for State Key Laboratories jointly constructed by provinces and ministries, by January 2021, the number of approved laboratories had already exceeded 50. These jointly constructed laboratories are an important measure for improving regional independent innovation capabilities and promoting the establishment of regional scientific and technological innovation systems. The objectives and tasks of these laboratories are to conduct high-level basic and applied research in alignment with regional development strategies and characteristics. Operating expenses for these laboratories are primarily funded through the self-financing of provinces, autonomous regions, municipalities, and the organizations entrusted with their operation. During the construction and operation period, local governments must provide annually agreed-upon construction and operation expenses for the laboratories. The central government establishes special funds to support laboratory operations, research instrument and equipment updates, and independent innovation research. Special funds are designated as separate special expenditures. Local governments must provide special funding support for each laboratory annually, which is used for daily operations, establishing open research topics, recruiting and training personnel, and incentivizing research and development staff

55 "国家重点实验室建设与运行管理办法" (http://www.gd.gov.cn/zwgk/wjk/zcfgk/content/post_2523988.html)

56 "国家重点实验室专项经费管理办法" (http://iap.cas.cn/gb/jgsz/glxt/jhcwc/kyjfgl/gjzd/202012/t20201208_5813750.html)

performance.

Corporate key laboratories rely on their companies and most hope to generate immediate effective results and profits. Therefore, most investment is directed toward applied technology research, with clearly insufficient investment in basic theoretical applications and general core technologies. The "Opinions from Two Ministries on Strengthening the Construction and Development of State Key Laboratories" [in Chinese] clearly stipulates policies to encourage enterprises and society to expand investment in basic research through government leadership and tax leverage methods, but local governments and tax departments have not established specific detailed rules, so support in these areas needs to be strengthened. According to research by the Chinese Academy of Sciences, Shandong, Zhejiang, and Guangdong provinces have published advisory opinions offering tax incentives for enterprise key laboratories. Local governments are expected to provide support through tax and funding assistance to enterprises by the end of 2022.

(3) Achievements and Issues of State Key Laboratories

State Key Laboratories have targeted global science and technology frontiers, achieving a series of scientific and technological breakthroughs that have significantly enhanced China's scientific and technological capabilities. The National Natural Science Award symbolizes China's standards in basic and applied research. Between 2016 and 2019, State Key Laboratories participated in and completed 108 National Natural Science Awards, representing 67.1% of all awards. This includes five first-class National Natural Science Awards, accounting for 100% of all first-class awards in this category.

The National Technology Invention Award represents China's capacity for independent innovation in core technology fields. From 2016 to 2019, State Key Laboratories participated in and completed 134 National Technology Invention Awards, accounting for 69.4% of all awards in this category.

The National Science and Technology Progress Award reflects the significant contributions of China's scientific and technological achievements to scientific advancement and socioeconomic development. Between 2016 and 2019, State Key Laboratories participated in and completed 308 projects that received the National Science and Technology Progress Award, accounting for 57.4% of all awards. This includes five Special Class National Science and Technology Progress Awards, all of which involved State Key Laboratories.

State Key Laboratories have combined academic and industrial strengths to fully utilize their scientific and technological resources and specialized talent advantages. They have promoted scientific and technological innovation in areas such as agricultural food production, economic crop breeding, animal husbandry and aquaculture, ecological prevention and management, and agricultural product processing, contributing to poverty alleviation and rural revitalization.

State Key Laboratories have gathered and cultivated high-level scientists, supporting crucial talent teams essential for building China into a scientific and technological powerhouse.

According to the *China Science and Technology Statistical Yearbook 2020* [in Chinese], by the end of 2019, State Key Laboratories had approximately 50,000 permanent staff members, including 393 academicians from the Chinese Academy of Sciences and 271 academicians from the Chinese Academy of Engineering, representing 47.8% and 29.7% of total academicians, respectively. Additionally, they include 1,843 recipients of the National Outstanding Young Scientists Fund, accounting for 43.2% of the total.

Seven scientists from State Key Laboratories have won the State Preeminent Science and Technology Award. Furthermore, State Key Laboratories have received 305 innovation cluster grants from the National Natural Science

Foundation, accounting for 52.8% of the total.

State Key Laboratories administered by the Chinese Academy of Sciences account for 30.8% of the total, while those under National Research Centers account for 58% of the total. Over the past five years, they have received 41 National Natural Science Awards, with their first-class awards accounting for 50% of the national total. Among China's top 10 scientific advances selected in the past five years, 31 research achievements were attained by State Key Laboratories under the Chinese Academy of Sciences, representing 62% of the total.

However, as State Key Laboratories have developed, new issues requiring resolution have emerged:

(1) Low degrees of openness and quality disparities

A key issue is that the authority of State Key Laboratory directors over open research projects and the role of academic committees lack clear definition, leading to dispersed open projects and biased research directions and characteristics. Some State Key Laboratories fail to recognize the importance of openness, and external openness has not become an internal requirement for their development.

(2) Impeded mobility channels and an absence of talent mobility mechanisms

State Key Laboratories have not become relatively independent research and development entities. Laboratory directors lack autonomous hiring authority, which hinders talent mobility.

(3) Limited substantive collaboration and poor collaborative outcomes

Collaboration remains superficial, with positive external appearances masking internal discord. There is minimal substantial collaboration, and collaborative results have not met expectations. The reasons are twofold: ① administrative constraints hinder organizational collaboration and ② the low administrative status of host organizations makes collaborative research between different departments and faculties within host organizations relatively difficult, as many State Key Laboratories operate under departmental or faculty management or receive the same treatment as ordinary laboratories.

(4) Low levels of competition and inadequate competitive mechanisms

Many State Key Laboratories are satisfied with the status quo and focus exclusively on competing for scientific research projects and funding. Laboratory directors are too occupied with project implementation to consider laboratory research and development plans or establish competitive frameworks for research and development, management, and talent between State Key Laboratories. As a result, research loses its distinctiveness, making it impossible for laboratories to develop competitive advantages on their own initiative.

These issues stem from multiple sources, with one crucial factor being whether State Key Laboratories' operational mechanisms can function normally and effectively. The operational mechanisms of State Key Laboratories remain a challenge to be addressed in the future.

(4) Future Outlook for State Key Laboratories

The 2021 Government Work Report emphasized the necessity of promoting State Key Laboratory development. New waves of scientific and technological revolution and industrial transformation are emerging worldwide. Major scientific frontier research achievements reflect interdisciplinary and cross-field characteristics. The cycle from basic research to technological innovation has shortened significantly, with disruptive technological innovations generating new industries and business models. Scientific and technological innovation is becoming increasingly complex and uncertain.

Accelerating innovation and development in the State Key Laboratory system is not only an effective approach to address the new round of scientific and technological revolution and industrial transformation but also provides essential support for implementing innovation-driven development strategies and building an innovation-oriented nation. To address new challenges and tasks, the state has introduced further optimized and reorganized development guidelines for State Key Laboratories regarding top-level design.

The Outline of the 14th Five-Year Plan, released in 2021, proposed the reorganization of State Key Laboratories. In this context, the approval of State Key Laboratories has noticeably slowed since 2021. Project proposals for laboratories independently established or jointly founded by the Chinese Academy of Sciences have been put on hold due to the Ministry of Science and Technology's requirement to first confirm the policy direction before granting approval.

In 2018, the Ministry of Science and Technology and the Ministry of Finance jointly issued "Opinions from Two Ministries on Strengthening the Construction and Development of State Key Laboratories," which demanded clear definitions of the functional positioning and target missions for various State Key Laboratories. Furthermore, it called for the comprehensive establishment of a National Key Laboratory system by 2025, significantly raising the level of scientific research and international influence. These opinions followed the "optimization of State Key Laboratory distribution" emphasized in "Opinions on Comprehensively Strengthening Basic Scientific Research," with the Ministry of Science and Technology and Ministry of Finance jointly clarifying the direction for State Key Laboratory construction and development.

Since "reorganization" was first mentioned in the 2019 government work report, related activities have been steadily advancing. In 2020, during consultations with the Chinese Academy of Sciences, Vice Minister Huang Wei of the Ministry of Science and Technology (at the time) indicated that the current academic direction of State Key Laboratories needed to be organized and adjusted and expressed the view that a series of new State Key Laboratories needed to be established in several important academic fields. Additionally, it was determined that personnel numbers in existing individual laboratories should be reduced while strengthening activities aligned with national needs and collaborative innovation initiatives. Regarding the placement of State Key Laboratories, the decision emphasized the need to establish new facilities with scale advantages through methods such as industry–academia–research partnerships, taking into consideration both regional and industrial development patterns. The problems of institutional competition and fundamental weaknesses in basic research, which became evident during the COVID-19 outbreak, led to proposals for long-term planning and organization of basic research in infectious diseases, along with creating connections between basic research and clinical applications.

At the Central Economic Work Conference, which sets economic policy direction for 2021, a significant new development was announced with the proposal to reorganize facilities into "National Key Laboratories." This indicates the potential for National Key Laboratories to replace State Key Laboratories and emerge as a crucial strategic scientific and technological force. The "Law on Scientific and Technological Progress" [in Chinese], which took effect on January 1, 2022, now includes provisions for establishing a laboratory system led by National Laboratories with support from National Key Laboratories.

A significant distinction exists between State Key Laboratories and National Key Laboratories. The reorganization into National Key Laboratories extends beyond merely restructuring individual laboratories or integrating internal units within commissioning organizations. Instead, it represents a systemic reorganization that encompasses partnerships with external research and development institutions and corporate research facilities.

At the National Science and Technology Work Conference in January 2022, the Minister of Science and Technology emphasized the need to dramatically strengthen national strategic scientific and technological capabilities, ensure full operation of National Laboratories, and complete the transition to National Key Laboratories. With the reorganization plan for the State Key Laboratory system completed in 2021, the system may begin transitioning incrementally into the National Key Laboratory system from 2022.

Currently, the reorganization of research and development institutions is being implemented in practice, primarily within university research and development institutions. On March 19, 2021, Hunan University's State Key Laboratory held a reorganization work conference, where the State Key Laboratory of Advanced Design and Manufacturing for Vehicle Body and the State Key Laboratory of Chemical Bio-sensing and Chemometrics reported on their current reorganization challenges and immediate reform approaches. The conference discussed adjusting State Key Laboratory names, implementing substantive reforms, and refining research directions. On May 24, 2021, the State Key Laboratory Reorganization Guidance Group of the University of Science and Technology of China held its first meeting, during which all participants attended the Chinese Academy of Sciences State Key Laboratory System Reorganization Conference via video conference. In early June, the University of Science and Technology of China completed its internal selection and nomination process for new National Key Laboratories. On July 8, 2021, Du Huifang, Communist Party Committee Secretary of East China University of Science and Technology, announced that the university was proceeding with the reorganization of three State Key Laboratories: Biomanufacturing and Reactor Engineering, Biomedical Materials and Devices, and Low-Carbon Energy Conversion. Furthermore, many universities, including Nankai University, Shandong University, Jilin University, Southeast University, South China University of Technology, China Agricultural University, and Xiamen University, are implementing new initiatives for the optimized reorganization of State Key Laboratories.

(5) Relationship between Doctoral Programs and Postdoctoral Support

The "National Outline for Medium and Long-term Education Reform and Development (2010–2020)" [in Chinese][57] dedicated a chapter to "Higher Education," explicitly outlining the promotion of "Two Leader Systems" for graduate student training through industry–academia–research collaboration. This would be achieved by establishing new systems for joint talent development among universities, research institutes, industries, and enterprises, as well as by implementing leader responsibility and leader project funding systems driven by scientific and engineering technology research. State Key Laboratories play a vital role in cultivating doctoral talent with "innovative consciousness and entrepreneurial spirit," as they possess internationally competitive resources in both hardware construction and software development.

The "Administrative Measures for the Construction and Operation of State Key Laboratories" [in Chinese] defines State Key Laboratories as essential components of the national science and technology system. They serve as advanced key sites where the state conducts high-level basic and applied research, attracts and develops outstanding scientific and technological talent, and advances high-level academic exchange and scientific research facilities. The establishment of national-level scientific research platforms is inherently part of the innovation system and carries both the obligation and responsibility for talent development. National-level State Key Laboratories regularly invite domestic and international subject matter experts to provide insights and explanations on frontier academic issues. In

57 "国家中长期教育改革和发展规划纲要(2010-2020年)" (http://www.gov.cn/jrzg/2010-07/29/content_1667143.htm)

addition, regular academic exchanges are conducted with relevant domestic research institutions. Doctoral students are provided with academic lectures covering a variety of topics, such as how to write project reports, scientific papers, and funding proposals, as well as how to present explanations. These sessions also offer guidance on specialized technical skills. These activities fulfill a fundamental role in doctoral talent development by stimulating students' professional interests and academic initiative.

In recent years, the Chinese government has expanded both its investment in and construction of State Key Laboratories. Using these research and development platform construction projects as a foundation has played a vital role in doctoral student development, leading to a training model that integrates research and development teams with the leader system. As research directions become more focused, various research and development teams have emerged. These research and development teams are equipped with sufficient research funding, clearly defined research directions, and collaborative research problems. Leaders work with their research and development teams to create an optimal environment where team members complement each other's strengths and cooperate in sharing responsibilities. Training organizations, working alongside the establishment of leaders and research and development teams, have developed distinctive approaches to doctoral student recruitment and selection, training plan development, specialized course instruction, topic selection, and dissertation guidance. They have explored doctoral training methods comprehensively, enhancing graduate students' sense of community while elevating their overall qualifications. Additionally, doctoral students participate in research and development under leader guidance, with research activities progressively deepening and developing into systematic theories.

6 Research and Development Funding

Professor Wang Chengwen of Tsinghua University provided insights into the current status of competitive research and development funding from the central government and funding from local governments.

6.1 Current Status of the Central Government's Competitive Research and Development Funding

(1) National Natural Science Foundation (General Program[58], Key Program, Major Program, Major Research Plan Program)

The National Natural Science Foundation concentrates on fundamentals, frontier research, and human resources, with an emphasis on innovation teams and interdisciplinary research. Grounded in innovation capabilities and basic research, it supports scientific and technological personnel in their pursuit of basic research and scientific frontiers, while providing special project funding to develop talent and teams. In 2018, under the "Plan to Deepen the Reform of Party and State Institutions," the National Natural Science Foundation Committee was transferred from being a direct institution under the State Council to operating under the Ministry of Science and Technology. The Ministry of Finance incorporates special project funding into the central fiscal budget in accordance with the National Science and Technology Development Plan, taking into account both the funding requirements of the National Natural Science Foundation Committee and national finances, while maintaining responsibility for macro-level management and supervision. The National Natural Science Foundation Committee handles the specific management and supervision of special project funding. The process works as follows: the Ministry of Finance allocates relevant funds to the Ministry of Science and Technology, which then distributes them to the National Natural Science Foundation Committee under its jurisdiction for unified management.

According to the latest statistics from the *China Science and Technology Statistical Yearbook 2021* [in Chinese] (unless otherwise specified, all statistical data in this chapter comes from this yearbook), the project funding implemented within budget by the National Natural Science Foundation Committee in 2020 was CNY 28.3 billion, representing an increase of approximately CNY 300 million compared to 2019. Excluding the impact of COVID-19 in 2019, special project funding has not increased since 2016, and there has been a decrease in the utilization of special project funding.

The General Program constitutes a crucial component of the National Natural Science Foundation's research project series. While scientific and technological personnel engaged in basic research freely choose their research topics within the scope of National Natural Science Foundation support, the General Program itself is designed to support scientific research with strong innovative elements. The General Program represents the most basic category of projects supported by the National Natural Science Foundation, accounting for approximately 60% of the total science foundation budget. In 2020, General Program funding totaled CNY 11.1 billion, with universities receiving CNY

58 General Program: Research based on individual researchers' original ideas.

9.4 billion and research institutions such as the Chinese Academy of Sciences receiving CNY 1.57 billion for their projects.

The Key Program of the National Natural Science Foundation Committee is one of its significant categories, supporting scientific research personnel engaged in basic research to conduct exploratory and systematic innovative research in promising basic research areas or emerging academic fields, fostering academic development and driving breakthroughs in specific important fields or scientific frontiers. In 2020, project funding totaled CNY 2.16 billion, with universities receiving CNY 1.77 billion and research and development institutions such as the Chinese Academy of Sciences receiving CNY 360 million.

The Major Program of the National Natural Science Foundation Committee primarily takes a proactive approach to major scientific issues involving scientific frontiers and significant needs related to national economic, social, and scientific-technological development, as well as national security. It demonstrates its support and leadership role by implementing interdisciplinary and comprehensive research spanning multiple academic fields. The Major Program provides support through a cost compensation method, with the use and management of funds following the "Administrative Measures for National Natural Science Foundation Project Funding" [in Chinese]."[59] In 2020, project funding amounted to CNY 790 million, with universities receiving CNY 613 million and research institutions receiving CNY 160 million.

The Major Research Plan Program of the National Natural Science Foundation targets major national strategic needs and significant scientific frontiers. It strengthens top-level design and refines scientific objectives while consolidating outstanding resources to form clusters of projects with relatively unified goals or directions. Through interdisciplinary integration and the development of innovative talent and teams, it aims to enhance China's original innovation capabilities in basic research and provide scientific support for national economic and social development as well as national security. In 2020, funding for this program amounted to CNY 870 million, with universities receiving CNY 640 million and research institutions receiving CNY 210 million.

(2) National Major Science and Technology Projects (Research and Development Fields and Achievements)

To achieve national objectives, major strategic products, general core technologies, and major projects were completed within designated timeframes through breakthrough achievements in core technologies and resource integration. The State Council defined 16 National Major Science and Technology Projects, including large aircraft, in the "National Medium and Long-term Science and Technology Development Plan Outline (2006–2020)" [in Chinese], which was officially announced and implemented in 2006.

These 16 National Major Science and Technology Projects include Core Electronic Components; High-end General Purpose Chips and Basic Software; VLSI Manufacturing Equipment and Complete Process Technology; New Generation Broadband Wireless Mobile Communications; High-end CNC Machine Tools and Basic Manufacturing Equipment; Large Oil & Gas Fields and Coalbed Methane Development; Advanced Pressurized Water Reactors and High-temperature Gas-cooled Reactors; Water Body Pollution Control and Treatment; Development of New

59 Full title: "Notice from the Ministry of Finance and the National Natural Science Foundation Committee on Issuing the 'Administrative Measures for National Natural Science Foundation Project Funding'" [in Chinese; 财政部 国家自然科学基金委员会关于印发《国家自然科学基金资助项目资金管理办法》的通知](https://www.nsfc.gov.cn/publish/portal0/tab434/info81896.htm)

Transgenic Varieties; Major New Drug Innovation; Prevention and Treatment of Major Infectious Diseases including AIDS and Viral Hepatitis; Large Aircraft; High-resolution Earth Observation System; and the Manned Space Program and Lunar Exploration Project. This compilation draws from the special achievement presentations on National Major Science and Technology Projects during the 13th Five-Year Plan period, held by the Ministry of Science and Technology and the Ministry of Industry and Information Technology from late 2017 to 2018, and from the 13th Five-Year Plan Science and Technology Innovation Achievement Exhibition held in Beijing in October 2021.

(1) Core Electronic Devices and Components

Leveraging the implementation of national strategies including "Made in China 2025" [in Chinese], comprehensive adjustments were made and continuous support was provided to specific projects focusing on key areas, leading to major breakthroughs in core electronic device and component technologies. The technology gap with foreign countries in specific fields has narrowed from more than 15 years before the implementation of specific projects to approximately 5 years. For instance, with certain core electronic devices and components such as SiC-MOSFET power electronic devices and 100G/200G silicon photonic coherent transceiver chips and modules for long-distance transmission, a new phase of comprehensive independent research, development, and innovation has begun. Additionally, individual product performance has improved significantly, completely eliminating import dependence and fundamentally changing the situation of external control. The gap with foreign countries in these core device and component technologies has narrowed, and the self-sufficiency rate of electronic components supporting equipment reliability has risen from less than 30% to more than 85%. The computing speed of supercomputing CPUs (double-precision floating-point peak) has achieved a 600-fold increase in overall CPU performance compared to 2006, before the special project began, reaching international advanced levels.

(2) High-End General-Purpose Chips and Basic Software

Through continued technological innovation, single-core performance of CPUs including Feiteng, Loongson, Sunway, and Zhaoxin has increased fivefold compared to the beginning of the 12th Five-Year Plan period. In particular, the Sunway TaihuLight, which ranked fourth in the TOP500 supercomputer performance rankings, uses software and hardware products supported by Major Science and Technology Projects. Its CPU peak computing speed has reached 93,015 TFlop/s, representing a 600-fold increase from 2006, and its core CPU technology has achieved international top-tier status. Mobile device CPU design technology has achieved parity with international mainstream standards, and desktop computers using independently developed CPUs and operating systems have become practically viable. While these systems were essentially unusable before the implementation of major projects, they are now fully functional.

Cumulative sales of C-core based SOC chips have exceeded 450 million units, ranking third globally. Smart TV SOC chip cumulative shipments have surpassed 20 million units. Annually, 20% of domestic smart TVs incorporate Chinese indigenous chips. This percentage continues to increase year by year. Alibaba Cloud's intelligent operating system has expanded to over 100 million smart devices, while Allwinner Technology Co., Ltd. has sold more than 53 million mobile terminal SOCs in smart device sectors including tablet computers, digital homes, and smart homes. Annual shipments of Spreadtrum Communications' mobile smart device series chips exceed 600 million units, approaching 30% of the global market share. Spreadtrum Communications has emerged as one of the world's top three mobile phone chip suppliers. UC, the next-generation mobile-specific browser developed by Alibaba Group based on project achievements, now serves over 500 million active users, including 100 million overseas users. Baidu's large-scale network application and service platform has attracted 2.5 million developers and established 48 innovation and entrepreneurship centers across 38 cities. This supports the robust implementation and development of China's "Double Innovation" policy. WPS Office has over 800 million users worldwide and accounts for 80% of the domestic procurement market. WPS has gradually become a significant office software provider not only domestically but internationally, emerging as a strong competitor to Microsoft Office. TravelSky's civil aviation ticket transaction system, based on domestically produced operating systems, databases, and middleware, is being used by Air China, China Eastern Airlines, Beijing Capital Airlines, and Tibet Airlines. The system processes over 500,000 tickets daily and serves 500 million users globally. The cumulative sales of internet-connected cars jointly launched by Alibaba Cloud and SAIC Motor have exceeded 250,000 units and gained user acceptance. Users can access an information highway that integrates vehicles and internet while driving on expressways.

(3) VLSI Manufacturing Technology and Integration Process

Centered on the integrated circuit manufacturing chain, innovation chains have been developed, attracting and cultivating numerous high-end talents, significantly improving China's independent innovation capabilities and industrial development in integrated circuits and greatly promoting the establishment of academic disciplines. As a result, gaps in the industrial chain for major equipment and materials have been filled. Specifically, key equipment such as etching machines has been developed from scratch and extensively applied in large-scale production lines. Furthermore, integration process standards have been raised to the fifth generation, with research and development of 55/40/28 nanometer third-generation processes achieving mass production, and breakthrough achievements in 20-14 nanometer process development. Backend packaging integration technology achievements have fully realized mass production, transitioning the entire industry's technical level from low-end to high-end, reaching parity with global standards. Hundreds of key materials including polishing agents and sputtering targets have passed large-scale production line verification and entered mass sales phase. These achievements cover China's entire integrated circuit industrial chain, reversing the previous passive situation where process technology was entirely imported from abroad, and establishing a solid foundation for independent and sustainable development of China's integrated circuit industry. The central government transferred special projects involving VLSI technology and related processes to two local governments, Beijing and Shanghai, with both governments leading their organization and implementation. This was the only National Major Science and Technology Project organized and implemented by local government and represents an innovative attempt at implementing China's National Major Science and Technology Project model.

The following results were obtained in Shanghai.

① Prior to the special project implementation, China's high-end integrated circuit equipment and materials sector was essentially nonexistent, with complete dependence on imports and severe gaps in the industrial chain. Through subsequent efforts, more than 30 types of high-end equipment were developed, including 14-nanometer etching machines and thin film deposition devices, along with hundreds of material products such as target materials and polishing solutions, achieving performance levels that match international standards. Additionally, after passing rigorous large-scale production line verification, batch production and overseas exports commenced, representing a complete breakthrough from zero. A complete industrial chain was established, building and enhancing China's integrated circuit manufacturing technology system and industrial ecosystem. According to statistics, cumulative sales of high-end equipment researched and manufactured through the special project have reached 300 units. A rudimentary support system for major system components in Japan has been established, with domestic component sales exceeding 3,500 units (sets).

② Strengthened Integration of Manufacturing Processes and Packaging, with Significant Improvements in Technical Capabilities and International Competitiveness

Prior to 2008, China's most advanced mass production process for integrated circuits was at 130 nanometers, with research and development reaching 90 nanometers. From the implementation of the special project to present, mainstream process standards have advanced to fifth generation, with mass production achieved through research and development of third-generation integrated processes at 55, 40, and 28 nanometers. Breakthrough achievements in leading technology research and development at 22 and 14 nanometers have resulted in the development of independent intellectual property rights. Semiconductor packaging companies have advanced from low-end to high-end operations, with 3D high-density integration technology reaching advanced international standards. Chip products manufactured using these processes, including those for smartphones, communication equipment, and smart cards, have entered the market in large volumes, strengthening the competitiveness of China's information industry.

③ Emergence of Innovative Inventions, Formation of Independent Intellectual Property Rights System, and Support for Enterprise Participation in International Competition

The lack of independent intellectual property rights has consistently been a bottleneck constraining independent innovation and development of China's integrated circuit enterprises. The integrated circuit special project emphasized innovative technology research and development, proposing a patent-oriented R&D strategy and strategically prioritizing intellectual property rights for core technologies. Over 23,000 domestic invention patents and more than 2,000 international invention patents have been filed, establishing an independent intellectual property rights system, significantly improving China's independent innovation capabilities in integrated circuit technology and promoting development. The approach has shifted from the traditional pattern of "introduce, digest, absorb, and re-innovate" to a new model focused on independent research and development with international cooperation. In the integrated circuit field, it is widely recognized that patents serve not only as a defensive shield but also as a powerful tool for market competition. While patent disputes are common, operating without an intellectual property protection system is like maintaining a position without fortifications. By strengthening independent innovation and establishing a systematic patent protection system, domestic companies have recently achieved unprecedented victories in patent disputes, something that had never occurred before.

④Establishment of Technical Innovation Collaboration Mechanisms and Development of Multiple Internationally Competitive Enterprises

The integrated circuit special project, aimed at developing world-class enterprises, has established a series of effective organizational methods, becoming a showcase of institutional and systemic innovation. First, to address the commercialization of scientific and technological achievements, a user evaluation system was implemented where downstream evaluates upstream, complete machines evaluate components, applications evaluate technology, and markets evaluate products, successfully developing numerous high-end innovative products that have proven viable through user and market assessment and verification. Next, by actively exploring new models for effective synergy between science, technology, industry, and finance; coordinating with major regional development plans; and actively guiding local and social industrial investment, an environment has been created for the collaborative development of industrial, innovation, and financial chains. This has strengthened enterprises while promoting industrialization of results, developing industrial scale, and improving overall industrial capabilities. Under the special project's support, numerous leading enterprises have advanced to the global forefront, multiple core enterprises have entered international markets, and many outstanding enterprises have successfully gone public. According to current statistics, since the establishment of the National Integrated Circuit Industry Investment Fund, over 60% of investment projects are enterprises that were supported and nurtured during the early stages of the special project.

⑤ Breakthrough from Individual Points to Comprehensive Coverage, with Widespread Application of Results Promoting Semiconductor Industry Development

As a fundamental industry, the integrated circuit manufacturing equipment industry has achieved extensive results. Core equipment technology derived from integrated circuit technology has significantly increased the domestic production rate of equipment in China's general semiconductor manufacturing sectors, including LED lighting, sensors, and solar power. Particularly in LED and solar power sectors, complete sets of major equipment are domestically produced, with domestic equipment dominating the market. Though statistics are incomplete, sales of domestic equipment in the semiconductor industry have reached 6,590 units. The domestic production of this equipment has substantially reduced China's investment costs in fields such as LED and solar power, driving significant improvement in the overall competitiveness of China's core industries. China's LED lighting and solar power industries have advanced to first place globally in scale, while also achieving international top-tier technical standards.

(4) Next-Generation Broadband Wireless Mobile Communications

Since the start of the specific project, there have been dramatic developments in mobile communications, from "2G tracking" and "3G breakthrough" to "4G tuning" and "5G practical application." China's mobile communications industry has shown significant improvement in both innovation capability and industrial strength compared to 2007.

This is evident in several aspects: First, the industry's research and development capabilities have been substantially enhanced. This has supported the formation of a complete industrial chain for 5G systems, terminals, chips, and equipment. System manufacturers now hold dominant positions in the global 5G field, while terminal chip companies have achieved breakthroughs in 5-mode, 10-band, and 28-nanometer chip technology. Second, they have achieved industrial applications in 4G and large-scale commercial use in 5G. They actively promoted the construction of high-speed broadband, represented by fiber optics and 4G. 4G base stations account for more than half of the world's 4G base stations, and over 690,000 5G base stations have been constructed. Third, there has been notable expansion in participation in international standard-setting. TD-LTE-Advanced, which China took the lead in promoting, has become one of the 4G standards. Fourth is the comprehensive advancement of 5G research and development. China took the initiative to establish the IMT-2020 (5G) Promotion Group; proposed 5G concepts and technical roadmaps for various sectors across industry, academia, and research; completed studies on 5G vision and requirements; and published white papers on topics including 5G wireless network technology architecture. Fifth, network speeds have doubled. The proportion of fiber optic users has increased from 34% to 93%. 4G users now account for 81%, far exceeding the global average. The current end-to-end speed for fixed networks is 43M, while mobile networks (4G) achieve 29M end-to-end speeds, significantly improving the user experience through these network speeds.

(5) High-End CNC Machine Tools and Basic Manufacturing Technology

The implementation of the targeted project for Computer Numerical Control (CNC) machine tools has deployed the entire industrial chain and domestically produced CNC systems have achieved unique technological advances, as represented by the "embedded integrated device hardware platform." Chinese enterprise products have reached international mainstream technical standards in key indicators including multi-channel operation, multi-axis linkage, and high-speed interpolation. CNC systems have continually improved their equipment support capabilities in key sectors. High-end CNC machine tools, exemplified by 5-axis machining centers, have achieved batch demonstration applications in typical aircraft structural components, aerospace composite parts, precision structural components, and rocket engine parts. They have also contributed to equipment manufacturing for national major special projects and key initiatives, including large aircraft, new fighter aircraft, and lunar exploration projects. The special project selected 562 themes and received CNY 9.114 billion in central government funding. The mean time between failures for machine tool bodies has increased from 400–500 hours before project implementation to generally over 1,200 hours, with some products exceeding 2,000 hours. In the high-end CNC machine tools sector, the project has broken through foreign technological monopolies and achieved batch production integration of major functional components.

Specifically, the successful development of heavy national machinery, including 80,000-ton large-scale die forging machines and 10,000-ton class aluminum plate stretch forming machines, indicates that China's aviation sector mold material manufacturing has joined the ranks of advanced nations. The project has manufactured specialized equipment for the space sector, including welding equipment for large storage tanks, large-scale powerful spinning equipment, and automated drilling and riveting equipment, providing substantial support for the successful launch missions of Long March 5 and Tianzhou-1. In the automotive manufacturing sector, Jinan No. 2 Machine Tool Group Co., Ltd. has developed a large-scale, high-speed, flexible automatic stamping press production line. The company has successfully exported nine production lines over the past five years, achieving over 70% of the domestic market share and exceeding 30% of the global market share.

(6) Development of Large Oil and Gas Fields and Coalbed Methane

Significant achievements have been made across six major areas, with remarkable results. First, in onshore oil and gas exploration, innovations have been made in exploration theory and technology for marine strata and deep formations, as well as in oil and gas accumulation theory and reservoir prediction technology for ancient marine carbonate deposits. Large gas fields, including Anyue and Yuanba, have been discovered in the Sichuan Basin. The Anyue gas field is China's oldest ultra-large gas field in terms of stratum age, with confirmed reserves of 1.5 trillion cubic meters, and is considered the most significant natural gas field discovery in history. Major breakthroughs have been achieved in deep-formation oil and natural gas accumulation theory, seismic imaging, and drilling technology. Exploration at depths of 4,000-8,000 meters has led to the discovery of five large-scale gas fields in Kuche City, Xinjiang Uygur Autonomous Region, each with reserves of 100 billion cubic meters. The combined gas field size exceeds 1 trillion cubic meters. Second, in onshore oil and gas field development, technological innovations have been made in high water-content oilfields and complex oil and gas field development, supporting the sustainable development of the Daqing, Shengli, and Changqing oilfields. ASP flooding-based tertiary oil recovery technology leads the world and has become the next-generation strategic alternative technology. Recovery rates at major oilfields exceed 50%, ensuring sustainable development of the Daqing oilfield. Safe and efficient development technology for high-sulfur gas fields has reached advanced international levels, leading to the development of the Puguang gas field with annual production of 10 billion cubic meters. Third, in the engineering technology field, 13 major pieces of equipment have been independently researched and developed, breaking foreign technological monopolies and leading to significant advancement in the oil and gas engineering and technical services industry. Next-generation wired seismometers

(G3i), seismic data processing and interpretation software (GeoEast), and Wide-azimuth, Broadband, and High-density (WBH) seismic exploration core equipment and software have achieved world-class breakthroughs, enabling the China National Petroleum Corporation Geophysical Exploration Company to rank among the world's top three in terms of comprehensive capabilities. The Fast and Imaging Logging System (EI Log) and The 3rd Generation Logging Software based on Java-NetBeans (CIF Log) have ended the long-standing reliance on imported advanced measurement equipment and software. Critical equipment such as precision-controlled pressure drilling and 3000-type compression fracturing units have broken through foreign technological monopolies. In offshore oil and gas exploration and development, from coastal waters to deep sea, underwater oil and gas engineering technology has reached advanced international standards. The 3000-meter deep-sea semi-submersible drilling platform has successfully conducted deep-sea drilling in the South China Sea, advancing operational water depth capabilities from 500 meters to 3000 meters.

Major breakthroughs in deep-sea oil and gas engineering technology have enabled the development of the 1500-meter Liwan 3-1 gas field in the South China Sea. New offshore heavy oil development technology has improved recovery rates by 5%–10%, and by the end of the 12th Five-Year Plan period, China's offshore oil and natural gas production exceeded 50 million tons. For overseas oil and gas exploration and development, through effective application of mature domestic oil and gas exploration and development technology, China has supported oil and gas development and cooperation with countries along the Belt and Road Initiative. Chinese oil companies are providing technical support for continued strengthening of overseas cooperation by independently developing global oil and gas resource evaluation methods and information systems, while significantly improving global oil and gas resource analysis capabilities. New models for oil and gas accumulation in the rift basins of Central and West Africa have been developed, supporting the discovery of multiple hundred-million-ton class oil and gas fields in regions such as Chad, Niger, the Caspian Sea, and the Amu Darya. Through innovative technologies for efficiently developing complex oil and gas fields including large carbonate formations, high-viscosity oil, and high pour point crude oil, five major overseas oil and gas cooperation zones have been established. In the field of unconventional oil and gas exploration and development, the industrialization of coalbed methane and coordinated development of gas and coal mining in coal mining areas have driven the development of the emerging shale gas industry. Cost-effective exploration and development technology for coalbed methane has been established, resulting in the construction of two coalbed methane industrialization bases in Qinshui and Baode. The coordinated development of gas extraction and coal mining in coal mining areas has ensured coal production safety. Basic shale gas development technologies have been established, leading to the construction of industrialization model zones in Fuling and Changning-Weiyuan.

(7) Large Advanced Pressurized Water Reactor (PWR)

The Large Advanced Pressurized Water Reactor (PWR) and High-Temperature Gas Reactor Power Plant Major Science and Technology Project (Nuclear Power Major Science and Technology Project) is strategically positioned in the world's leading nuclear power sector to achieve breakthrough developments in nuclear power technology. Since its launch in 2008, development of the comprehensive AP1000 technology, which represents the world's most advanced level, has been pursued based on domestic nuclear industry foundations, achieving four symbolic results.

The first is general technology research. In 2007, AP1000 technology was imported from the United States, but many manufacturers had significant gaps in their third-generation standards and third-generation equipment manufacturing capabilities. Through subsequent efforts in the Major Science and Technology Project, issues with core equipment and materials have now been essentially resolved. Currently, following national requirements, core technologies, key technologies, core materials, and key equipment have been essentially domestically produced, which is crucial for improving national capabilities.

The second is technology introduction, assimilation, and absorption, through which China developed the CAP1000 model based on the AP1000. The CAP1000 thoroughly incorporates the original AP1000 technology and, building on China's equipment manufacturing and construction capabilities, has successfully passed Chinese safety inspections. The resulting CAP1000 possesses strong competitive potential for the future.

The third achievement is a symbolic project: the development of the high-output CAP1400 with independent intellectual property rights based on the AP1000, which is significant on a global scale. Following completion of conceptual design, preliminary design, construction design, comprehensive testing and verification, safety reviews, and relevant government department examinations, it has established the foundation for both ongoing projects and future serial production.

The fourth is that in addition to its relatively advanced technology and excellent safety features, particular focus has been placed on economic efficiency. The CAP1400 possesses outstanding economic characteristics and maintains relatively high competitive advantages in economic efficiency compared to both current global models and China's initial models. Additionally, through the major special project, multiple testing and research facilities were subsequently constructed, specifically including 12 new testing facilities and improvements to 4 existing facilities, leading to the development of subsequent core facilities. These have established an excellent foundation, including testing conditions for the CAP1400 development process. Through these Major Science and Technology Projects, an independent design and software system has been developed, and a comprehensive safety review system has been established throughout the entire process. Notably, the current safety review system ranks among the world's highest standards, and a complete manufacturing system for third-generation nuclear power equipment materials and facilities has been established. Throughout this process, multiple teams of scientific and technological talent have been formed, creating a solid foundation for the future safe, economical, and efficient development of nuclear power.

(8) High-Temperature Gas Reactor Nuclear Power Plant

This special project was implemented systematically by the National Energy Administration under the guidance of the Ministry of Science and Technology, National Development and Reform Commission, and Ministry of Finance, establishing an industry–academia–research collaboration team. Within this framework, an implementation organization was established for the construction and operation of the demonstration plant, led by Huaneng Group with participation from China Nuclear Engineering & Construction Group Corporation (at that time) and Tsinghua Holdings Co., Ltd. (a state-owned enterprise funded by Tsinghua University). China National Nuclear Corporation and Tsinghua Holdings assumed leadership roles, with China General Nuclear Power Group joining the project implementation organization. The Institute of Nuclear and New Energy Technology at Tsinghua University was responsible for technology research and development.

To date, the special project's progress can be summarized as "1-3-3" in relation to overall goals and requirements.

The first "1" signifies the formal commencement of power transmission from the 200,000 kW high-temperature gas reactor demonstration reactor constructed at Shidao Bay in Rongcheng, Shandong Province. The "3" represents new developments in three areas of innovation: high-performance nuclear fuel, industrial scale expansion and engineering technology testing and verification, and research and manufacturing of major core equipment.

First, the all-ceramic high-performance nuclear fuel utilized technical achievements from Tsinghua University's intermediate test production line. The Northern Nuclear Fuel Company, under China National Nuclear Corporation, constructed a manufacturing plant for high-temperature gas reactor nuclear fuel elements with an annual production capacity of 300,000 units. The fully domestically equipped fuel plant ranks among the world's leaders in both technical capability and production scale.

During mass production, 10 fuel spheres were randomly selected for a 3-year neutron irradiation experiment at 1100°C in a European high neutron flux experimental reactor. The irradiated fuel spheres were heated to 1650°C in experimental equipment shielded by thick lead glass. Under these extreme conditions, radioactive leakage from nuclear fission in the nuclear fuel was measured. Currently, all planned tests have been completed successfully, demonstrating that the fuel elements can effectively prevent radioactive leakage even at temperatures of 1650°C, with related indicators achieving world-leading levels.

Next, regarding research and development activities, all industrial scale-up and engineering technology testing and verification has been completed. The primary helium fan with magnetic suspension bearings, a core component of the reactor, underwent more than 500 transient state tests and various extreme condition tests over thousands of hours on a test bench replicating the reactor's thermal conditions. The completed steam generator concluded operational measurement tests under conditions of 10MW thermal output, 570°C steam outlet temperature, and 13.25MPa pressure.

The third element of the first "3" involves equipment research and manufacturing, completing the production of several major equipment types for the first time globally. For example, Shanghai Electric completed the research and manufacture of critical equipment including the reactor pressure vessel, metallic internal reactor structures, and control rod drive mechanisms. Shanghai Electric's Fan Factory and Harbin Electric's Jiamusi Electric Machinery Factory completed the research and manufacture of the primary helium fan. Breakthroughs were also achieved in core technology and processes for the steam generator. The manufacture of the steam generator was contracted to Harbin Electric. The Baoji Taihua Magnetic and Electric Research Institute was responsible for manufacturing the main equipment of the fuel loading system. Through the major project's research and development, the demonstration project achieved a 90% domestic production rate.

The second "3" represents three keywords that demonstrate this project's significant meaning and application prospects.

The first keyword is "Fourth Generation." The demonstration project began power transmission in December 2021, positioning China closest to commercializing the high-temperature gas reactor, with this reactor type representing the safest fourth-generation nuclear technology. The high-temperature gas reactor is recognized as a reactor that cannot experience core meltdown. Using the experience and proven technology from the Shandong Province demonstration project, China can construct a 600,000 kW combined heat and power unit by combining multiple modules without modifying the main equipment and systems. This type of unit can replace coal-fired power plants of the same output capacity while achieving high-efficiency power generation. Since the power generation system is similar to that of a 600,000-kilowatt thermal power plant, the original equipment and infrastructure of coal-fired power plants can be effectively utilized. Additionally, steam extraction from the steam turbine not only provides high-parameter steam for the petrochemical industry but also supplies low-parameter steam needed in sectors like large-scale centralized heating, achieving high energy utilization efficiency.

The second keyword is "high-temperature." The demonstration reactor's outlet temperature is 750°C, and under the same reactor design and material conditions, it can supply high-temperature heat of 950°C–1000°C. This level of high temperature can be used for large-scale hydrogen production, providing hydrogen as a new energy source for various fields such as the steel industry and automotive transportation, thus promoting cross-sector development.

The third keyword is "gas cooling." All nuclear and atomic power devices must undergo a conversion process of "nuclear-thermal-electrical or power." In the "thermal-electrical" conversion process, in most cases, high-energy gas drives the turbine. When the fuel performance of the High-Temperature Gas Reactor reaches an exceptionally high level, the above "nuclear-thermal-electrical" conversion can be highly integrated into a single loop, achieving the required "helium turbine direct cycle power generation." This is also demanded in the overall objectives of the Major Science and Technology Project. The High-Temperature Gas Reactor achieves maximum output and efficiency in minimal space.

(9) Control and treatment of water pollution

This Major Science and Technology Project is China's first major scientific and civilian project to systematically solve environmental problems and is a national strategy for the coordinated development of Beijing-Tianjin-Hebei and the preservation of clean water. The project aims to establish systems for watershed water pollution prevention, water environment management, and drinking water safety assurance. It has implemented comprehensive demonstration projects in Lake Taihu, Beijing-Tianjin-Hebei, and other river basins (regions), working to continuously improve China's environmental quality and shift the water quality in key watersheds such as the "Three Rivers and Three Lakes" from continuous deterioration to sustained improvement The project provided strong scientific and technological support for the rural drinking water safety project in Hebei Province, which aims to provide safe drinking water to the population. The major scientific and technological achievements of this Major Science and Technology Project include construction of ecological corridors for the coordinated development of the Beijing-Tianjin-Hebei region, early warning and treatment/disposal systems for cyanobacteria in Lake Taihu, whole-process water pollution management in the steel industry, high-level urban wastewater treatment and recycling, core technologies for "source-to-tap" drinking water safety assurance, next-generation mobile water quality monitoring vehicles, and digital diagnostic systems for urban drainage pipes.

(10) Development of New Varieties of Genetically Modified Organisms

As of 2017, functional genes cloned through specialized projects reached 3,160. These include 130 important genes with significant breeding applications related to pest resistance, stress resistance, and other traits. Several of these important genes are being utilized to create new genetic materials. There have been 1,872 patent applications and 1,036 patents granted, including 40 international patent applications with 9 approvals. Gene cloning and genetic transformation technologies have reached world-class levels, with research in rice gene cloning achieving global leadership. Two-thirds of the world's significant rice genes have been cloned by Chinese scientists, with the majority funded through the Special Gene Project Fund. They have developed innovative gene expression regulation and safe genetic modification technologies with independent intellectual property rights, leading to breakthroughs in genome editing technology as applied to molecular breeding of rice and wheat. Large-scale genetic modification technology systems for eight major organisms have been improved, particularly achieving breakthroughs in rice and wheat genetic transformation technology, with japonica rice transformation efficiency improving from 40% to 93%. Wheat transformation efficiency has increased from 1% to over 20%, providing effective support for transgenic development. The cultivation of new biological varieties has succeeded in breaking the long-term monopoly on genes and technology previously maintained by developed nations and multinational seed industry groups.

The Special Genetic Modification Project has established a comprehensive platform for safety evaluation, testing, and monitoring of genetically modified organisms, while forming a stable team dedicated to genetic modification safety assessment, testing, and monitoring activities. Research and development activities encompassed 206 new technologies and methods for biosafety evaluation, testing, measurement, and monitoring; 138 technical standards and regulations; and 84 types of reference materials. Centered on specific projects, the research focused on genetically modified varieties with industrialization prospects, including insect-resistant rice, insect-resistant cotton, insect-resistant corn, and herbicide-resistant soybeans, with systematic safety evaluations conducted on 33 key transformants. Systematic monitoring has been implemented to assess potential ecological impacts from large-scale plantings of genetically modified Bt cotton for pest control. The Special Genetic Modification Project has developed 124 new varieties of pest-resistant genetically modified cotton, which have been distributed across 370 million mu (1 mu equals 6.7 ares). This has resulted in a reduction of pesticide use by 370,000 tons, with increased yields generating social and economic benefits of CNY 42 billion. The market share of domestically produced pest-resistant cotton has reached 96%. Three-line hybrid pest-resistant cotton has resolved the technical challenge of high production costs associated with artificial emasculation seeds. When compared to conventional hybrid cotton, seed production costs have been reduced by 60%, efficiency has increased by 40%, and yield has improved by 20%. China has emerged as the second-leading nation in research and development of genetically modified cotton with independent intellectual property rights, second only to the United States.

(11) Development of Major New Pharmaceuticals

The year 2020 marked the conclusion of China's Major New Drug Innovation Major Science and Technology Project. Since its inception in 2008, this Major Science and Technology Project has facilitated a gradual transition from imitation-based to innovation-based development, achieving a historic transformation from a major pharmaceutical producer to a pharmaceutical science and technology leader. It supported 3,000 initiatives with central government funding of CNY 23.3 billion. Between 2008 and 2018, China developed 41 Class I new drugs, with 10 of these introduced in 2018. An additional 12 Class I drugs were introduced in 2019, followed by 15 more in 2020. The initial objectives of the Major Science and Technology Project have been comprehensively and satisfactorily achieved. Under the Major New Drug Innovation Project, China's pharmaceutical innovation has maintained steady progress. Among the world's top 500 pharmaceutical companies announced in 2020, the United States had 15 companies and Japan had 10, while China and Germany each had 4 companies listed, placing them jointly in third position globally. This achievement marks a significant step forward in the development of China's pharmaceutical industry. Chinese-produced pharmaceuticals and vaccines have achieved international accessibility, with an increasing number of Chinese pharmaceutical products entering international clinical trials. The vaccine regulatory system has received WHO approval, and international technology transfer and cooperation have expanded in scope.

More than a decade after the implementation of the Major Science and Technology Project, China's drug development and pharmaceutical industry has undergone substantial transformations, garnering increased international attention. For instance, many Chinese pharmaceuticals, including domestic small-molecule targeted drugs, have significantly reduced the gap with international counterparts and now maintain comparable standards. Domestically produced small-molecule targeted drugs, including BTK inhibitors, third-generation EGFR inhibitors, PARP inhibitors, and CDK4/6 inhibitors, are continuously entering the market and are expected to end the dominance of imported targeted drugs in the domestic market.

(12) Prevention and Treatment of Major Infectious Diseases Including AIDS and Viral Hepatitis

A screening technology system has been established capable of identifying 300 known and unknown pathogens within 72 hours, achieving significant advances in core technologies for pathogen monitoring, early warning, detection, confirmation, and emergency patient treatment. This system has provided crucial support during major disease outbreaks, including H1N1 influenza, H7N9 influenza, Middle East Respiratory Syndrome, and Ebola fever. Breakthrough achievements in key technologies for the diagnosis and prevention of three diseases (AIDS, Hepatitis B, and tuberculosis) have provided scientific and technical support for reducing their incidence and mortality rates. With regard to AIDS, HIV nucleic acid screening reagents are now manufactured in China, reducing the detection window period (the interval between infection and when the virus becomes detectable through testing) from 28 days to less than 7 days, significantly lowering the risk of transfusion-related infections. The implementation of comprehensive and intensive intervention technology programs has been promoted, resulting in a 62% reduction in HIV transmission between spouses in families where one partner is HIV-positive in China. The primary treatment regimen has been optimized using domestically produced medications, reducing treatment costs by 79%. For Hepatitis B, the immunization strategy for the Hepatitis B vaccine has been optimized, significantly reducing both non-response and low-response rates to vaccination. This has improved mother-to-child transmission blocking rates, and the Hepatitis B surface antigen carrier rate among children under 5 years old has dropped below 1%. The treatment plan for severe Hepatitis B has been optimized, reducing the mortality rate of acute and subacute severe hepatitis from 88.1% to 21.1%, and chronic severe hepatitis from 84.6% to 56.6%. Regarding tuberculosis, a series of diagnostic reagents have been developed that reduce tuberculosis bacteria detection time from 4–8 weeks to less than 6 hours, increasing the detection rate of tuberculosis bacteria in sputum from 25% to over 50%. Many technically competitive platforms have been established and improved. In these three disease areas, the integration of basic research with clinical diagnosis and treatment has been strengthened, significantly enhancing the comprehensive support capabilities for infectious disease prevention and control technologies. For the prevention and management of emergent acute infectious diseases, technical platforms have been established and improved for pathogen detection, surveillance and early warning, animal testing, biosafety, product development, and evaluation. In the field of emerging infectious diseases, particularly in disease etiology and the structural biology of pathogens, China has achieved numerous breakthrough results that rank among the world's leading accomplishments. Since the implementation of the special project, a total of 21 national science and technology awards have been received. Among these, Academician HOU Yunde, who served as technical director of the Major Special Project for Prevention and Treatment of Major Infectious Diseases, won the 2017 State Preeminent Science and Technology Award, while a project involving Deputy Director Academician LI Lanjuan received the Special Prize of the State Science and Technology Progress Award.

(13) Large Aircraft (C919 Project)

The Commercial Aircraft Corporation of China (COMAC) 919 represents China's first large passenger aircraft with independent intellectual property rights. Developed and manufactured domestically, it marks a significant technological breakthrough for China, ending the nation's long history without its own large passenger aircraft. The C919's total body weight is approximately 42.1 tons, with aluminum alloy serving as the primary material, constituting 65% of the total weight. The aircraft incorporates third-generation aluminum-lithium alloy, which provides more than 5% weight reduction compared to conventional aluminum alloy under identical load conditions. This achievement meets the target of being 5%–10% lighter than aircraft with comparable seating capacity, such as the Boeing 737 and Airbus A320. In May 2018, the domestically developed large aircraft engine CJ1000A, created by AECC Commercial Aircraft Engine Co., Ltd., reached a milestone when its first CJ-1000AX prototype achieved successful ignition in Shanghai. The core unit demonstrated a maximum rotation speed of 6,600 rpm, allowing preliminary verification of component functionality and system compatibility.

The major scientific and technological special project for large aircraft has achieved significant progressive results, marked by the successful maiden flights of several domestically produced aircraft: the Yun-20 large military transport aircraft, the C919, and the AG600 large amphibious aircraft. The C919 has completed its iron bird testing, avionics integration, electrical systems integration testing, and joint testing of the complete aircraft systems. The aircraft completed its maiden flight on May 5, 2017. By the end of September 2019, the C919 had secured orders for 851 aircraft from 26 customers.

(14) High-Resolution Earth Observation System

The system's primary objective is to establish a comprehensive high-resolution ground data acquisition system that integrates satellites, stratospheric airships, and aircraft, while enhancing the associated reception, processing, and application systems. When combined with other observation methods, this system aims to provide continuous global Earth coverage in all weather conditions, at all times. The system comprises at least seven satellites in the Gaofen series, numbered sequentially from Gaofen-1 through Gaofen-7. Since the special project's inception, multiple satellites have been successfully deployed, including Gaofen-1 for high resolution imaging, Gaofen-2 with 1-meter panchromatic capability, Gaofen-3 featuring 1-meter radar, Gaofen-4 for synchronized staring observation, Gaofen-5 for high-spectral observation, and Gaofen-6 for land emergency monitoring. The data collected from these satellites has found wide-ranging applications. On November 3, 2019, the Taiyuan Satellite Launch Center successfully launched the Gaofen-7 satellite using a Long March 4 carrier rocket as part of the major special project for high-resolution Earth observation. The launch also included three additional satellites: a precision Gaofen test satellite, Sudan's first scientific experimental satellite, and Tianyi-15. The Gaofen-7 represents China's first sub-meter optical transmission stereometric survey satellite and is expected to serve crucial functions in land surveying, urban construction, and statistical surveys. The system has now established comprehensive observation capabilities covering land, atmosphere, and oceans. It supports missions across multiple sectors including agriculture, disaster prevention and mitigation, resource management, environmental monitoring, and public safety, while simultaneously advancing the development of the space information industry chain.

(15) Manned Space Flight

Tiangong-1, China's first space laboratory, launched and successfully entered orbit on September 29, 2011. Later that year, on November 1, Shenzhou-8 launched and achieved two significant milestones by completing two automatic rendezvous and docking operations with Tiangong-1. The next major milestone occurred over June 11-26, 2013, when the Shenzhou-10 spacecraft carried out China's fifth crewed space flight, successfully performing an automatic rendezvous and docking with Tiangong-1. On September 15, 2016, China launched its second space laboratory, Tiangong-2, which successfully entered orbit. This was followed by the launch of the Shenzhou-11 spacecraft on October 17. Several months later, on April 20, 2017, the unmanned cargo spacecraft Tianzhou-1 launched and successfully docked with Tiangong-2 on April 22. During these missions, thirteen distinct scientific objectives were accomplished, encompassing orbital verification of new component types, exploration of the space environment, measurements of dynamic environmental conditions, and life science research. The Tianzhou-1 mission marked several technological breakthroughs in essential capabilities, including cargo transport, propellant resupply, and rapid docking procedures. This spacecraft represents a significant achievement in China's three-stage development strategy for its piloted space program, which encompasses research and manufacturing, launch capabilities, and operations. These accomplishments signal the approaching era of space station operations.

(16) Lunar Exploration Project

The Lunar Exploration Project represents the third milestone in space science and technology development as a national major scientific and technological special project, following artificial satellites and crewed spaceflight. The National Space Science Center serves as one of the central research institutions for the lunar exploration project, with responsibilities including.

① Overall payload management

② Onboard payload subsystem integration control systems

③ Ground-based comprehensive payload testing systems

④ Development of certain scientific exploration payload equipment

⑤ Space weather support missions.

As of the end of 2019, the Center had completed missions including Chang'e-1, Chang'e-2, Chang'e-3, and Chang'e-4.

On November 24, 2020, Chang'e-5 was successfully launched using the Long March 5 rocket and entered its planned orbit. On December 2, the Chang'e-5 probe successfully completed automatic sample collection from the lunar surface. the proper packaging and storage of these samples in the ascender module's storage devices; The mission culminated on December 17 when the Chang'e-5 return capsule landed safely in Inner Mongolia. This marked the successful completion of China's first sample return mission from a celestial body beyond Earth.

(3) Special Project for Technology Innovation Guidance

In 2014, the State Council initiated reforms to the management of central fiscal science and technology planning by issuing the Notice of the State Council on Issuing the Program for Deepening the Reform of Central Fiscal Science and Technology Planning Management (Special Projects, Funds, etc.) [in Chinese].[60] This initiative called for establishing a framework and structure for a new science and technology planning system. The program proposed consolidating nearly 100 existing science and technology plans (special projects, funds, etc.) into five categories, with

60 "国务院印发关于深化中央财政科技计划(专项、基金等)管理改革方案的通知"
(http://www.gov.cn/zhengce/content/2015-01/12/content_9383.htm)

reorganization based on scientific evaluation.

① National Natural Science Foundation of China

② National Science and Technology Major Projects

③ National Key Research and Development Program

④ Technology Innovation Guidance Special Projects (Fund)

⑤ Base and Talent Special Projects

Among these, the Technology Innovation Guidance Special Projects aim to fully leverage market functions to promote the transfer, capitalization, and industrialization of scientific and technological achievements through enterprise technology innovation activities guided and supported by market mechanisms. This is accomplished through various methods including research and development (technology transaction) subsidies, angel guidance, and risk compensation. These projects include initiatives for nurturing innovation-oriented enterprises, integration of science, technology and finance, special projects for industry–academia–research cooperation, and special projects for "Enriching and Benefiting the People." The "Intelligent Group" entrepreneurship program, which serves as a special fund for science and technology-oriented small and medium-sized enterprises, has been integrated into the special projects for nurturing innovation-oriented enterprises. The Angel Investment Guidance Fund and Science and Technology Credit Guarantee Fund have been consolidated into the Science and Technology Finance Special Project. Projects involving international science and technology cooperation, industry–academia–research collaboration in online technology markets, and subsidies for technology transfer transactions have been merged into the Industry-Academia-Research Cooperation Special Project. The Rural Science and Technology Innovation and Entrepreneurship Fund and the Agricultural and Social Development Research & Application Program have been reorganized and incorporated into the "Enriching and Benefiting the People" Science and Technology Special Project.

The Special Project for Technology Innovation Guidance primarily encompasses the National Science and Technology Achievement Transformation Guidance Fund, the National Emerging Industry Venture Capital Guidance Fund, the National Small and Medium Enterprise (SME) Development Special Project Fund, and central government-guided special funds for local science and technology development.

The Science and Technology Achievement Transformation Guidance Fund supports the transformation of scientific and technological achievements through the following methods: establishing venture capital sub-funds, providing loan risk compensation, and offering performance incentives. Venture capital sub-fund establishment refers to sub-funds jointly established and launched by the transformation fund and qualified investment institutions to provide equity investment to enterprises engaging in the transformation of scientific and technological achievements. Loan risk compensation refers to the transformation fund providing specific risk compensation for science and technology achievement transformation loans issued by partner banks that meet designated conditions and procedures. Performance rewards consist of financial incentives provided by the transformation fund to enterprises, research and development institutions, universities, and technology intermediary service organizations that have made exceptional contributions to the transformation of scientific and technological achievements. According to data released by the National Science and Technology Achievement Transformation Guidance Fund in June 2021, since 2015, the number of venture capital sub-funds established under the National Science and Technology Achievement Transformation Guidance Fund has reached 30, with a scale approaching CNY 50 billion, and the fund's expansion rate has exceeded 400%.

(4) National Emerging Industry Venture Capital Guidance Fund

In January 2015, the State Council Executive Meeting decided to establish the National Emerging Industry Venture Capital Guidance Fund. In July 2016, State Development & Investment Corp., Ltd. (SDIC) established SDIC Unity Capital Management Co., Ltd. as both the mother fund and the guidance fund management platform. This company serves as the fund's primary management organization and possesses extensive experience in managing guidance funds and mother funds. Eighty percent of the guidance fund is invested in venture capital funds focusing on emerging industries in their establishment, early, and middle stages, while 20 percent can be directly invested in unlisted mature companies. The former fund has raised approximately CNY 100 billion and manages funds encompassing financial institutions, social security funds, state-owned and private capital, making it one of China's largest specialized private equity management institutions. Currently, it manages 16 sub-funds with a management scale of approximately CNY 100 billion. In 2021, contributions from fund operations, pharmaceuticals, and other business profits exceeded 70 percent, with total profits increasing by 108 percent compared to the previous year. Net profit growth was 139 percent, and together with China Water Environment Group under SDIC, it led the development of the first technical guidelines and regulations for submersible sewage treatment facilities, coordinating environmental considerations, land conservation, and water resource reuse. The "National Employment Initiative"[61] was elevated to a national-level employment project. The fund led the establishment of a CNY 15 billion Guangdong-Hong Kong-Macao Greater Bay Area Science and Technology Achievement Transformation Fund. Forty companies receiving direct investment or fund investment debuted at the "13th Five-Year Plan" Science and Technology Innovation Achievement Exhibition, while 17 companies received the National Science and Technology Progress Award. The fund has hosted an ESG (Environmental, Social, and Governance) Responsible Investment Forum and is leading green and low-carbon development among state-owned enterprises.

(5) National SME Development Special Project Fund

The National SME Development Special Project Fund is allocated from the central fiscal budget and encompasses funds for optimizing the development environment for small and medium enterprises, supporting local development of small and medium enterprises, and developing enterprises specifically producing ethnic trade goods and ethnic minority specialties. In June 2020, with State Council approval and under the leadership of the Ministry of Industry and Information Technology and the Ministry of Finance, the National SME Development Fund Co., Ltd. was formally established. Its purpose is to fully leverage the driving force and leadership role of fiscal funds, employ market-oriented methods to guide social capital, expand equity investment in small and medium enterprises, and support their innovative development. By the end of August 2021, the National SME Development Fund Co., Ltd. had established 14 sub-funds, reaching a scale of CNY 43.3 billion. Central fiscal funds have been amplified at two levels, with a multiplier effect approaching 8 times, and the fund scale is projected to reach CNY 100 billion in the future. From an investment perspective, the established sub-funds have accumulated 525 investment projects, with a total investment amount of CNY 18.3 billion. Among these entities, SMEs account for over 85% of the share, with

[61] National Employment Initiative: A media-integrated recruitment initiative jointly launched by China Media Group together with the Ministry of Education, Ministry of Human Resources and Social Security, State-owned Assets Supervision and Administration Commission, and the Central Committee of the Communist Youth League of China, co-hosted by China Media Group Mobile and SDIC Human Resources Service Co., Ltd.

their investment amounts exceeding 78% of the total. SMEs in the startup growth phase represent 73% of the share, accounting for over 65% of investment amounts. The cumulative number of investments in Specialization, Refinement, Uniqueness and Innovation SMEs[62] is 68, while Little Giant enterprises number 42.[63] Additionally, in fields prioritized by the state, such as new energy and new materials, the fund's cumulative investment has reached CNY 14.4 billion, representing nearly 80% of the total. In February 2021, the Ministry of Finance and the Ministry of Industry and Information Technology jointly issued the Notice on Supporting High-Quality Development of Specialization, Refinement, Uniqueness and Innovation Small and Medium-sized Enterprises [in Chinese],[64] requiring the allocation of over CNY 10 billion in incentives and subsidies from central fiscal funds through the Special Project Fund for SME Development during 2021–2025. This aims to guide localities to improve support policies and public service systems, while providing focused support in three phases for the high-quality development of more than 1,000 national-level Little Giant enterprises, promoting their role as demonstration cases. Furthermore, by supporting several national (or provincial) public service demonstration platforms for SMEs and strengthening service levels, the initiative aims to concentrate resources such as funding, talent, and technology to develop approximately 10,000 SMEs into national-level Specialization, Refinement, Uniqueness and Innovation enterprises. In June 2021, to strengthen the management of the Special Project Fund for SME Development and ensure the fund achieves results and effectiveness in SME development, revisions were made to the Management Measures for the Special Project Fund for SME Development [in Chinese].[65]

(6) Local Science and Technology Development Funds

The centrally-guided local science and technology development funds are fiscal authority transfer payments that support and guide local governments to use central fiscal resources to implement national innovation-based development strategies and science and technology reform policies, while optimizing regional science and technology innovation environments and improving regional science and technology innovation capabilities. According to the Notice on Printing and Distributing the Management Measures for Centrally-Guided Local Science and Technology Development Funds [in Chinese][66] issued in November 2021, the guidance funds support the following four areas:

① Free exploratory basic research

This primarily refers to science and technology plans (special projects, funds, etc.) that local authorities independently establish for conducting free exploratory basic research, focusing on exploring unknown scientific problems in combination with regional basic research deployment. Examples include locally established natural science funds, basic research plans, and basic and applied research funds.

② Construction of science and technology innovation bases

This refers to various science and technology innovation bases that local governments construct in accordance with relevant regional plans, including innovation bases established in affiliation with universities, research and

62 Specialization, Refinement, Uniqueness and Innovation refers to enterprises possessing these four characteristics of excellence. A company with four outstanding characteristics: "specialization, precision, characterization, and novelty."

63 Little Giant: The Chinese government aims to nurture 10,000 emerging enterprises with high growth potential, known as "Little Giant" enterprises, by 2025.

64 "关于支持"专精特新"中小企业高质量发展的通知"(http://www.gov.cn/zhengce/zhengceku/2021-02/03/content_5584629.htm)

65 "关于印发《中小企业发展专项资金管理办法》的通知" (http://www.gov.cn/zhengce/zhengceku/2021-06/19/content_5619517.htm)

66 "关于印发《中央引导地方科技发展资金管理办法》的通知" (http://www.gov.cn/zhengce/zhengceku/2021-12/22/content_5663957.htm)

development institutions, enterprises, and incorporated research and development institutions (including State Key Laboratories jointly established by provinces and ministries, and Clinical Medicine Research Centers), as well as Industrial Technology Research Institutes, Technology Innovation Centers, and New-Type Research and Development Institutions that possess independent legal status.

③ Transfer and transformation of scientific and technological achievements

This focuses on activities for transferring and transforming scientific and technological achievements by key regional industries based on local conditions. It includes the establishment of technology transfer institutions, talent teams, and technology markets, as well as demonstration projects for transforming scientific and technological achievements that have clear public benefit, demonstrable leadership roles, effectively enhance industrial innovation capabilities, and benefit the broader population.

④ Construction of regional innovation systems

This involves building regional innovation systems such as national independent innovation demonstration zones, international science and technology innovation centers, comprehensive national science centers, sustainable development agenda innovation demonstration zones, national agricultural high-tech industry demonstration zones, and innovation-type counties (cities). It primarily supports cross-regional research and development cooperation and research and development activities of science and technology-oriented SMEs within regions.

According to the notice issued by the Ministry of Finance, the 2022 budget for centrally-guided local science and technology development funds is CNY 2.068 billion, which will be used for basic research, construction of science and technology innovation bases, transfer and transformation of scientific and technological achievements, and construction of regional innovation systems in relevant provinces (autonomous regions, municipalities directly under the central government, and cities designated as having special economic administrative status in the state plan).[67]

[67] Cities with Special Economic Administrative Status: Dalian, Qingdao, Ningbo, Xiamen, and Shenzhen.

Advance allocation budget table for centrally-guided local science and technology development funds for 2022

No.	District	Budget Amount (CNY 10,000)
1	Beijing	7360
2	Tianjin	4400
3	Hebei	6560
4	Shanxi	5360
5	Inner Mongolia	3920
6	Liaoning	5360
7	Dalian	1920
8	Jilin	4320
9	Heilongjiang	4480
10	Shanghai	4480
11	Jiangsu	11600
12	Zhejiang	9360
13	Ningbo	1920
14	Anhui	8400
15	Fujian	4880
16	Xiamen	1920
17	Jiangxi	6240
18	Shandong	8160
19	Qingdao	2480
20	Henan	8000
21	Hubei	8720
22	Hunan	7360
23	Guangdong	12160
24	Shenzhen	4560
25	Guangxi	4800
26	Hainan	2640
27	Chongqing	5440
28	Sichuan	13040
29	Guizhou	4080
30	Yunnan	4880
31	Tibet	3600
32	Shaanxi	7840
33	Gansu	5520
34	Qinghai	3040
35	Ningxia	3760
36	Xinjiang	4240
Total Amount		206800

Source: Ministry of Finance Official Website
(http://www.gov.cn/zhengce/zhengceku/2021-12/01/content_5655194.htm)

(7) Research and Development Bases and Talent Training Programs

According to the relevant provisions of the Program for Deepening the Management Reform of Central Fiscal Science and Technology Plans (Special Projects, Funds, etc.) (December 2014), research and development bases and talent training programs include bases such as national (key) laboratories, national clinical medicine research centers, national engineering research centers, and related talent programs such as the Innovation Talent Promotion Plan.

According to the Ministry of Science and Technology bulletin, with the official announcement of the fourth list of national clinical medicine research centers on May 24, 2019, the first 50 projects to establish national clinical medicine research centers were basically completed. Through academic exchanges, technical training, and network services, a total of 172 appropriate technologies and scientific achievements were systematically disseminated, reaching a cumulative total of 318,900 trained medical personnel. Additionally, 43 science outreach platforms were constructed, and 15 online mobile training applications[68] (apps) were independently designed. According to the Five-Year Development Plan for National Clinical Medicine Research Centers (2017–2021) [in Chinese],[69] by the end of 2021, approximately 100 centers would be uniformly planned and constructed in major disease areas and clinical specialties, while guiding the construction of sub-centers and establishing a series of standardized large-scale healthcare big data platforms and biological sample banks and databases. Furthermore, the plan aims to conduct 20–30 cohort studies with disease populations of over 10,000 people and develop 50–80 comprehensive treatment programs for various diseases. Additionally, it aims to investigate and formulate more than 15 international-level clinical guidelines, strengthen standardized training for clinical research professionals in scientific research design, data management, statistical analysis, quality control, and case follow-up, establish a training model incorporating intensive training (including special training at high-level international medical research institutions), unified review, and qualification assessment, and form large-scale high-level clinical research talent teams.

According to the Management Measures for National Engineering Research Centers [in Chinese][70] (September 1, 2020), National Engineering Research Centers aim to enhance independent innovation capabilities and strengthen industrial core competitiveness and development, based on the National Development and Reform Commission's strategic needs to build an innovation-oriented nation and optimize and upgrade industrial structure. Specifically, these centers are research and development entities established by organizing universities, research institutions, and enterprises with relatively strong research, development, and comprehensive capabilities. According to Article 6 of these measures, one of the centers' main tasks is to cultivate high-level talent for engineering technology research and management. Furthermore, in 2021, the National Development and Reform Commission conducted a reorganization and consolidation to optimize 349 National Engineering Research Centers, resulting in a final arrangement of 191 organizations after rigorous review. Among these, university-led National Engineering Research Centers account for 52 centers, or 27% of the total. Looking at the list of 191 centers by managing organization: Tsinghua University (6), Zhejiang University (4), Peking University (3), Shanghai Jiao Tong University (2), Tongji University (2), Xi'an Jiaotong University (2), Central South University (2), and Huazhong University of Science and Technology (2). These centers

68 Online mobile training clients (software that receives functions and information from other computers or software).

69 "国家临床医学研究中心五年(2017-2021 年)发展规划"
(http://gdstc.gd.gov.cn/msg/image_new/wenjian/2017/12/20171215gz33-02.pdf)

70 "国家工程研究中心管理办法"
(https://www.ndrc.gov.cn/xxgk/zcfb/fzggwl/202008/t20200811_1235816.html?code=&state=123)

serve as one of China's talent cultivation routes in the engineering research field, and through partnerships with organizations such as universities and enterprises, they have focused on cultivating mid- to high-level scientific and technological talent nationwide who possess research capabilities and can link research results with industrialization.

6.2 Current Status of Departmental Funding to Affiliated Institutions

According to the 2020 National Science and Technology Expenditure Investment Statistical Bulletin published by the National Bureau of Statistics, China's research and experimental development (R&D) expenditure continues to show high growth, with investment intensity also growing steadily. However, due to factors including COVID-19, the growth rate of investment slowed, and national fiscal spending on science and technology decreased from the previous year.

In 2020, national R&D expenditure reached CNY 2,439.81 billion, an increase of CNY 224.95 billion from the previous year. The growth rate was 10.2%. This growth rate decreased by 2.3 percentage points from the previous year. R&D investment intensity (investment as a proportion of GDP) was 2.4%, an increase of 0.16 percentage points year-on-year. Per capita expenditure for full-time equivalent R&D personnel was CNY 466,000, an increase of CNY 5,000 from the previous year.

By activity type, national basic research expenditure was CNY 146.7 billion, up 9.8% from the previous year. Applied research reached CNY 275.72 billion, a 10.4% increase year-on-year, while experimental development expenditure was CNY 2,016.89 billion, showing 10.2% growth.

National fiscal science and technology expenditure in 2020 was CNY 1,009.5 billion, decreasing by CNY 62.24 billion or 5.8% from the previous year. Of this, central fiscal science and technology expenditure was CNY 375.82 billion, a 9.9% decrease from the previous year. This accounted for 37.2% of fiscal science and technology expenditure.

The Chinese Academy of Sciences, a department directly under the State Council, had expenditures of CNY 67.1 billion in 2020, of which CNY 28.1 billion was allocated to basic research, CNY 30.3 billion to applied research, and CNY 8.5 billion to various experimental development expenses.

According to the 2021 budget documents (final accounts to be completed by June 2022) published by departments and committees directly under the State Council, research and development expenditure for major departments including the Ministry of Science and Technology, Ministry of Education, Ministry of Finance, and Ministry of Industry and Information Technology showed increases in 2021, though with variations.

The Ministry of Science and Technology's 2021 budget for science and technology expenditure was approximately CNY 53.8 billion, a 12.42% increase compared to the 2020 execution amount. This is primarily due to budget increases for tasks related to scientific and technological basic resource surveys. Additionally, spending for basic research was relatively large, with a 2021 budget of CNY 7.69 billion, representing 14.23% of the Ministry of Science and Technology's total expenditure. This represents a 64.58% increase compared to 2020, primarily allocated to national science and technology innovation base expenditures.

According to the Ministry of Education's 2021 budget, funds allocated for scientific research expenditure were CNY 5.45 billion, of which CNY 3.94 billion was for basic research, CNY 1 billion for applied research, CNY 45 million for scientific fields and services, and CNY 240 million for major science and technology projects.

The Ministry of Ecology and Environment's scientific research expenditure for 2021 was CNY 6.8 billion, with other expenditures including general public services and energy conservation and environmental protection spending.

The Water Resources Department's scientific research funding for 2021 was CNY 3.44 billion, of which CNY 21 million was for basic research, CNY 3.33 billion for applied research, CNY 81 million for science and technology conditions and services (special projects for improving science and technology conditions), and CNY 4.2 million for major science and technology projects.

Through the Ministry of Agriculture and Rural Affairs' mid-term budget compilation for 2021–2023, the 2020 final accounts show that scientific research expenditure for 2019 was CNY 7.846 billion. Of this, CNY 694 million was for basic research, CNY 4.76 billion for applied research, CNY 570 million for science and technology conditions and services, and CNY 1.8 billion for major science and technology projects.

6.3 Current Status of Local Government (Provincial and Municipal) Funding

According to the 2020 National Science and Technology Expenditure Investment Statistical Bulletin published by the National Bureau of Statistics, China's research and experimental development (R&D) expenditure continues to grow, with investment intensity also showing an increasing trend. In 2020, science and technology expenditure from local government finances was CNY 633.68 billion, a 3.2% decrease from the previous year. This accounts for 62.8% of national fiscal scientific research expenditure. By region, eight provinces and municipalities had R&D expenditure exceeding CNY 100 billion: Guangdong Province (CNY 347.99 billion), Jiangsu Province (CNY 300.59 billion), Beijing Municipality (CNY 232.66 billion), Zhejiang Province (CNY 185.99 billion), Shandong Province (CNY 168.19 billion), Shanghai Municipality (CNY 161.57 billion), Sichuan Province (CNY 105.53 billion), and Hubei Province (CNY 100.53 billion). Seven provinces and municipalities exceeded the national average for R&D investment intensity (proportion of regional GDP): Beijing, Shanghai, Tianjin, Guangdong, Jiangsu, Zhejiang, and Shaanxi.

2020 Research and Experimental Development (R&D) Expenditure by Region

District	R&D Expenditure (CNY 100 million)	R&D Investment Intensity (%)
National	24393.1	2.40
Beijing	2326.6	6.44
Tianjin	485.0	3.44
Hebei	634.4	1.75
Shanxi	211.1	1.20
Inner Mongolia	161.1	0.93
Liaoning	549.0	2.19
Jilin	159.5	1.30
Heilongjiang	173.2	1.26
Shanghai	1615.7	4.17
Jiangsu	3005.9	2.93
Zhejiang	1859.9	2.88
Anhui	883.2	2.28
Fujian	842.4	1.92
Jiangxi	430.7	1.68
Shandong	1681.9	2.30
Henan	901.3	1.64
Hubei	1005.3	2.31
Hunan	898.7	2.15
Guangdong	3479.9	3.14
Guangxi	173.2	0.78
Hainan	36.6	0.66
Chongqing	526.8	2.11
Sichuan	1055.3	2.17
Guizhou	161.7	0.91
Yunnan	246.0	1.00
Tibet	4.4	0.23
Shaanxi	632.3	2.42
Gansu	109.6	1.22
Qinghai	21.3	0.71
Ningxia	59.6	1.52
Xinjiang	61.6	0.45

Source: 2020 National Science and Technology Expenditure Statistics Bulletin
(http://www.stats.gov.cn/tjsj/tjgb/rdpcgb/qgkjjftrtjgb/202109/t20210922_1822388.html)

7 Questionnaire Survey on the Mechanism of Discovery and Promotion of the Excellence in China's Research and Development System

The purpose of this survey is to clarify the trends and future prospects of research and development system reform in China, particularly the mechanisms and actual conditions for identifying and promoting excellence in the R&D system, and to further deepen the analysis of science and technology policies to date. To this end, we conducted a survey of experts working on the frontlines of universities, research institutions, research institutions under state-owned central enterprises, research-oriented companies, and corporate research departments to explore the background of China's rapid progress in science and technology and current challenges.

Survey Respondents (in no particular order, honorifics omitted):

ZHU Hongyong	(Deputy Director, China Institute of Atomic Energy)
WANG Shengwen	Professor at the School of Environment, Tsinghua University, and Director of the Environmental Assessment Office, Tsinghua University
XUE Lan	(Professor, School of Public Administration, Tsinghua University; Director of Academic Committee, School of Public Administration, Tsinghua University; Standing Committee Member, China Association for Science and Technology)
JIN Changqing	(Researcher, Institute of Physics, Chinese Academy of Sciences; Chief Scientist of National Key R&D Program Project; Innovation Research Group Leader of National Science Fund for Distinguished Young Scholars, National Natural Science Foundation of China)
LIU Huijuan	(Distinguished Professor at the School of Environment, Tsinghua University; Researcher at the Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences; and Director of the State Key Laboratory)
WANG Zhenpo	(Professor, Beijing Institute of Technology; Director, National Engineering Laboratory for Electric Vehicles)
WANG Wei	(Professor, Institute of Solid Waste Pollution Control and Resource Recovery, School of Environment, Tsinghua University)
MA Weiguo	(Deputy Chief Engineer, R&D Department, Datang Telecom Technology & Industry Group)
WANG Bo	(General Manager and Party Secretary, Marine Chemical Research Institute Co., Ltd.)
YUAN Chengyin	(Director, National Innovation Center for New Energy Vehicles)

1. Are expert and researcher opinions reflected in national policies? Can research funding be freely applied for? Are researchers' intentions respected when submitting project proposals? Are they benefiting from "Strategic Open Recruitment" system (a self-nomination-based recruitment system for innovation project leaders that is not bound by age or position requirements)?

(1) ZHU Hongyong (China Institute of Atomic Energy)

Initial science policy drafts are developed by national department think tanks and their affiliated research institutions. After research institutions affiliated with the Ministry of Science and Technology complete similar proposals, symposiums are organized under the leadership of the Ministry's Strategy Division and Policy Division. These symposiums include participation from other ministry departments of equal standing, the Chinese Academy of Sciences, the Chinese Academy of Engineering, and others, while also gathering external input. This process fundamentally represents a crystallization of expert and researcher wisdom, with national policies advancing under expert and scholarly leadership. Science policies essentially reflect expert and scholar opinions. Scientific research funding applications are fundamentally based on principles of freedom and voluntary participation.

The submission of proposals for scientific research funding is fundamentally based on the principles of freedom and voluntariness. After considering the actual circumstances of their affiliated organization or cooperating entrusted organization—such as research and development capabilities and the degree of industry consolidation—individuals make independent decisions.

The first-time inclusion of Strategic Open Recruitment in the Five-Year Plan primarily addressed existing issues in talent and project selection, evaluation, and review through a unified approach. It was results-oriented and represented a bold measure under new circumstances that emphasized basic technology and crucial core technologies. This deserves encouragement as it can directly benefit specific projects and individuals beyond systemic reform. In the nuclear power field, particularly regarding safety, current scientific and technological progress primarily involves technology absorption and improvement. While innovation and leadership based on these technologies remain relatively limited at this stage, this system provides a good opportunity to encourage young people in the nuclear industry, where seniority traditionally predominates.

(2) WANG Chengwen (Tsinghua University)

The first issue concerns the consolidation of expert opinions. While current national policies have established channels for expert input, these channels primarily target elite and top-tier experts. Many frontline researchers' opinions fail to influence policies, creating a disparity in policy consultation. Issues affecting numerous frontline researchers, including control over scientific research funding, have persisted for more than two decades. A significant problem was that central government and policy attention to frontline researchers' opinions only materialized after several criminal cases occurred, as these issues minimally impacted elite researchers who controlled substantial research funds. Fortunately, major departments, committees, and national institutions have now established supervisory committees. Their methods have become more practical than before, resulting in more flexible and targeted policies. All of this represents social and institutional advancement.

Submission of proposals is fundamentally unrestricted and procedural in nature. Applicants clearly state their own ideas in their proposals. Generally, applicants receive input from their supervisors or the host organization, as well as suggestions from collaborating organizations. However, after consolidating various opinions, the applicant submits the proposal as their own. The applicant's personal views remain central to the process.

Strategic Open Recruitment represents an alternative approach outside the existing system. Following the collapse of the "Four-Only" evaluation criteria (which restricted assessment to papers, positions, academic credentials, and honors alone), a robust evaluation system has not yet been established. Current exploration takes the form of bold pilot programs, with domestic science and technology policies generally aligning with domestic policies. The common thread is a practical reform approach of "two steps forward, one step back," beginning with freedom and gradually strengthening management and systems. As a beneficiary of the current scientific evaluation system, Tsinghua University shows limited enthusiasm, while universities outside the "985" and "211" projects and local research institutions stand to gain substantial benefits.

(3) XUE Lan (Tsinghua University)

From a policy standpoint, the principle of "tolerance and prudence" is emphasized. Through institutionalized policy consultations, experts can provide systematic and comprehensive insights into the inherent and ubiquitous nature of social activities. Expert opinions maintain significant importance in China and are valued by policymakers, as the government absorbs input and makes judgments and appropriate directives through both governmental and non-governmental channels.

Research funding consists of government-allocated funds and project-specific funds. Government-allocated funds are determined by macro-level policies, while project-specific funds are open to independent proposals.

Project proposals are primarily submitted by the applicant based on their own intentions and expertise, accompanied by the required project plans and supporting documents. The judgment of research and development personnel takes priority. While some topics are adjusted according to university and government agreements, these so-called "political assignments" are becoming increasingly rare. Ultimately, the policy of simplifying administration and delegating power, combining delegation and management, and optimizing services (Ch. "fang guan fu") will become the guiding principle for future research activities.

Strategic Open Recruitment is an attempt to adopt a results-oriented approach to promote the evaluation of scientific research activities, aiming to break through existing scientific evaluation systems and inspire enthusiasm for academic activities among research and development personnel, especially young researchers. This represents one direction, and if successful, it could enable breakthrough development in current science and technology system reform. Ultimately, it is more efficient to construct a new building than to renovate an existing one. The implementation of Strategic Open Recruitment can promote major reform measures in scientific research management. Regarding team selection, it can break through the "small framework" of scientific research by selecting talent with a more open attitude. Regarding resource allocation, it shifts from academic-led to needs-led, implementing problem-oriented and needs-oriented approaches. Regarding review and evaluation, it stimulates the initiative of various innovation entities and promotes truly excellent work. Of course, this process requires scientific guidance and a transparent and fair system. My laboratory has not submitted any proposals for such projects.

(4) JIN Changqing (Chinese Academy of Sciences)

Expert opinions serve to add luster to what is already beautiful and, while not changing the mainstream, can function as a foundation and source of forward-looking information.

Currently, all proposals by research and development personnel are submitted under the support of their affiliated organizations. However, due to limited project funding, institutions such as local universities may be ranked by priority during the application process. However, in recent years, the introduction of research funding and systems such as Strategic Open Recruitment and Competitive Project Selection has created opportunities for researchers, even at the general doctoral level, to apply for research funding. However, there is now the issue of "age-35 anxiety." That is, the age of 35 years has become the watershed for scientific research funding. It marks a crucial milestone for applying to several scientific research funding projects and talent programs, including the prestigious Young Scientists Fund and Young Top Talents Support Program. Researchers aged 35–45 years are in a difficult phase, as they find it challenging to compete with professors and experts for regular projects due to qualifications, background, experience, and network connections. In such cases, they must collaborate as members of academic teams.

The Strategic Open Recruitment system provides substantial assistance to young and middle-aged scientific researchers between 35 and 45 years and also presents important opportunities for young researchers within several institutional research organizations.

(5) LIU Huijuan (Tsinghua University)

Expert opinions are incorporated into policy through formal advisory meetings, strategy conferences, and other official research discussions. In China's decision-making process, while relevant leaders with true decision-making power don't necessarily need to be experts in the field, there remains a very high degree of reliance on experts. The opinions of general researchers are increasingly valued, and the elite can reflect their views at the policy-making level through speeches at the Two Sessions (National People's Congress and Chinese People's Political Consultative Conference) and various academic opportunities. Currently, there is a need to further incorporate the opinions of ordinary and frontline young researchers into policy. However, as a professor from Shanghai Jiao Tong University reported to the Ministry of Science and Technology, online and third-party platforms are increasingly emerging, and it is expected that opinions from such informal channels will be increasingly valued by policymakers.

Applying for scientific research funding usually requires negotiations with the designated agency. Some higher research institutions at the "985" and "211" project levels continue to do excellent work in respecting researchers' wishes. However, local universities compete for rankings and funding support, and there have been instances where researchers were tasked with coordinating certain project proposals. The Ministry of Education has since taken steps to address and rectify these issues.

While there are no specific statistics on "posting and hiring" it is clear that young People's enthusiasm for applying is increasing. Three of the doctoral students under my supervision have each submitted proposals for approximately three research topics under the Strategic Open Recruitment system, which has become a significant force in attracting and engaging young researchers.

(6) WANG Zhenpo (Beijing Institute of Technology)

The role of expert opinion has largely been passive in nature. Since the founding of New China, seven science and technology plans have been formulated. For example, when developing plans such as the National Medium and Long-term Science and Technology Development Plan Outline (2006–2020) [in Chinese], strategic research forums were convened with participation from science and technology experts, academicians (i.e., members of the Chinese Academy of Sciences and Chinese Academy of Engineering), and enterprise representatives.

Approximately 2,000 experts participated in the preliminary preparation activities and discussions. Chinese intellectuals can be characterized as having a strong sense of national responsibility and a spirit devoted to pursuing truth. The opinions of general research and development personnel have been reflected through numerous channels. As an example, in 2018, the Ministry of Science and Technology established a column on their portal site titled "Crowdsourcing Opinions and Suggestions for Strengthening and Reforming Science and Technology Management" [in Chinese]. Through this platform, frontline researchers raised various issues including expanding autonomy in scientific research, improving technical evaluation mechanisms, simplifying project funding management, and reducing the burden on R&D personnel—all of which led to steady improvements.

With the exception of certain strict qualifications and conditions, researchers are generally free to apply for scientific research funding. Researchers are responsible for preparing their application documents. Apart from certain applications that must be conducted under academic advisor supervision, those at the doctoral or post-doctoral level are essentially free to apply based on their own initiative. Academic advisor opinions are increasingly treated as reference points. While core elements such as research and development themes, approaches, and outcomes primarily reflect the applicant's own views, advisor cooperation and guidance become more necessary for team composition and personnel allocation due to qualification requirements.

Currently, (we) are not participating in posting and hiring projects. However, in 2022, we may have the opportunity to participate in the competition for Beijing Automotive Industry Corporation New Energy Vehicles' (BAIC BJEV) inspection measurement and management system project. Since we can secure funding support, we are primarily considering an industry–academia–research platform with enterprises, which would also have significant implications for the conversion of scientific research outcomes.

(7) Wei Wang (Tsinghua University)

In 1986, the Chinese government launched administrative system reforms with "Scientific and Democratic Policy-Making" as a primary goal. Leadership presented guiding opinions to improve information and intelligence support systems for policy decisions while encouraging the role of experts and scholars in policy-making, which sparked enthusiasm among experts and scholars to participate in public policy formulation. At present, there are many channels through which expert opinions can reach national policy. In addition, there are two effective methods. One is publishing documents and making policy proposals through Internal Reference materials of the Ministry of Science and Technology or the State Council. This is the most direct channel. Internal Reference materials are not made public and are read only by a small number of power elites. Since some experts are aware of frontline scientific research conditions, their analysis of certain issues is sufficiently insightful to attract leaders' attention. Another channel has emerged in response to the needs of the times alongside the development of a diverse society: an indirect participation channel where experts promote influence on public opinion through public media to advance policy agenda setting. Moreover, government agencies have also begun to proactively seek expert opinions through active and open formats such as symposiums and hearings, and it is believed that expert opinions are being conveyed relatively smoothly to policymakers.

While master's and doctoral students are also researchers, their status as students means their research funding typically comes through academic supervisors and various scholarships. It is very difficult for students to submit proposals; however, postdoctoral researchers, professors, and other researchers still have considerable autonomy when applying for research funding or research projects.

Beyond the fixed-format requirements, the main components of a proposal, such as the research topics and technical approaches, generally respect the intentions of the applicant.

The Strategic Open Recruitment system targets major technological needs and tests results through market mechanisms. As important institutional content for improving and supplementing the current mechanism, it carries both strategic importance and practical guiding significance. At present, while Tsinghua University's School of Environment has relatively little involvement, the science and engineering schools participate in more projects. Particularly in many projects where local governments seek to attract high-tech talent through projects, Tsinghua University is selected relatively frequently.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

There are certain restrictions to this, and not all opinions can be incorporated into policy. Filtering and screening by research institutions and advisory bodies directly under each ministry and commission (government ministries) is necessary. The direct advisory bodies of ministries and commissions conduct reviews and provide advice from strategic and global perspectives, submitting policy proposals. The degree to which expert and researcher opinions are reflected at the decision-making level varies according to the views of institutions under these ministries and commissions. However, to date, everyone's evaluation of the leading and scientific nature of policies, especially their appropriateness in adapting to China's national circumstances, remains very high.

As long as strict conditions such as age and academic background are met, the application for scientific research funding is fundamentally open to anyone.

The Strategic Open Recruitment system was formally implemented at the national level in May 2021, with the Ministry of Science and Technology working on comprehensive pilot projects. The basic national policy positions scientific research institutions as the main force, fulfilling pilot project and guidance roles. Furthermore, while state-owned enterprises take the lead in demonstration roles and private enterprises participate in pioneering roles, government departments need to take the initiative in organizing and coordinating work. While this is the system's blueprint, at this stage there are issues such as information asymmetry, problematic channels, and incomplete organizational systems. At the enterprise level, they follow national policy.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

Chinese policy remains very pragmatic, and since there are no successful reform models to follow, many policies are problem-oriented. In the problem-oriented approach, existing issues are focused upon and elevated, leading to highly targeted measures. This is what experts should do as a matter of course. Policy formulation has key points for general opinion collection, and strong opinions from general researchers are also incorporated and elevated into policy. While policymakers may not be industry experts, the system allows industry expert opinions to be elevated to and implemented as policy. These are the main characteristics at the current stage.

Overall, the application process is essentially unrestricted. The organization to which the applicant belongs may impose requirements on research and development personnel, such as setting up laboratories, recruiting graduate students, and managing expenses. Depending on the circumstances, they may also provide specific input to applicants.

Proposals for research and development projects are fundamentally completed by the applicants themselves, based on their own preferences, by detailing the research topics, technical approaches, and task plans. While academic issues require guidance from academic supervisors and others, the applicants themselves make final decisions.

At present, there is no designated theme for Strategic Open Recruitment. The beneficiaries of this policy are young researchers at universities and R&D institutions. Under the previous "Four-Only" system of evaluation criteria (which restricted assessment to papers, positions, academic credentials, and honors alone), age and publication count have restricted many selection possibilities. Currently, results-oriented research projects with clear objectives are not only stimulating researchers' enthusiasm but also providing excellent opportunities for them to distinguish themselves. Qingdao City has established the Zhihu Langu Valley Strategic Open Recruitment[71] project base, which commenced exploration and implementation in early 2021. All projects employ the posting and hiring methodology. To date, nearly 300 projects have been announced, with 61 collaborative projects established and total contract values reaching CNY 127 million. As an evaluation and assessment organization, we participated in the project review process. We consider it highly innovative, offering numerous learning opportunities not only in solving technical challenges but also in the industrialization and transformation of scientific and technological achievements.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

The government places significant emphasis on input from experts and R&D personnel. I am affiliated with two departments: the National New Energy Vehicle Technology Innovation Center and the China Automotive Chip Industry Innovation Strategy Alliance. Both were established under the oversight of the Ministry of Science and Technology, the Ministry of Industry and Information Technology, and the Beijing Municipal Government. The two departments regularly submit work reports, and all members' opinions are conveyed to government policymaking bodies. Furthermore, the Ministry of Science and Technology and the Ministry of Industry and Information Technology have assigned resident experts to ensure both sides' views are reflected in a timely manner. These two organizations comprise domestic automakers, including BYD and Geely. In upstream operations, they collaborate with battery manufacturers NING Deshidai (Contemporary Amperex Technology) and Hefei Guoxuan High-tech Power Energy. In the intelligent technology sector, they work with Baidu, while in automotive safety, they partner with Qihoo 360. For downstream business operations, they maintain a cooperative relationship with DiDi. Collaboration beyond the automotive sector includes partnerships with entities such as China Petrochemical Corporation. The organizations also encompass research and development institutions and educational institutions, including Tsinghua University, the Chinese Academy of Sciences, the China Automotive Technology and Research Center, other universities and research institutions, as well as certain capital partners (investment funds). Since these two organizations encompass experts from virtually every sector of the industry chain, the government can gather opinions and proposals on a larger scale and within the scope of policymaking.

Applications for scientific research funding are unrestricted. As long as there is a host organization and the relevant qualifications are met, proposals can be submitted freely.

We are stakeholders and beneficiaries of the Strategic Open Recruitment system. Previously, the challenges faced by social organizations at the national forefront primarily targeted research and development institutions and universities

[71] Langu Valley is a geographical name referring to an industrial park established by the Qingdao City Government in Shandong Province in 2016 to promote marine technology R&D and the application of research outcomes. Zhihu Langu Valley signifies the concentration of advanced technology and technical application expertise in Langu Valley. Zhihu Langu Valley Strategic Open Recruitment refers to a competition launched in October 2021, jointly conducted by multiple public research institutions, national key laboratories, and Shandong University, among others. It announced technical requirements and cooperation projects to research institutions nationwide to promote marine technology research, development, and results application. The initiative aims to establish China's largest marine technology innovation base. The initiative aims to establish China's largest marine technology innovation base.

within the system, with few opportunities for collaboration with enterprises and private research institutions. However, now the Strategic Open Recruitment system enables the integration of capabilities across the industry chain, including private enterprises and scientific research institutions, while maximizing industry chain integration and generating promotional effects. In 2022, the National New Energy Vehicle Technology Innovation Center plans to implement Strategic Open Recruitment in the areas of basic software (EDA), basic materials, and process equipment, announcing three to five scientific research projects to the broader society, with an expected investment of approximately CNY 8.7 million.

2. Regarding funding applications: Do researchers receive sufficient support from the host organization, and are the administrative procedures for applying for and managing research funding not overly burdensome for carrying out the research? Are researchers benefiting from the Green Channel (simplified procedures)?

(1) ZHU Hongyong (China Institute of Atomic Energy)

Our organization primarily conducts research projects within or receives funding from our group (China National Nuclear Corporation). Due to this close relationship and frequent collaboration, we receive substantial support from the group.

Administrative burden used to be a significant challenge, but the situation has been improving gradually. Several improvements have been implemented: during budget preparation, only basic cost estimates are now required; budget templates are provided; and there is no longer a need to submit detailed calculation standards for indirect costs. The Science and Technology Progress Law, which took effect in 2022, elevates several existing pressure-driven policies to legal status, suggesting this issue may continue to see gradual improvement in the future.

The Green Channel was initiated by Premier LI Keqiang to reduce administrative burden on scientific researchers, though specific operational indicators and guidelines have not been established. However, many of the country's leading scientific research institutions, including the Chinese Academy of Sciences, handle the entire process from applying for funding to its utilization as part of their practical operations. Speaking personally, I hope this policy will be given an official slogan in the future, implementation regulations will be introduced, and its scope will expand both horizontally and vertically.

(2) WANG Chengwen (Tsinghua University)

This support functions as a reciprocal relationship, with host organizations maintaining their own expectations of research personnel. Requirements exist for all aspects, including attribution of scientific research outcomes, screening of collaborative teams, and publication of collaborative results. Under these same conditions, host organizations provide maximum support for administrative procedures and integration of scientific research resources. Situations have arisen where representatives of local universities travel to Beijing to submit project proposals. Following the 18th National Congress of the Chinese Communist Party, as regulations against socially unjust practices became more stringent, these issues have seen substantial improvement.

Prior to the introduction of policy refor ms aimed at improving the management of central government research funding, several unscientific and impractical elements existed in the system. For instance, many national-level projects required the completion of an "expenditure budget" before any actual research could begin. This essentially amounted to "forecasting," as researchers were required to calculate precise costs for various future project expenditures before initiating their research work. The management approach for scientific research funding employed an oversimplified methodology that failed to adequately account for the fundamental differences between social sciences and natural sciences. The system overlooked the fact that social science projects such as planning design, consulting services, and archaeology require substantial personnel input and associated labor costs. It is natural that the new financial expenditure management system has shifted from process-oriented to results-oriented approaches, leading to the simplification of various procedures. Numerous policies were issued in the latter half of 2021, and many research and development projects starting in 2022 may benefit from these changes.

The Green Channel policy in scientific research began with pilot projects at universities in 2018. While individual projects have not directly benefited, according to faculty at the School of Environment, the system has been highly effective. The "one-time submission" system for documentation has reduced administrative burden by combining financial and technical inspections and decreasing the frequency of inspections. This system has also shown notable effectiveness in industry–academia–research cooperation during emergency scientific and technological research projects for COVID-19 prevention and control in recent years. Specifically, streamlining the procedures for submitting proposals and initiating projects, while adopting a "rear-end scientific research + front-end practice" implementation model to address critical issues, represents an institutional advantage. It is expected that this approach will be promptly advanced within the broader post-pandemic context.

(3) XUE Lan (Tsinghua University)

The Host Organization System (依托組織制度) is an important administrative framework established under the Regulations of the National Natural Science Foundation of China [in Chinese].[72] At the proposal stage, where the primary focus is on reviewing documents, support does not pose an issue.

The complexity of administrative and financial reporting procedures has faced consistent criticism over the years. The publication of "Opinions on Reforming and Improving the Management of Central Fiscal Scientific Research Funds" [in Chinese][73] has addressed these challenges by streamlining and merging budget categories. Through the implementation of one-stop services managed by scientific research administrative departments and the digitization of numerous approval processes, the shift toward paperless administrative procedures has successfully reduced researchers' workload.

The Green Channel has achieved the most benefits in project implementation, specifically through two types: the Green Channel for project launch verification[74] and the Green Channel for interim inspections. The Green Channel for project launch verification applies to major research achievements that have had widespread impact and exempts them from going through the project launch verification phase. The Green Channel for interim inspections refers to special projects with major research achievements that have had widespread impact during the project execution period and exempts them from the interim inspection review phase. However, a self-evaluation report must still be submitted. The exemption criteria vary by research and development organization. The Chinese Academy of Sciences takes a relatively lenient approach. This serves as one method of attracting talent.

(4) JIN Changqing (Chinese Academy of Sciences)

The level of support varies by research institution and cannot be generalized. In recent years, after the number of project proposals became an evaluation metric for some universities, support for universities has significantly expanded. This has led to undesirable competition, with situations arising where university leaders personally intervene to secure project approvals. While administrative procedures have long faced criticism, the burden has

72 "国家自然科学基金条例"(https://www.nsfc.gov.cn/publish/portal0/tab471/info70222.htm)

73 "国务院办公厅关于改革完善中央财政科研经费管理的若干意见" (http://www.gov.cn/zhengce/content/2021-08/13/content_5631102.htm)

74 "Project launch verification" refers to the process of evaluating a project's feasibility and validity from scientific and regulatory perspectives during the launch phase within the research institution.

gradually decreased, with particular improvements in areas such as procedure integration and consolidated reporting of self-use expenditure details.

The Chinese Academy of Sciences needs to take the lead in implementing the Green Channel system. This is part of the "streamlining administration, delegating power, and optimizing services" reform, which, after gaining recognition across various sectors, gradually spread to other research institutions. From personal experience, the system remains highly efficient, especially regarding project planning, where domestic and international awards can eliminate many verification requirements. In projects I have personally participated in, this saved at least one-third of the time. The same applies to other procedures.

(5) LIU Huijuan (Tsinghua University)

This creates a mutually beneficial relationship in which host organizations actively provide support. However, instances of excessive support have emerged, leading to situations where relationships with applicants become unbalanced.

The State Council issued and implemented policies laid out in "Opinions on Reforming and Improving the Management of Central Fiscal Scientific Research Funds" [in Chinese], resulting in reduced time requirements for procedures and management. The entire process, from budget formulation through fund allocation and usage to auditing and oversight, has been streamlined to unprecedented levels. Notably, the simplified budget preparation process has cut required time by approximately half. This represents a highly practical policy measure.

The Green Channel began pilot programs in 2018, with efforts focused on widespread adoption. The Research Center for Ecology of the Chinese Academy of Sciences became one of the pilot organizations for expanding autonomous authority over expenditure use. This authorization allowed them to utilize indirect costs as performance incentive funds, which resolved significant challenges while enhancing flexibility and improving research efficiency.

(6) WANG Zhenpo (Beijing Institute of Technology)

Beijing Institute of Technology continues to provide meticulous support and oversight for various project funding applications, with particular emphasis on the quality control of application documents. The university's academic committee organizes and guides expert groups to advance these initiatives. This level of activity is uncommon among other universities and research institutions.

Administrative procedures have been substantially streamlined through reforms, with many processes now handled through digital and online application systems, representing a quantum leap in quality compared to several years ago.

One aspect of Beijing Institute of Technology's Green Channel system involves expanded autonomy in scientific research fund utilization combined with a post-implementation reporting system, an approach that has gained widespread acceptance. Given that uncertainty and unpredictability are inherent characteristics of scientific research activities, the previous system of advance budgeting was clearly impractical. Through its Green Channel system, Beijing Institute of Technology has circumvented these inflexible regulations and harnessed the enthusiasm of all participants. The return to principles that align with the fundamental nature of scientific research represents a genuine step forward in reform.

(7) WANG Wei (Tsinghua University)

While the application's initial period and management process have been sufficiently proactive and satisfactory, there are several special circumstances to consider. One of the postdoctoral researchers I supervise submitted a proposal over a year ago and has since signed a contract with a new research institution. However, this involves the issue of transferring their research topic, and the university has not provided procedural support. Furthermore, there is a policy gap in this area, highlighting the need for improvement.

The conflict between scientific research uncertainty and expense management systems has become particularly prominent since 2000. The main reason is that the pace of scientific research system reform has not kept up with the speed and depth of basic research and frontier exploration. There have even been cases where research and development personnel became involved in criminal cases due to issues with expense reporting. Along with the deepening of reforms over these 20 years, particularly from the perspective of a general framework emphasizing basic research, there has been parallel exploration of systems such as the "Comprehensive Funding System"[75] and Strategic Open Recruitment. Within the existing framework, the central government continues to reform and enhance its scientific research funding management policies, with notable improvements in procedural matters and spending authority. Through budget consolidation and other measures, the overall administrative burden has been significantly reduced, giving researchers more flexibility in how they allocate their funds.

The research management Green Channel has simplified expense reporting procedures and permits a portion of direct costs to be allocated for performance-based compensation. Though Tsinghua University allocates only 20 percent for this purpose from its basic project funding, these resources enable the hiring of at least three research assistants. In my personal observation, this has enhanced both the administrative and utilization efficiency of research funds.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

Competition is fierce among exceptional teams within supporting organizations. Teams possessing specific research capabilities and academic networks have attained certain levels of support, receiving backing through channels not explicitly outlined in policy. For example, this manifests in coordination between prestigious universities and established research teams. At this stage, researchers who lack sufficient capabilities may find their support withdrawn. However, this process remains manageable for applicants. Ultimately, the arrangement benefits both parties.

In the past, budget planning, expense utilization, and application processes were complex, with strict controls severely limiting operational freedom. Recent reforms have streamlined these processes. While documentation still follows templates, the increased digitalization and online processing have significantly reduced operational strain and inconvenience.

Numerous special policies under the Green Channel framework have become widespread. The Green Channel began as a pilot project policy and, due to its success, has been implemented broadly. Consequently, what were once Green Channel policies have become standard practice, and the term "Green Channel" is now rarely used.

75 The Comprehensive Funding System (包干制, baogan zhi) establishes a total budget without requiring detailed line-item budgeting. This allows research and development personnel to allocate and categorize expenses according to actual needs during the research process, while still adhering to regulations. This system effectively reduces the administrative burden on research and development staff. This system was first mentioned in the 2019 Government Work Report.
(Reference: http://www.gov.cn/zhengce/2021-07/29/content_5628134.htm)

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

Regarding the functions of supporting organizations, one can refer to the Management Measures for National Natural Science Foundation Host Institution Fund Work [in Chinese][76] and Opinions on Further Strengthening the Management of Science Fund Work at Host Institutions by the National Natural Science Foundation Commission [in Chinese].[77] Research and development personnel seek assistance from their host organizations with procedural matters. At my organization, research and development personnel face challenges with budget preparation, though they receive support from specialized staff and departments in document preparation. A transition from research management to research services is underway, but the primary issue remains the quality of research management personnel, making it necessary to improve service quality.

At present, administrative procedures do not represent a significant burden. The university employs dedicated staff for both financial and procedural matters, with their costs covered by university administrative funds. Even when a project stalls, the administrative procedures typically do not impose a substantial burden.

The Green Channel system has proven highly effective for project initiation. The Marine Chemical Research Institute can waive project initiation reviews and implement direct registration for projects meeting either of these criteria: winning provincial or ministerial-level scientific research competitions or having evaluation participation from prestigious universities listed under Project 985 or Project 211. The institute has also implemented a streamlined process where both funding assessments and outcome acceptance are completed in a single review round. As a scientific and technological enterprise under China National Chemical Corporation Limited, the Marine Chemical Research Institute traditionally required extensive procedural steps for project initiation, with most scientific research projects taking over six months to process. However, with the implementation of the Green Channel system, this timeline has been reduced to one week, enabling direct reporting and approval from the headquarters' scientific research department.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

For research projects primarily funded at the enterprise level, the applicant's individual competence and academic abilities may be required. However, even more important is the applicant's academic experience and expertise in the core aspects of the research. The host organization provides supplementary support regarding formal requirements and procedural matters. Government-funded national projects demand more than just individual academic capabilities—they require a comprehensive understanding of the industry and field, the ability to coordinate academic resources within the discipline, and specific social competencies. For these projects, host organization support plays a vital role. In this regard, the host organization continues to actively support the entire process, from the announcement of the project to proposal submission and subsequent presentations. Therefore, the platform's coordinating ability becomes an important reference indicator based on the (high level of) capability of the affiliated organization, leading to competition in providing support to applicants.

The reform process has been thoroughly implemented, encompassing everything from budget streamlining to the establishment of financial support systems for scientific research. While the administrative burden on researchers has

76 "国家自然科学基金依托单位基金工作管理办法"(https://www.nsfc.gov.cn/publish/portal0/tab475/info70264.htm)

77 "关于印发《国家自然科学基金委员会关于进一步加强依托单位科学基金管理工作的若干意见》的通知"(https://www.nsfc.gov.cn/publish/portal0/tab442/info74694.htm)

already seen significant reduction, it continues to decrease further through the implementation of contract systems and the transition to networked paperless operations.

The Green Channel system represents a transitional policy during the reform period that delegates authority downward to R&D personnel. Many current policies have emerged as an evolution of this system to a more advanced level. This fundamental improvement in delegating authority to R&D personnel has effectively shifted R&D leadership from administrative control to the researchers themselves. The research and development institution at Beijing Automotive Group Co., Ltd. had already implemented even more progressive methods than the Green Channel system to reduce the burden on their R&D personnel. The scientific research financial support system has undergone pilot testing at institutions including the Chinese Academy of Sciences and Beijing Automotive, which can be considered early beneficiaries of the Green Channel system.

3. Is it easy to submit funding proposals for ambitious research topics? Does the environment accept research-related risks (including the possibility of failure)? Additionally, are researchers held accountable for failures?

(1) Hongyong ZHU (China Institute of Atomic Energy)

This question cannot be answered in general terms. Within China, there is relative tolerance for proposals of this nature. Scientific themes fall into two categories: qualitative and quantitative. With qualitative themes, the methodology serves as the primary focus, making failure difficult to define. Quantitative themes, while results-oriented and subject to results scrutiny, do not lead to accountability measures—the process undergoes logical verification only.

(2) WANG Chengwen (Tsinghua University)

Innovation within the academic research process can be understood as a process of trial and error. Reforming evaluation mechanisms for innovation-oriented research constitutes a form of systems engineering that necessitates leveraging the functions of academic communities and peer review evaluation. The "Guiding Opinions of the General Office of the State Council on Optimizing the Academic Environment" [in Chinese][78] explicitly advocates for establishing a tolerant academic environment and an atmosphere that deliberately accepts failure as a means to achieve more innovation-oriented research outcomes. The current ranking incentive system has undergone improvements, with ongoing discussions regarding ranking criteria proposals for various funds, including the National Natural Science Foundation of China. A key emphasis in these discussions is on the requirement that future peer reviews must emphasize internal academic community norms. Scientific research progress can be recognized when academic research content and methodologies receive peer review approval and align with academic community standards.

(3) XUE Lan (Tsinghua University)

Submitting proposals for ambitious topics is relatively unrestricted, which represents a fundamental guarantee of academic freedom.

The "Opinions of the State Council on Comprehensively Strengthening Basic Scientific Research [in Chinese] (2018)[79]" specifically addressed the necessity of establishing innovation-oriented mechanisms that embrace failure tolerance. Currently, the implementation of scientific and technological innovation and fault tolerance mechanisms extends across multiple sectors, fostering coordinated promotion among scientific and technological management, judicial, accounting, and financial departments, as well as organizations implementing scientific and technological projects. However, a persistent challenge has emerged: interdepartmental coordination and advancement remain insufficient due to limited shared channels for information and communication regarding the oversight, inspection, and auditing of scientific and technological projects between relevant departments. In response to the state's heightened investment in and prioritization of basic research, questions have surfaced concerning the establishment and implementation of related systems. The Chinese Academy of Sciences is set to launch a pilot program this year

78 "国务院办公厅关于优化学术环境的指导意见"(http://www.gov.cn/zhengce/content/2016-01/13/content_10591.htm)

79 "国务院关于全面加强基础科学研究的若干意见"(http://www.gov.cn/zhengce/content/2018-01/31/content_5262539.htm)

implementing fault tolerance mechanisms in fundamental academic disciplines, including mathematics. The outcomes of these programs may potentially lead to policy-level elevation and nationwide implementation.

(4) JIN Changqing (Chinese Academy of Sciences)

The approach to proposing ambitious research projects typically differs from person to person. Some distinguished experts actively encourage their students and junior colleagues to pursue ambitious research while serving as advisors who oversee various aspects, including stakeholder interests and professional reputation.

Regarding fault tolerance mechanisms and accountability, I believe establishing a credible system of rewards and penalties founded on integrity must be the first step. If such a system cannot be properly established and implemented, there exists a risk that fault tolerance provisions could be misused. While the supervision and inspection of scientific research processes and outcomes maintain relatively comprehensive coverage, we must accept the possibility of errors in certain qualitative and methodological issues that defy clear explanation, provided these occur within the framework of a trustworthy integrity-based system.

(5) LIU Huijuan (Tsinghua University)

At present, qualitative analyses of national-level research projects predominantly emphasize process over results. This approach leads to a relatively ambiguous definition of errors in this context. The quantitative analysis of research projects does not merely determine success or failure but instead seeks to establish process-based accountability.

At the enterprise level, research projects and many recent Strategic Open Recruitment research initiatives tend to demonstrate a stronger results-oriented focus. These projects typically include clear stipulations regarding financial risk-sharing and outcome accountability, presenting researchers with a distinct type of challenge.

The existing accountability framework primarily evaluates researchers based on their integrity, credibility, and adherence to proper processes, while maintaining a more lenient approach toward final outcomes.

(6) WANG Zhenpo (Beijing Institute of Technology)

Submitting research proposals for ambitious research projects is relatively simple and depends mainly on the initiative of the applicant. The evaluation process for several ambitious research projects has seen improvements. At universities and other institutions, innovative research activities tend to focus exclusively on technological aspects, particularly emphasizing the advancement of technical parameters and indicators. However, there is inadequate understanding of market needs and discipline, along with serious deficiencies in the evaluation process. The classification evaluation and reform efforts currently underway promote diverse evaluation approaches and classification assessments while incorporating market and financial elements. These measures are essential for addressing current deficiencies, and their immediate implementation and practical application is desired. Failure of scientific research results is still very tolerated, including projects at the international level and some research projects within universities, where clear revised opinions and target demands are presented at the end of a project and when results are evaluated, and basically, the objective situation of the project executor is also taken into account.

(7) WANG Wei (Tsinghua University)

Submitting research proposals is unrestricted. For research projects primarily funded by corporations and those undertaken by private institutions, risk management is relatively feasible. Contracts specifically stipulate potential failure scenarios and their consequences, with all scope and grounds for accountability implemented under legal conditions acceptable to scientific researchers. Currently, the most controversial issues concern government-sourced funding, particularly involving fiscal funds and investment funds from state-owned enterprises. This area remains ambiguous, given the absence of unified standard guidelines. At the Two Sessions (National People's Congress and Chinese People's Political Consultative Conference) in March 2021, CPPCC members proposed testing non-standardized review methods during the pre-project screening phase, including discretionary reviews, cross-reviews, and favorable reviews. The proposal also included implementing classified investment, diversified investment, and phase-based investment during the project investment stage, while establishing science and technology innovation "fault tolerance" mechanisms during the project execution stage, such as transition mechanisms between old and new schemes and exit mechanisms. The Law of the People's Republic of China on Progress of Science and Technology (Amendment Draft) [in Chinese], which was deliberated during the 13th meeting of the 13th National People's Congress in August 2021, incorporated a "fault tolerance" mechanism for scientific research activities. The law explicitly states, "The State shall encourage S&T personnel to explore freely and dare to take risks, creating a good atmosphere that encourages innovation and tolerates failure. Where original records and so on are able to prove that S&T personnel who take on highly exploratory and risky S&T R&D projects have performed their duties diligently but they are still unable to complete such projects, they shall be exempt from liability." The timing of this policy incorporation is very appropriate, and specific follow-up policies may emerge in the future. This remains a guideline, and it is possible that the level of tolerance will continue to expand, potentially generating greater enthusiasm for participation in ambitious projects.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

The proposal submission process itself is not an issue. The current challenges concern review criteria and outcome certification. While domestic industrial chains are comprehensive and fully developed at scale, critical issues have emerged. This means that under the present mature but low-level scientific research standards, everyone continues to pursue efficiency repeatedly. However, the research and development environment for innovation-oriented research projects remains inadequate. China has become acutely aware of this through its confrontation with the United States and is making timely policy adjustments. Reports indicate that the Ministry of Science and Technology is expected to launch Disruptive Technology Innovation special priority projects within the key research and development programs during the 14th Five-Year Plan period. The ministry intends to take the initiative in strategically prioritizing potentially crucial technological fields, including electronic information, artificial intelligence, future communications, and virtual reality. Furthermore, the Science and Technology Innovation 2030 – "Next-Generation Artificial Intelligence" Major Project[80] [in Chinese] will implement a trial program for the Principal Scientist Liability Exemption System. New evaluation and support systems will be adopted to address innovation-oriented research projects. With recognition and implementation at the national level, these issues are expected to see further improvement through institutional guarantees and guidance.

80 http://gdstc.gd.gov.cn/attachment/0/429/429490/3344234.pdf

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

Evaluating and assessing ambitious research projects and frontier academic issues is difficult. While the barrier to submitting proposals is not particularly high, there remain many points of contention during the review phase.

The experts who review such research projects must possess extensive knowledge and a high level of international perspective and experience. However, even for specialists, it is challenging to comprehensively track and evaluate all activities. It is difficult to determine whether project failures stem from the inherent uncertainties of scientific research or from problems with research methodology or execution errors. Furthermore, implementing the science innovation "fault tolerance" mechanism involves multiple departments and requires cooperation among various sectors including science and technology management, judicial, audit, and financial departments, as well as the departments implementing science and technology projects. This remains an ambiguous area, and judgments in these unclear aspects are based on national guidelines and policies. This remains an ambiguous area, and judgments in these unclear aspects are based on national guidelines and policies. Currently, the Chinese government encourages scientific and technological innovation while promoting young researchers to tackle innovative research projects through systems such as Strategic Open Recruitment and Competitive Project Selection. From an accountability perspective, aside from extreme cases such as clear academic misconduct or misappropriation of funds, researchers are not held responsible for specialized issues related to academic direction.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

Submitting research proposals for these types of projects is relatively straightforward. Both national and local governments consider the establishment of fault tolerance mechanisms in science and technology innovation to be a crucial element in implementing innovation-driven development strategies. However, the fault tolerance mechanism system for science and technology innovation remains inadequate. The boundary criteria and related institutional arrangements are insufficient, making it difficult to establish scientific parameters for what constitutes acceptable mistakes. Moreover, the supervision and disciplinary mechanisms for maintaining scientific and technological integrity and credibility are incomplete. This situation increases the risk of moral hazard in scientific research activities and, consequently, makes implementing fault tolerance in science and technology innovation more challenging. As a result, in the current phase, accountability measures for research entities primarily focus on the use of funds and clear mistakes, while there is comparatively little scrutiny of technological pathway selections and the fulfillment of research responsibilities. Research projects that take on challenging problems are generally viewed with greater tolerance.

4. In recent years, there is a perception that China is exercising a certain flexibility in implementing policy modifications and changes. How does this process work? Are policies that emphasize research based on the new concept of "zero to one" playing an important role in how research topics are selected and implemented in the field?

(1) ZHU Hongyong (China Institute of Atomic Energy)

The Standing Committee is a key organization in the context of policy decisions. Its authority is relatively significant in policy-making not only at the national level through the Ministry of Science and Technology, but also within departments at provincial, city, and county levels, allowing for rapid policy decisions and revisions.

With the new "zero to one" policy approach, the country is emphasizing the connection between originality and basic research. The aim is to resolve technical problems that have hit roadblocks due to issues like the neglect of several long-term accumulation projects and systemic challenges. This has two directions, and the top-down approach will also be an important direction for future scientific research. The next step is to establish evaluation criteria at the micro level and develop talent. Related to this, our parent company, China National Nuclear Corporation, has made strategic moves in research and development, achieving its goal of combining originality with forward-looking technology in nuclear power generation. This is exemplified by the independently developed third-generation nuclear power technology "Hualong One" [in Chinese], fast reactor test facility, and high-temperature gas-cooled reactor.

(2) WANG Chengwen (Tsinghua University)

They first implement pilot programs that break through existing legal and institutional frameworks by adopt ing experimental promotion methods within a limited scope. Based on the results of these pilot programs, they make swift adjustments and elevate them to the policy level (this is China's approach). The domestic decision-making system is fundamentally based on decisions by elite politicians, which makes the process more flexible and rapid.

This has two main impacts. The first is an increase in basic research topics that require exploration. As basic research topics in mathematics and physics increase, interdisciplinary research topics grounded in fundamental academic fields are also growing. Recently, there has been a marked increase in topics that combine applied chemistry and environmental protection at schools of environmental studies. The second impact involves not just comparing the latest scientific research outcomes and trends but selecting technical pathways for research topics. To explain and analyze the feasibility and scientific merit of technical approaches from the perspective of fundamental academic fields, we need to focus on scientific principles and increase the involvement of basic science teams in project groups. This has emerged as one of the new trends in research grant applications.

(3) XUE Lan (Tsinghua University)

Since the reform and opening up period, China's science and technology policy mechanism can be characterized as a diverse policy mechanism led by administration. Under this mechanism, senior and lower levels of government maintain specific roles and operate through division of labor, with certain factors accelerating the formation of policy mechanisms. The government has enhanced its capacity to reform the acquisition of knowledge and information, thereby establishing micro-level mechanisms including policy experimentation, policy dissemination, and the incorporation of intellectual elites. Problems with policy mechanism misalignment arise when there are mismatches between administration-led mechanisms and policies in market or social sectors. Thus, in practice, they have considered building intermediate bridges between top-level design and grassroots exploration, flexibly employing three types of policy mechanisms within the same key reforms. Adaptive measures bring institutional advantages to policy mechanisms and can enhance governance efficiency. In this way, the current institutional system has been established with both strategic and flexible capabilities.

Policy emphasis functions as a form of guidance that specifically needs to be implemented at the micro level through five major scientific research programs and various research projects.

(4) JIN Changqing (Chinese Academy of Sciences)

This could be considered a Chinese institutional advantage. While China is not a case law nation, there are instances where precedents matter. Throughout its reform process, China's emphasis on practical implementation and exploration of actual progress has led to policies that must keep pace with rapidly evolving situations. This process is fundamentally one of democratic centralism; after gathering expert opinions within a limited scope, leaders make decisions, which allows subsequent steps to proceed very quickly.

The new "zero to one" approach impacts two areas: people and projects. Regarding personnel evaluation, it further breaks from the representative evaluation system using the "Four-Only" evaluation criteria, and after moving away from "papers only" and "SCI supremacy," it has proposed solutions for how to restore balance to these disrupted relationships. In terms of projects, there has been longstanding criticism about the intense and unstable competition for basic research funding. Many researchers believe this has created a bottleneck that restricts originality in basic research. This approach enables the formation of continuity in basic research.

(5) LIU Huijuan (Tsinghua University)

Chinese policymaking proceeds through elite decision-making and incremental models. In China, the absence of differentiation in levels of socialization means that the interests of all social strata are reflected in the social structure. This makes it impractical to implement either collective or institutional decision-making systems in which decision-making groups would balance the interests of all societal layers. The system is fundamentally an elite centralized decision-making model that combines top-down and bottom-up approaches to gather input. Within this system, political power elites support scientific research institutions in presenting relevant opinions and proposals. Social interests identified through rapid analysis, research, and investigation, along with their methods of promotion, are incorporated into public policy. This swift and efficient decision-making approach has the potential to yield high efficiency in decision-making and policy adaptability. This can be characterized as a moderate approach that successfully combines rule by man and rule by law.

Historically, basic research has suffered from a clear lack of funding, with limited revenue streams from either research outcomes or their commercialization. State guarantees and incentives for dedicated research have been notably insufficient, resulting in prolonged financial hardship where scientists committed to methodical research could only expect minimal returns. Consequently, most researchers began gravitating toward projects that would produce quick results, focusing on paper follow-ups, duplications, and compilations, as well as research topics requiring minimal investment while generating short-term returns. This led to a decline in researchers who would either continuously pursue specific research topics or conduct intensive research. Looking ahead, as basic research projects increase and funding for basic research grows steadily, researchers selecting research topics will not only be more likely to engage in time-consuming basic research with uncertain outcomes but will also dedicate more effort to basic research projects such as field surveys and data collection. This policy direction will have a significant impact on the trajectory of scientific research.

(6) WANG Zhenpo (Beijing Institute of Technology)

China operates within a market economy framework under planned economic control. A market economy ensures respect for diversity and efficiency, allowing for maximum problem identification and discovery of the most effective solutions. Conversely, the planned economy—namely governance by the Communist Party—rapidly makes policy decisions regarding guidance and resource allocation outside existing systems and processes, maximizing the advantages of centralized authority.

The emphasis on basic research represents a crucial guiding direction for China's future scientific research development, with all scientific and technological reforms—including research management, evaluation, and incentives—focusing on the continued deepening of basic research. Regarding research topic selection and scientific research, there is expected to be an increase in the selection of topics such as basic physics and mathematics, with particular growth anticipated in research outcomes related to interdisciplinary fields between basic disciplines and mechanics, as well as applied fields such as mechanical applications. This trend must be strengthened and reflected in the review, selection, and promotion of positions both within and outside universities moving forward. Additionally, as a future challenge, more experiments may be necessary to obtain original data. For example, indicators we previously used such as SoC (State of Charge) and DoD (Depth of Discharge) were originally referenced against industry averages or approximately equivalent levels under similar conditions, primarily based on foreign references. To secure support for basic research funding and original research, we believe support for direct and original data will be necessary, leading to expanded experimental work.

(7) WANG Wei (Tsinghua University)

The policymaking process has activated three key drivers of policy innovation—central government, local government, and the general public—establishing a decision-making system that fundamentally combines top-down and bottom-up interactions among these three entities. Currently, internet and multimedia platforms have expanded the channels for reflecting public opinion, with trending social issues and public sentiment serving as important reference material for policy development. Another approach is to first implement trial programs that include evaluation of scientific and technological achievements. Issues such as delegating authority to technicians and deregulation have been piloted at institutions like the Chinese Academy of Sciences and universities, enabling policy adjustments based on outcomes and ensuring practical and accurate policy implementation.

This is a matter of research topic selection orientation. Previously, topic selection was considered to have numerous clear indicators and strong implementation potential. This proves convenient when organizing and adjusting resources for unsuccessful applications. Combined with the Tsinghua University brand, research project applications are relatively procedural, with everyone understanding which projects are appropriate to apply for and implement. Now, as a key research institution, Tsinghua University must take the initiative in conducting research projects with high risk factors, unclear evaluation indicators, and no established evaluation standards or systems, thereby establishing its own criteria. While the difficulty has increased, there is growing awareness of institutional autonomy in research project applications. Young researchers around age 35 are showing particular enthusiasm and forward-thinking attitudes.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

Policy changes and modifications are indeed more flexible compared to other countries. This system primarily involves absorbing diverse opinions, enabling elite politicians to make rapid decisions, and synthesizing these into policies through party opinions and leadership speeches beyond legal frameworks. Under these conditions, policy trial programs are implemented, provided they do not violate general laws and systems, and are subsequently elevated to policy and institutional levels through the Standing Committee's decision-making mechanism.

Progressing "from zero to one" represents original innovation. There are three types of innovation. These are original innovation, integrated innovation, and digestive absorption re-innovation. Digestive absorption re-innovation was the predominant form of innovation following the Reform and Opening Up, followed by integrated innovation driven by industrial upgrading, which established China as the world's factory. China has consistently demonstrated weakness in original innovation. Emphasizing original innovation enables a focus on basic research and interdisciplinary research projects between basic research and other fields. Within the broader framework of unknown territories, applicants possess forward-looking strategic vision to identify problems that can address fundamental technological deficiencies China needs at present, rather than focusing on specific current technologies and solutions. In concrete scientific research activities, there may also be increased investment in research related to original data, basic experiments, and experimental theory.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

In Chinese policymaking, changes and adjustments occur not through formal legislation and rigid institutional frameworks, but through implementing policy modifications within feasible parameters and conducting pilot programs. Based on the results of these pilot programs, policies can advance to the decision-making level and become immediate policy through centralized decision-making. This approach ensures the benefit of combining progressive policymaking with practical application, offering potential immediate results in addressing various issues.

The emphasis on moving "from 0 to 1" reflects a focus on originality and basic research, which proves advantageous in both the selection and implementation of research projects. For research institutions like ours within corporate structures, basic research is goal-oriented rather than purely exploratory. Our coating research is grounded in materials science and chemical engineering, and research institutes in these fields employ a Chief Scientist system. In the collaboration between Sinochem Group and Tsinghua University, top experts from these two fields were recruited as chief scientists. These scientists independently determine research directions, establish research topics, select research teams, and manage funding allocation. This represents a breakthrough in operational mechanisms and a new institutional framework emphasizing innovation. This project has been submitted to both Sinochem Group and the National Development and Reform Commission, with plans to launch in the second half of 2022.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

Industry associations and federations have played a crucial role in submitting policy recommendations. These organizations compile and integrate findings about the current state and issues in frontline scientific research, reporting to decision-making bodies from a practical perspective, while also collaborating with national advisory bodies to submit numerous policy proposals from an expert standpoint. These organizations serve as essential bridges between upper and lower levels. They also play a vital role in ensuring flexible and practical policies. In the policymaking process, the Communist Party Central Committee and the Standing Committee system play essential roles in adjusting policy direction and making rapid decisions.

The current life-or-death issue stems from the neglect of basic research. While external pressure has led to recognition and efforts to address this problem, this represents the correct policy direction. Regarding scientific research topics, efforts to resolve automotive chip infrastructure deficiencies will focus on four aspects. Basic devices encompass chips, operating systems and other basic software, various EDA (Electronic Design Automation) tools, as well as basic materials, processes, and equipment. These constitute the four core areas of this critical issue and are also fields of basic research. This field represents a key focus for national development and aligns with research topic selection priorities. In scientific research activities, despite increased investment in hardware and testing platforms, where previously much data and achievements were borrowed, research must now start from zero using advanced equipment.

5. Are the preferences of researchers (both applicants and participants) being respected in terms of project implementation, modifications, team composition, and setting of research periods?

(1) Hongyong ZHU (China Institute of Atomic Energy)

Research projects requesting funding fundamentally align with the questions as stated. The entire process, including review, execution, and final acceptance, is carried out based on the project plan submitted by the applicant. While both host organizations and review bodies may present several proposals, the project applicant (typically the project director) makes the final decisions regarding adoption and execution. However, there are also some designated research projects that must comply with the relevant requirements of research institutions.

(2) WANG Chengwen (Tsinghua University)

In principle, both the Academic Committee and Scientific Research Management Department must approve the review of an applicant's academic level and comprehensive scientific research conditions. The university's Scientific Research Management Department guarantees and provides cooperation in the qualification review and examination process for applicants. While these matters require approval, individual preferences are fundamentally respected, and applicants must obtain permission before beginning the application process. In the application process, individual preferences take highest priority.

(3) XUE Lan (Tsinghua University)

Generally, professors may freely organize their applications, but doctoral students must consult with their academic advisors and must complete the organization and integration of relevant resources with their advisor's suggestions and support.

(4) JIN Changqing (Chinese Academy of Sciences)

Individual preferences are essentially respected. External research projects have relatively greater flexibility, but there are many constraints on independent research projects within the Chinese Academy of Sciences. This particularly applies to the selection of collaborative relationships (with internal collaboration given priority) and the sharing of scientific research outcomes.

(5) LIU Huijuan (Tsinghua University)

The will of individual applicants is essentially respected. Furthermore, with expanded autonomy in expense management and more scientific and rational performance evaluations, research personnel are demonstrating increasingly higher motivation in their research.

(6) WANG Zhenpo (Beijing Institute of Technology)

Purely academic matters in scientific research are basically decided through consultation between academic advisors and applicants. While the university provides some technical support, it does not actively intervene. These boundaries are very clearly defined. When forming teams, given the premise of project completion and existing friendly relations such as inter-university cooperation and strategic partnerships, these elements are considered in optimal combination.

While the university does not impose requirements, in terms of procedures and financial management, they formally seek opinions from host organizations (such as universities) to maintain good relationships with commissioning organizations.

(7) WANG Wei (Tsinghua University)

There were unwritten rules particularly regarding doctoral students' scientific research projects. When applying for such projects, it was customary to pay respects to relevant administrative department leaders and arrange for team participation. Additionally, when expert support in the field was needed, it was sometimes necessary to allocate subprojects to part of the expert team in return. Such practices were once an open secret. However, since the 18th National Congress of the Chinese Communist Party, there has been increased oversight of research styles and scientific researchers' integrity and credibility, with disciplinary inspection and supervision teams being deployed to various universities and research institutions. The detection and reporting systems have become more effective compared to before, constraining the practices of research and development personnel. As a result, the research and development environment has improved significantly compared to the past, and scientific discipline has been restored.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

The Datang Telecom Research Institute uses a research project proposal discussion system. As a basic rule, research and development personnel submit proposals to the institute's administrative office before submitting their research project proposals. The administrative office invites internal financial experts and specialists in the same field to discuss the feasibility, implementation, and advancement of the research project proposal. While the individual opinions and wishes of those submitting proposals are respected as a basic principle, the company presents revision suggestions or recommendations against submission based on the discussion results from the research discussion meeting and the company's development strategy. One project I participated in directly competed with a university, but since this university was one of our technical support organizations, we withdrew our proposal to avoid conflict. Ultimately, as a company, we must consider company profits rather than pure academic research.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

This is an important starting point for research institutions to ensure academic freedom and for researchers to actively engage in academic research, and as a basic principle, maximum support is provided to fulfill researchers' wishes.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

When applicants demonstrate enthusiasm and aspirations, they must prove they have both a certain degree of authority to speak in their field and the ability to organize and integrate. While some early-career researchers who have just begun submitting proposals do not value individual preferences, they personally want guidance and suggestions from their affiliated research institutions, and as researchers, they respect such suggestions. The role of mentors, such as academic advisors, is extremely important in this process. The mentors' enthusiasm and ideas directly influence the quality of proposals and the ability to integrate teams. Therefore, the matter of respecting applicants' individual preferences requires concrete analysis.

6. Are applicants permitted to freely select participating members from institutions (e.g., universities, research institutions, private enterprises, and other research institutions)? Furthermore, are these mixed teams able to conduct their work at any national or private institution?

(1) Hongyong ZHU (China Institute of Atomic Energy)

Yes, they are. Research can be conducted in the affiliated laboratories and experimental facilities of the host organization, and proposals can be submitted to conduct experiments and research projects at related research institutions.

(2) WANG Chengwen (Tsinghua University)

With the exception of classified projects that have clear restrictions related to defense and military industries and participating organizations, applicants may generally freely combine research institutions and conduct research on various subprojects based on research efficiency and research outcomes.

This is possible in principle, though many state-owned research institutions and platforms (such as laboratories) require application and approval, based on the characteristics of research institutions. The State Council is actively promoting the construction of public technology platforms such as key laboratories and large-scale scientific equipment centers, encouraging them to open to society, and the application procedures have now been greatly streamlined.

(3) XUE Lan (Tsinghua University)

The composition of research teams is generally determined by the applicant's own discretion. Private research institutions are generally open for use but charge fees. As the use of national-level research and development platforms is subject to relatively strict regulations, the application procedures are complex, and project leaders primarily focus on coordinating operational resources.

(4) JIN Changqing (Chinese Academy of Sciences)

Decisions are based on project rationale. applicants are generally thorough regarding expenses and the inherent attributes of the research project, and host organizations and unified management departments respect the applicants.

While state-owned research facilities, particularly key laboratories, have many restrictions on external access, private research institutions generally operate on a fee-based system and present few major obstacles. Using state-owned research institution equipment and facilities requires application and approval, but research institutions within key laboratories are becoming more externally accessible, and applications involving general or state-owned research organizations typically receive approval. However, organizations related to military or confidential matters are exceptions.

(5) LIU Huijuan (Tsinghua University)

For general research projects, project leaders (applicants) have complete freedom in selecting both participants and participating institutions, with exceptions only for military and confidential research projects that require special qualifications. However, in recent years, peer review processes have been affected by subjective factors—including personal bias and factional interference—which have created limitations on applicants' ability to select research collaborators. Academic groups inherently contain various factions and circles with their own unwritten rules and cultural norms, a situation that cannot be entirely eliminated. These issues are showing gradual improvement through enhanced academic oversight and reporting mechanisms.

Under standard procedures, project participants can utilize shared resources and access each other's laboratories and research equipment, coordinated through the project leader and host organization. Nevertheless, some key research and development facilities, including National Key Laboratories, exhibit a degree of protectionism, making access requests particularly challenging. This situation calls for improvement in project leaders' coordination capabilities.

(6) WANG Zhenpo (Beijing Institute of Technology)

Project leaders have the authority to freely arrange team members and determine sub-project assignments in their capacity as applicants. Collaboration with corporate research institutions requires a signed contract that explicitly defines both the division of responsibilities and ownership of results.

Research facility access is typically managed by sub-project leaders from the relevant departments. Access to national-level research and development platforms, such as National Laboratories, requires submission and approval of applications in accordance with the governing organization's facility use regulations. The project leader bears responsibility for coordinating and processing these arrangements.

(7) WANG Wei (Tsinghua University)

The above assessment is accurate. Significant overall improvements have been made in these areas recently. Tsinghua University conducts anonymous surveys of research assistants annually—these individuals, being outside the formal organizational structure, tend to provide candid feedback—and the results show notably high satisfaction levels, now surpassing 90%.

Most applicants conduct their research using the research and development platforms at their home institutions. However, access to state-owned research and development platforms, particularly State Key Laboratories, requires formal application and approval processes.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

This response corresponds to Question 5, which asks whether researchers' preferences—including both applicants and participants—are respected in terms of project implementation, modifications, team composition, and research period determination. The response also addresses content from research symposia held during the project application process. Sometimes an applicant's individual preferences must be subordinated to the broader organizational interests.

Research activities are primarily conducted at the applicant's host institution, which represents one of the fundamental infrastructure requirements for project acceptance. The applying department typically guarantees that the host institution will provide coordination platforms for research activities without charging fees.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

The Marine Chemical Research Institute maintains a recommended collaboration directory[81] to improve the acceptance rate of project applications. This directory comprises national-level research institutions and universities, both within the group and those maintaining cooperative relationships with the group. While individual researchers retain autonomy in selecting their collaborators, projects involving partnerships with organizations listed in the directory become eligible for project-related expenses and support measures.

Chemical coating tests frequently involve confidentiality requirements, and testing facilities must satisfy specific criteria. General project discussions and tests free from confidentiality or safety concerns take place in the group's conference rooms and research platforms.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

Respect for individual preferences does not mean they are always clearly articulated. At certain stages, researchers may lack definitive preferences, making this a process of exploration that requires guidance and support. When individuals do express specific preferences, their host institutions provide full respect for their ideas and wishes. The applicant, serving as the principal investigator, maintains ultimate responsibility and authority for project implementation.

Implementation locations are determined within the framework of cost containment requirements, under which research is conducted at either state or private institutions. Use of state research equipment must adhere to the relevant borrowing regulations.

81 The Marine Chemical Research Institute operates as a wholly-owned subsidiary of China National Chemical Corporation (ChemChina), a central state-owned enterprise. ChemChina encourages joint research projects, either between enterprises within its group or with established cooperation partners, to optimize the utilization of internal research and development resources. To facilitate subsidiary companies' understanding of encouraged activities, group headquarters compiles and distributes lists outlining potentially supported projects. Projects appearing on these lists have enhanced approval prospects and may receive financial support from headquarters.

7. Can project leaders freely determine how research funds are used? Do researchers have a voice in the allocation of indirect costs? Are they benefiting from the Comprehensive Funding System—an approach that eliminates the separation between direct and indirect costs, enhances flexibility by minimizing restrictions on budget allocations and expenditure categories, and increases researcher autonomy?

(1) ZHU Hongyong (China Institute of Atomic Energy)

Under the current research project system, applicants must adhere to relevant regulations established by the State Council, various organizational levels, and project sponsoring bodies rather than having complete discretion over funds. The Institute of Atomic Energy audit department typically conducts its audits around the fifteenth day of each quarter.

While researchers cannot comment on indirect cost totals and proportions, applicants maintain significant influence over how these funds are used.

The Comprehensive Funding System has created significant practical changes. Previously, projects required detailed budget preparation before commencement, with expenditure strictly following these allocations. The inflexible budget management system could not effectively maximize team member motivation, particularly regarding personnel costs. The newfound ability to adjust equipment budgets, including those within host organizations, has enabled greater infrastructure flexibility. These changes have all served as beneficial improvements.

(2) WANG Chengwen (Tsinghua University)

Researchers do not have complete discretion over research fund allocation. While the Comprehensive Funding System applies to basic research and talent development projects, other project categories generally follow the management regulations established by project administrators and host organizations for scientific research projects.

The proportion of indirect costs continues to increase, with considerable autonomy in their utilization—host organizations generally impose no specific requirements, allowing flexible allocation. Since host organizations frequently base their indirect cost requirements on project leaders' recommendations, the use of indirect costs remains essentially unrestricted aside from rigid project management regulations.

The Comprehensive Funding System is currently undergoing pilot implementation in selected projects and has not yet been fully implemented. Though our team has not yet directly benefited from this system, we expect to be included in future coverage.

(3) XUE Lan (Tsinghua University)

Regarding the first question, decisions cannot be made with complete freedom. Research project leaders must pay careful attention to understanding three principles when utilizing scientific research funds: First, expenditure must conform to national fiscal policies and the financial management systems of the scientific and technological programs under which the research project operates. Second, with the project's mission objectives serving as the foundation, expenditures must maintain a close relationship with the research project's tasks. Additionally, both the amount and composition of these expenditures must align with the discipline and characteristics of the research mission. Third, expenditure levels should remain approximately equivalent to spending levels observed in similar categories of research.

While regulations exist governing the use of indirect costs, the authority to utilize performance-based rewards—

which has been a subject of controversy—now rests entirely with the project leader.

The Comprehensive Funding System provides project leaders with even greater latitude in decision-making. This measure represents a return to scientific principles and seeks to minimize other factors that hinder the precise pursuit of scientific advancement. As scientific research inherently possesses certain uncertainties, it must fulfill its fundamental characteristic of exploring the unknown. This system began as a pilot program for the National Outstanding Young Scientists Fund projects in 2019. Several doctoral students under my supervision have obtained these grants, and their responses have been positive. Tsinghua University's financial system approaches the Comprehensive Funding System through individual project accounting, special expenditures, and independent financial management. Project leaders do not need to establish budgets for each item within their projects; they only need to record the total budget amount. Thus, the previously troublesome issue of performance-based rewards is resolved by facilitating communication between direct and indirect costs within project funding. The original intent of the Ministry of Science and Technology's policy is to first implement trials with National Outstanding Young Scientists Fund projects, then expand to the Excellent Young Scientists Fund projects, general projects, and Youth Science Fund projects, followed by widespread implementation across various other projects under the Ministry of Science and Technology. We expect these processes to accelerate.

(4) JIN Changqing (Chinese Academy of Sciences)

There is currently a broad trend toward expanding autonomy in expense management across the system. This shift aims to encourage research and development personnel to step away from administrative duties and focus entirely on scientific research. Under the present system, applicants have substantial freedom to determine and use most expenses, with the sole exception of equipment adjustment funds, which remain under the authority of the responsible organizations. The authority to adjust both labor and operational costs has been fully transferred to project leaders.

The total amount of indirect costs, which is calculated as a proportion of direct costs, remains under management oversight. However, this proportion continues to show an upward trend. The authority to use indirect costs, while still subject to overall amount management, increasingly reflects the input of applicants. Though this technically requires consultation with the applicant's host organization (supporting organization), the practical reality is that applications are typically approved without significant objection from the supporting organization.

XU Ruiming, Director of the Institute of Biophysics, Chinese Academy of Sciences, pioneered the Comprehensive Funding System concept, which was first implemented as a one-year pilot program in 2000 for Outstanding Young Scientists projects. The Institute of Physics, Chinese Academy of Sciences is not currently running any pilot projects. In their evaluation of Outstanding Young Scientists projects, the Institute of Biophysics, Chinese Academy of Sciences highlighted the advantages of the Comprehensive Funding System. Frontline personnel have particularly welcomed several aspects of the trials: the elimination of detailed budget requirements for individual project categories, the simplification to recording only total amounts, and the removal of barriers between direct and indirect costs within project expenses, allowing more flexible fund utilization.

(5) LIU Huijuan (Tsinghua University)

Apart from certain strict regulations and usage proportion restrictions, decisions are essentially made with discretionary authority. When amounts exceed certain thresholds, calculation methods and details must be provided. Otherwise, merely explaining the calculations is sufficient. Furthermore, with the issuance and implementation of "Several Opinions on Reforming and Improving Central Financial Scientific Research Fund Management" [in Chinese], all usage authority, including budget adjustment rights, has been delegated to both the project's host organizations and project leaders. The next step is considered to be further clarifying the scope of authority between project leaders and host organizations. Additionally, the Comprehensive Funding System is being advanced for talent development and basic research projects. This progress has led to greater autonomy and increasingly flexible fund utilization without the need for detailed project budget formulation. At the 2022 Two Sessions (National People's Congress and Chinese People's Political Consultative Conference), leadership from the Chinese Academy of Sciences was set to propose aligning the scope and authority of the Comprehensive Funding System with the institutional framework of new research and development organizations. This proposal is likely to be discussed and steadily advanced.

Under conditions where indirect cost proportions remain limited, there is now discretionary authority over expenses including labor costs and performance-based rewards.

The Chinese Academy of Sciences initiated the Comprehensive Funding System pilot program in 2019. The program has received notably positive feedback, having resolved issues related to income and expenditure reporting and cumbersome administrative work through several measures: simplifying budget formulation and adjustment, streamlining financial inspection and acceptance processes, expanding the scope of accounting within project accounting systems, and providing comprehensive coverage of travel and accommodation expenses within standard cost parameters.

In 2022, a "negative list" pilot program for expense management was set to begin. This regulation, similar to requirements for "new-type research and development institutions," allows autonomous use of funds for anything not explicitly prohibited on the list. As the system expands in these directions, it will likely receive universal acclaim.

(6) WANG Zhenpo (Beijing Institute of Technology)

At present, funds cannot be used with complete freedom. Management must maintain upper limits according to certain prescribed ratios. Direct and indirect expenses are subject to specific proportion-based restrictions, though funds can be used freely within these constraints.

The authority to use indirect costs primarily resides with the host organization. However, the host organization's primary use of these funds is for performance-based incentives, and they generally respect the applicant's input. As a result, applicants retain certain authority over the main indirect cost usage.

The Comprehensive Funding System represents an organizational approach to research projects with pilot program characteristics and is currently being tested in basic research and talent development projects. While there are no projects directly participating in the Comprehensive Funding System at present, Beijing Institute of Technology issued the "Administrative Measures for Comprehensive Funding System of Beijing Institute of Technology-Beijing Natural Science Foundation Projects (Trial)" [in Chinese] on December 21, 2021. According to the relevant provisions of these measures, budget reviews have been eliminated in favor of ongoing and post-project supervision. Additionally, usage authority adopts the same "budget + negative list" approach as "new-type research and development institutions." Currently, the first wave of projects is being implemented in programs including those at the School of Information and Electronics. Project teams have signed contracts with the university based on the administrative measures. This model significantly reduces the initial administrative burden that was once cumbersome, serving as a driving force to encourage scientific research personnel to actively participate in research projects.

(7) WANG Wei (Tsinghua University)

While funds cannot be used freely and must be executed according to relevant regulations for expense management, researchers applying for grants have increasingly greater authority over fund usage. For indirect costs, aside from management fees that are set at fixed proportions by host organizations, the use of other expenses is now essentially unrestricted.

Systems similar to the Comprehensive Funding System are already being implemented at the frontlines of scientific research, and the Comprehensive Funding System consolidates and strengthens the experience gained through these implementations. Prior to this, Tsinghua University increased the proportion of performance-based rewards for scientific research projects within their internal pilot projects. More than 40% of the remaining balance of scientific research funds was allocated to incentive systems such as bonuses for project leaders. Some universities in Beijing have developed their own negative lists tailored to the actual circumstances of scientific research projects, implementing systems where project leaders can independently determine the use of research funds for anything not on the negative list. Following the implementation of Comprehensive Funding System projects, rather than merely repairing the existing system, this represents complete liberalization, which significantly helps enhance the enthusiasm of scientific researchers.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

Spending authority encompasses several key areas: budget adjustments, direct expenses, indirect expenses, scientific research equipment procurement, carryover and surplus funds, and expenses from enterprise sources. Funding is divided into direct and indirect categories. Direct costs are subject to total amount management, within which one category encompasses materials costs, measurement testing, chemical inspection, processing fees, fuel and electricity costs, and expenses related to publication, literature, information dissemination, and intellectual property administration. A second category manages labor costs, expert consultation fees, conference expenses, business travel expenses, international cooperation and exchange costs, and other expenditures. Budget adjustments between these two categories follow the contracting organization's internal review procedures. Within the budget limits of the same category, the contracting organization may approve or authorize project leaders to adjust and use funds according to actual circumstances. Both categories essentially require internal consultation and approval. While authority rests with the applicant, internal review and approval typically involves a single procedure. Budget adjustments for equipment expenses within direct costs must be submitted to and approved by the specialized project management organization. Indirect costs are determined as a proportion not exceeding the amount of direct costs minus equipment purchase expenses. Specifically, the indirect cost ratio is set at no more than 30% for portions under CNY 5 million, no more than 25% for portions between CNY 5 million and CNY 10 million, and no more than 20% for portions exceeding CNY 10 million. For purely theoretical basic research projects such as mathematics, the indirect cost ratio is increased to no more than 60%. While the use of funds within these proportions is officially decided through consultation between the host organization and applicants, in practice, the opinions of internal staff members take precedence. Regarding scientific equipment procurement, the system employs special handling and on-demand procurement mechanisms for urgently needed research equipment and consumables, bypassing the bidding process to shorten procurement cycles. For exclusively produced equipment and facilities, a single-source procurement method is adopted following established procedures. While bidding is fundamentally conducted by the host organization responsible for the project, applicants bear responsibility for review and maintain a certain degree of input. However, they cannot make final decisions unilaterally, and the extent of their influence varies by individual. During the implementation of scientific research projects, surplus funds from the current fiscal year may be carried over for use in the following year. After project objectives are completed and acceptance inspection is passed, surplus funds may be retained by the implementing organization according to regulations and can be directly expended on scientific research activities conducted within two years. If funds remain unused after two years, they are recovered according to regulations. These matters fundamentally fall under the authority of the organization responsible for the project. Research project funds obtained through market channels from enterprise sources are managed and used according to the requirements of the commissioning party or contractual requirements, with unified management by the receiving organization's financial department. Project leaders have freedom of use but must follow relevant internal procedures and regulations.

While indirect costs are fundamentally under the administrative authority of the project management organization, in actual scientific research activities, the applicant takes the lead and has significant influence in decision-making.

The Comprehensive Funding System is currently being implemented across talent development and basic scientific research projects. The primary concern centers on authority over expenditure management. Numerous policies have been implemented to date, particularly regarding the relationship between project management organizations and applicants, leading to better understanding of how to encourage applicant initiative. Control over expenditure serves as one crucial mechanism in this process. The reforms to the Comprehensive Funding System have incorporated lessons learned from practical experience. At Datang Telecom, research projects at the engineering level have largely adopted a management model closely resembling the Comprehensive Funding System, which has proven to be an important method for motivating researchers.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

Research project management organizations maintain clear stipulations regarding both the purposes and proportions of fund allocation. Although funds cannot be utilized freely, authorization for their use has been progressively liberalized, with applicants receiving increasingly broader discretionary authority.

Authority over indirect cost utilization currently resides with project management organizations. Within our organization, we take into account applicant input regarding indirect cost allocation. Following the deduction of essential expenses, all other expenditure purposes fundamentally conform to applicant preferences.

The Principal Scientist System, which is currently being implemented at the Marine Chemical Research Institute, was established by adapting the Comprehensive Funding System framework and extends the regulations set forth by the national government and the Ministry of Science and Technology.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

Experimental projects operating under the Comprehensive Funding System, Competition System, and Strategic Open Recruitment System allow for unrestricted use of funds. These projects do not require budget documentation. However, other projects, particularly research initiatives receiving government funding, face fundamental restrictions on fund utilization. Despite these limitations, applicants continue to gain expanded authority over expenditure management. Policy trends suggest evolution toward frameworks resembling the Comprehensive Responsibility System.

Authority over indirect costs encompasses administrative expenses and incentive payments for research and development personnel. While this authority remains with the project management organization, significant consideration is given to applicant input

The Comprehensive Funding System currently operates within talent development and basic research pilot projects. Through the Strategic Open Recruitment system, our federation and center are methodically advancing the delegation of financial authority to scientific research personnel. Future developments may see all financial systems converging toward the Comprehensive Funding System model.

8. Do you consider the measures for identifying and nurturing young and female researchers conducting innovative research to be adequate? Are provisions in place to promote graduate student and postdoctoral researcher participation in national research projects? To what extent can doctoral students and postdoctoral researchers propose and modify research projects?

(1) Hongyong ZHU (China Institute of Atomic Energy)

In official Chinese policy contexts, these 13 ministries (including the Ministry of Science and Technology) have issued "Measures to Support Women in Science and Technology Playing a Greater Role in Scientific and Technological Innovation" [in Chinese].[82] Considerable emphasis is being placed on discovering young talent and supporting the development of outstanding young professionals, from government to enterprises and research institutions, as evidenced by policies such as the Chinese Academy of Sciences' "Implementation Opinions on Strengthening the Training of Young Scientific and Technological Innovation Talent" [in Chinese].[83] The China Institute of Atomic Energy has established dedicated funding projects for young science and technology personnel as well as training programs for female scientific researchers, both representing targeted initiatives.

The Chinese government does not provide substantial support for graduate student participation in projects, primarily because it encourages participation in academic discussions and scholarly presentations instead. Doctoral education is viewed as a process of independent knowledge creation, and it is based on the reform requirements of the government's classified graduate student training models, there is support for doctoral students' active participation in research projects. Currently, the delayed graduation rate for domestic doctoral students exceeds 60%, primarily due to involvement in research projects and development initiatives. These activities fall under the authority of academic advisors, who often serve as project leaders, making it relatively straightforward for students to modify, revise, or propose research projects.

(2) WANG Chengwen (Tsinghua University)

The primary challenge for female scientific researchers stems from biological factors that cause interruptions in their research process, making it difficult to maintain consistent research engagement and often leading them to suspend their academic careers of their own accord. This is unavoidable and does not require resolution. While government policies protecting female scientific researchers represent a key initiative, they do not address the fundamental issue.

The challenges facing young researchers may arise from institutional and human factors, and the seniority-based academic environment indeed diminishes the enthusiasm of some young scholars. For government-funded research projects, new staged evaluation methods and reforms in diverse assessment systems are creating more opportunities for young researchers. Recent initiatives such as the Competitive Project Selection System and Strategic Open Recruitment have proven beneficial for young researchers. In corporate-funded research projects, there is a stronger emphasis on results, with evaluation becoming more equitable and objective through market-based and social assessment methods. Therefore, while competition intensifies, the overall research environment and policies for young

82 "科技部等十三部门印发《关于支持女性科技人才在科技创新中发挥更大作用的若干措施》的通知"
(http://www.gov.cn/zhengce/zhengceku/2021-07/19/content_5625925.htm)

83 "关于加强青年科技创新人才培养工作的实施意见"
(https://www.hf.cas.cn/rjc/gzzc/rczc/zky/201603/t20160303_4541742.html)

researchers are becoming more comprehensive.

Modifications to research projects at the doctoral and postdoctoral levels are relatively straightforward, primarily depending on individual interests and research direction. Research projects assigned upon entering postdoctoral positions are provisional, requiring willing cooperation from academic advisors. There are no rigid procedural regulations in this regard.

(3) XUE Lan (Tsinghua University)

In scientific research activities, female scientists face several challenges compared to their male counterparts due to physiological factors. These include producing relatively fewer research outputs and managing fewer projects. Their limited time for scientific research consequently results in fewer opportunities for professional development. In response, the government has established "Measures to Support Women in Science and Technology to Play a Greater Role in Scientific and Technological Innovation" [in Chinese]. This policy introduces 16 specific initiatives that provide institutional solutions and safeguards, including cultivating high-level female talent in science and technology; actively supporting innovation and entrepreneurship among women in science and technology; improving evaluation and incentive mechanisms for female scientific personnel; providing support for women's research activities during pregnancy and nursing periods; strengthening the development of female backup talent; and enhancing foundational support for women in science and technology. Although these solutions have been proposed from the top down, the primary challenge lies in their practical implementation.

Graduate students rarely submit independent research project proposals. They generally remain in a learning and support phase, with doctoral students typically beginning to submit independent scientific research proposals in their second year. While there are relatively few policies directly encouraging this practice, programs such as the National Natural Science Foundation's Young Talent Fund and the Chinese Postdoctoral Science Foundation offer favorable conditions for postdoctoral researchers. Furthermore, research funding mechanisms that incorporate incentives such as "Breaking the Four Only's," the Competitive Project Selection System, and Strategic Open Recruitment aim to overcome the current system's disadvantages for young doctoral and postdoctoral researchers, encouraging their participation in more scientific research projects.

While becoming an independent applicant is relatively straightforward, most doctoral experiences and accumulated research work require joint applications and supervisor guidance, making the procedural and coordination aspects somewhat complicated.

(4) JIN Changqing (Chinese Academy of Sciences)

The state provides substantial support for young researchers and women in scientific and technological innovation. During the "Third Five-Year Plan" period (2016–2020), the National Key Research and Development Program established young scientist pilot projects within eight major special projects. These projects included nanotechnology, protein machinery and life process control, synthetic biology, quantum control and quantum information, developmental processes and metabolic regulation, stem cell and transformation research, digital diagnostic equipment, and research on the causes and control technologies of atmospheric pollution. Under these initiatives, scientists under 35 years of age were supported to lead national research projects, with no restrictions on content or evaluation criteria. According to the 2021 guidelines for the first batch of key special projects launched during the "14th Five-Year Plan" period (2021–2025), young scientist projects were established within 43 special projects. This represents 80% of the first batch of key special projects launched during the "14th Five-Year Plan" period, clearly demonstrating the policy's intent.

Currently, there are three policies supporting young talent and women in scientific and technological innovation. The first concerns the age requirements for young scientist projects. Building upon the continuity of activities from the "13th Five-Year Plan" period and fully considering the characteristics of different fields, the age requirements for young scientist projects have been designed with differentiation across disciplines. Generally, the age requirement for project leaders has been set at 40 years or younger. Additionally, as part of efforts to support women in playing a greater role in scientific and technological innovation, the policy framework includes more lenient age restrictions for women compared to men in young scientist projects. The second policy component establishes young scientist projects through two distinct implementation methods: specialized projects and independently established research topics. Both the research content and evaluation criteria are designed with openness and flexibility in mind. To further support women's participation in scientific and technological innovation, in June 2021, 13 government ministries, led by the Ministry of Science and Technology, issued the "Measures to Support Women in Science and Technology to Play a Greater Role in Scientific and Technological Innovation" [in Chinese]. This document outlines institutional guarantees through comprehensive measures, including establishing a data indicator system for women in science and technology; creating nursing-friendly workplace environments; implementing flexible working arrangements; constructing lactation rooms; offering childcare services; developing conditions that enable pregnant and nursing women to conduct scientific research; and promoting the establishment of funds to support women returning to scientific research activities.

Scientific research personnel also face what is known as the "age 35 crisis." This refers to the disadvantages young researchers around age 35 face under the "Four Only's" evaluation criteria for securing research funding, as they have only recently graduated, have few published papers, and lack important positions or titles. In response, the government has taken an alternative approach by specifically establishing several young researcher projects for master's and doctoral students. These projects, which can be applied for by those aged 30–40 years who have completed their studies, represent significant support for young researchers. Recently, the "Huang Kun Phenomenon"[84] has attracted considerable attention. Huang, born in the 1990s, served as the first author on a basic frontier research project completed through collaboration with multiple research teams, under an advisor born in the 1980s.

Personally, while becoming a project leader is very challenging, I find that the proposal and modification processes for doctoral and postdoctoral research projects are relatively flexible, and the pathway for proposing and modifying projects through supervisors and project leaders is comparatively smooth.

(5) LIU Huijuan (Tsinghua University)

The Chinese Academy of Sciences and Tsinghua University attract a large number of international students from Japan. According to Japanese international students, China appears to be particularly considerate of women in the

84 The Huang Kun Phenomenon refers to HUANG Kun, a young researcher born in the 1990s who, at just 30 years old, led a research team at the Center for Excellence in Molecular Plant Sciences, Chinese Academy of Sciences. He completed internationally recognized scientific research projects, with findings published in the prestigious journal *Science*. Notably, he was still a graduate student when the project was completed, and his supervising professor was also under 40 years old. Leading a research team and achieving such high-level research results at this young age is rare in China. Huang's success in breaking through the disadvantageous "Four Only's" evaluation system, supported by numerous government and educational institution policies and funding, has garnered significant attention as a successful case study.

field of scientific research and innovation. Since the founding of the People's Republic of China, achieving gender equality and respect for women has been highly prioritized and has consistently remained a mainstream social value. The Law of the People's Republic of China on the Protection of Rights and Interests of Women [in Chinese][85] and policies such as the Ministry of Science and Technology's "Measures to Support Women in Science and Technology to Play a Greater Role in Scientific and Technological Innovation" [in Chinese] have expanded opportunities for women in science and technology. These measures specifically support women's active participation in scientific and technological innovation and encourage their involvement in international scientific and technological exchange and cooperation. From a practical standpoint, creating supportive work environments for women in science and technology during pregnancy and nursing periods, along with implementing retirement policies for high-ranking female scientists and technologists, is considered a matter of significant importance.

The Chinese government's policy encourages organizations training master's and doctoral students to select research projects either in high-risk frontier fields or projects with substantial significance for national economic development, technological advancement, and social progress. However, due to factors such as the expansion of graduate school enrollment, the large number of students makes it impractical for individuals to submit applications independently. Doctoral students begin applying for grants such as the General Program of the National Natural Science Foundation of China from their first year. Graduate student research project applications are primarily concentrated within their respective universities, with institutions organizing innovation-focused research projects specifically targeted at graduate students to build foundations for future research.

During the first two years of doctoral studies, supervisors typically allocate collaborative activities and basic research investigations. They may assist students in submitting independent applications until the start of the second semester of their second year. The number of successful applications achieved through supervisor assistance has become one metric for evaluating supervisor quality across many universities.

Postdoctoral researchers have significant influence in their roles. However, when it comes to doctoral students' personal experience and academic network connections, supervisor guidance and assistance remain necessary. Consequently, some modifications to proposals are made based on supervisor recommendations.

(6) WANG Zhenpo (Beijing Institute of Technology)

While the system itself does not discriminate against female researchers, physiological factors and cultural traditions may create inequalities in actual scientific research activities. Through the implementation of policies such as the Law on the Protection of Women's Rights and Interests [in Chinese] and "Several Measures to Support Women in Science and Technology to Play a Greater Role in Scientific and Technological Innovation" [in Chinese], several disparities in research advancement and opportunities have gradually been eliminated. Innovation activities for young scientific researchers are concentrated in young talent projects, but their reach remains limited and they have not yet succeeded in providing young researchers with a stable innovation environment. In particular, there is relatively little stable innovation environment and continuous financial support for those under 35 who are still in the experience accumulation phase. In recent years, several industry–academia collaboration and research institution–enterprise cooperation talent development projects focused on innovation have all concentrated on the under-35 years

85 "中华人民共和国妇女权益保障法（修正）"(http://www.gov.cn/banshi/2005-05/26/content_980.htm)

age requirement. Furthermore, while there are no means to modify certain systems within the existing framework, mechanisms outside the system such as Strategic Open Recruitment and the Competitive Project Selection System provide maximum assurance for young research personnel to continuously engage in innovation activities. These are all well-designed processes. Currently, as the emphasis on basic research continues to expand domestically, opportunities will increasingly grow as long as young people remain devoted to scientific research and innovation.

At the graduate school level, students face considerable challenges when attempting to apply for research projects as primary investigators. Although some universities have established graduate student innovation competitions and project contests, these remain confined to specific projects and have not yet evolved into comprehensive policy support. Furthermore, there are no national promotional policies targeting this academic level. The national government does, however, actively support research project applications from doctoral students and postdoctoral researchers. The "Doctoral Innovation Program" (Ch. *bo xin jihua*), also known as the Postdoctoral Innovation Talent Support Program, and similar initiatives focus on doctoral students and postdoctoral scientific researchers. These projects aim to promote scientific research in areas of major national strategic importance, strategic high-technology fields, and basic science frontiers, and they receive relatively substantial support. The program provides financial support of CNY 630,000 over four years, distributed in two-year installments, enabling doctoral students to pursue self-directed research projects. Universities have shown strong engagement with these initiatives. In competing to serve as project management organizations, institutions vie to attract exceptional doctoral students and postdoctoral researchers capable of securing such projects by offering additional financial support.

For doctoral students and postdoctoral researchers, making modifications to their research projects is considered standard practice, with decisions made through consultation with academic advisors. It is important to note that this decision-making authority fundamentally resides with the individual researchers rather than their academic advisors.

(7) WANG Wei (Tsinghua University)

Currently, the protections for women are adequate. Since the establishment of the People's Republic of China, the country has consistently emphasized women's rights to participate in scientific research and social activities. Moreover, the selection of scientific researchers must always follow capability-based evaluation criteria. Regarding competence in scientific research fields, blindly pursuing political correctness not only fails to achieve high-quality and efficient development of scientific research but can even result in stagnation by becoming mired in political correctness. Recently published policies, such as "Measures to Support Women in Science and Technology to Play a Greater Role in Scientific and Technological Innovation" [in Chinese], demonstrate an excessively protective tendency toward women. So-called equity represents a different form of inequity for female researchers. For all scientific researchers, recognition of their knowledge and abilities constitutes the highest form of respect.

When general graduate departments submit funding proposals, many application requirements remain at the doctoral level. Doctoral students may begin submitting research proposals from their second year. Regarding doctoral student research proposals, Tsinghua University strongly supports this initiative and provides specialized courses for proposal guidance. Doctoral students, particularly those submitting research proposals for the first time, can take these courses at no cost and receive subsidies for their initial proposals. Tsinghua University also coordinates resources and supports doctoral students in organizing and integrating academic resources at both national and global levels. The Tsinghua University Student Affairs Office maintains a dedicated service desk for research proposal submissions, providing one-stop assistance to help doctoral students find supervisors and connect with academic resources both within and outside the university.

Important elements such as research project themes and technical approaches must be entered on application forms and submitted to project administrators, though the procedures are relatively complex. As proposals involve core technical issues, project managers approach them with caution. Additionally, matters such as the number and changes of support staff and adjustments within submission deadlines are all managed through a reporting and documentation system, requiring no formal application.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

The opportunities for young employees at our company can be considered moderate. In research positions, unless one achieves a management position by around age 35, they are transferred to support roles or laboratory positions considered less demanding, being moved away from key research positions to create opportunities for younger researchers. Young researchers receive relatively favorable consideration regarding opportunities. The employment of female researchers follows national regulations, without any special considerations or preferential principles. Ultimately, it comes down to individual capability; excessive consideration for women constitutes disrespect and is effectively inequitable.

Graduate students are primarily hired as research assistants to conduct basic research. After two years of work, doctoral researchers and postdoctoral fellows can submit applications for independent research projects. During this two-year preparation period, the company provides training and guidance courses, with research proposal training courses available for 3-5 days per month. Upon successful application, the company provides specific financial and leave incentives. If one succeeds in securing research projects worth more than CNY 5,000,000 for two consecutive years, they may be promoted directly to department head.

The modification and proposal of research projects are determined entirely by the applicants themselves and can be done freely.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

Young researchers have certain advantages in innovative research and are better suited for studying innovative topics from the perspectives of knowledge structure and thought patterns. Sinochem Group holds an annual science and innovation competition within the group to promote innovation among researchers under 35 years of age. Additionally, based on a 5,800-square-meter research and experimental facility utilizing a State Key Laboratory, they have used a postdoctoral research activity station to jointly train graduate students with Qingdao University of Science and Technology, as well as collaborating with Beijing University of Chemical Technology and Qingdao University to recruit postdoctoral researchers and conduct postdoctoral research projects in fields such as materials science. They have enhanced the development of young talent with innovative capabilities. Given the unique nature of their industry, which involves considerable fieldwork and maritime research activities, frontline research personnel are generally predominantly male, while women primarily occupy administrative positions.

There is no clear policy of support for graduate student research proposal applications. For doctoral students and postdoctoral researchers, there is an assistance system combining one-on-one guidance and funding. Doctoral candidates who successfully secure national-level research project funding for two consecutive years are also eligible for both monetary incentives and potential position advancements.

The processes for proposing and modifying research projects are distinct from each other. For proposals, the Marine

Chemical Research Institute maintains a prioritized list of potential projects. This list is collaboratively created by Beijing University of Chemical Technology and ChemChina Group, with all entries specifically aligned with national strategic priorities and group development objectives. Research project proposals must be selected from this predetermined list, and candidates may only submit proposals after receiving formal endorsement from the Marine Chemical Research Institute. Regarding modifications to existing proposals, which encompass changes to technical methodologies and research activities, these fall under the applicant's personal discretion and thus remain outside the Institute's sphere of influence.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

Young and female scientific researchers have historically been regarded as disadvantaged groups within the scientific research community. These groups have faced systemic inequities across treatment, opportunities, and career advancement. Recent reforms and policy initiatives have led to increased institutional and policy considerations for young and female scientific researchers. From my personal perspective, this support has perhaps become excessive, as scientific research should be evaluated based on academic achievements and scholarly principles. Social equity should not come at the expense of genuine academic merit.

The research community has long placed substantial emphasis on research project applications from highly educated personnel. These talented individuals possess strong academic foundations and capabilities but often lack academic experience and access to resources. To address this, project management organizations actively facilitate expert mentorship and provide extensive support in accessing external resources. When researchers need to connect with specific academic resources, the managing organizations typically maintain dedicated activity funds for this purpose. Their support encompasses both policy measures and financial assistance, including funding for participation in industry expert conferences and lectures, as well as financial backing for the implementation of related research projects.

Research project leaders retain complete autonomy over their research topics, technical methodologies, and modifications to specific academic issues. While academic advisors provide input for consideration, the ultimate decision-making authority resides with the research project leader.

9. Are research and development personnel satisfied with their salaries and compensation? Is there a high proportion of non-regular employment among researchers at universities and research institutions? How significant is the difference in salary and compensation between non-regular and regular researchers?

(1) Hongyong ZHU (China Institute of Atomic Energy)

Regarding satisfaction levels, there are actually considerable disparities within the field. Universities listed in Project 985 and Project 211, state-owned central enterprises[86], and several national-level research institutes offer favorable treatment. With the recent expansion of graduate school enrollment and intense competition within the industry, opinions on income levels remain divided.

Non-regular employment refers to staff members who are not formally appointed. Research institutions and enterprises have relatively few non-regular staff members who lack formal appointments. While many projects recruit external personnel for temporary projects, universities represent a special case, as their scientific research staffing levels are determined by student enrollment numbers. For economic efficiency, universities may employ scientific support staff, including doctoral and master's students, which results in a relatively higher proportion of non-regular employees. Regarding compensation, the primary difference between non-regular and regular employment lies in welfare benefits. In terms of remuneration, project leaders can make reasonable adjustments based on project contributions, though the differences are not significant. In particular, non-regular staff compensation may increase due to policy improvements such as expanded authority over indirect costs and the removal of caps on performance-based compensation.

(2) WANG Chengwen (Tsinghua University)

When the source of expenses is the government, everyone is relatively satisfied. In recent years, major internet companies have taken the initiative to increase investment in scientific researchers, resulting in intensified competition for talent. The compensation and benefits in this sector are substantially higher than national averages. Stability represents another significant factor. The job security offered within the institutional system has become particularly attractive to scientific researchers. Currently, the most pressing issue lies in the persistent serious management problems at domestic research institutions. Administrative staff positions incur substantial costs, with many of these positions being at the leadership level. When funding comes from corporate sources, scientific researchers perceive a notable disparity.

Non-regular employment is relatively common, including project outsourcing, which constitutes a form of indirect non-regular employment. At Tsinghua University, such staff members comprise approximately half of the workforce.

The salary differential is relatively modest, typically amounting to a difference of a few thousand yuan. However, the disparities in benefits and job security are substantial. Many non-regular employees work on a project basis without guarantees or benefits beyond their base salary. Few qualify for the Five Insurances and One Fund (pension insurance, medical insurance, work-related injury insurance, maternity insurance, unemployment insurance, and

[86] State-owned central enterprises: State-owned enterprises under the jurisdiction of the State-owned Assets Supervision and Administration Commission of the State Council. There are approximately 100 industrial central enterprises that support China's core industries.

housing provident fund).

(3) XUE Lan (Tsinghua University)

Personnel are generally satisfied with their compensation. In recent years, the nation has expanded its investment in research and development funding, leading to significant improvements in compensation and benefits. Naturally, differences in treatment vary according to institution, region, and field of specialization (project). Leading domestic universities, research institutes within the Chinese Academy of Sciences system, institutions directly under state-owned enterprises, military research institutions, and state research institutes maintain certain advantages in their compensation packages, making them relatively attractive employers.

The proportion of non-regular employees is not insignificant when including master's and doctoral students at university research institutions. At research institutions in Beijing, non-regular employees constitute approximately half of the workforce.

While salary disparities are not particularly pronounced, the main differences concentrate in benefits packages. When considering intangible benefits such as social security, welfare programs, and educational opportunities for children, the gap between regular and non-regular employees becomes quite substantial.

(4) JIN Changqing (Chinese Academy of Sciences)

With specific regard to our Chinese Academy of Sciences, all personnel express high satisfaction with their compensation. The Chinese Academy of Sciences maintains a relatively low proportion of non-regular employees, with a ratio of approximately three regular employees to one non-regular employee (3:1). Universities demonstrate a comparatively higher proportion, exceeding two regular employees to one non-regular employee (2:1). This higher proportion at universities results from the employment of research assistants (*keyan zhuli*). Employment patterns have shown two distinct peak periods. The first emerged in the aftermath of the 2009 financial crisis, when the government implemented measures to address graduate employment challenges through this system. During this period, universities did not conduct large-scale recruitment of research assistants. The second peak period extends from 2020 to the present, as the COVID-19 pandemic has decreased employment rates while graduate numbers have simultaneously increased due to expanded enrollment policies. The government has reactivated its research support program, establishing a clear target to create 100,000 research assistant positions. This figure may increase further in 2021.

Non-regular employment primarily consists of contract-based positions, typically spanning three-year terms. While the principle of equal pay for equal work represents the prevailing trend, contract-based positions generally receive approximately 20% lower compensation. Beyond base salary considerations, the most significant issue stems from the non-mandatory nature of the Five Insurances and One Fund, which frequently results in non-payment of these benefits. In most instances, third-party staffing agencies coordinate the administration of the Five Insurances and One Fund.

(5) LIU Huijuan (Tsinghua University)

Compensation varies by discipline and field of study. Science, engineering, and frontier technology positions receive both higher deductions and higher remuneration, while basic sciences and sociology may receive comparatively lower amounts. While support for basic research has shown improvement, there remains a notable lack of stable funding mechanisms.

Non-regular employment encompasses positions not included in official staffing allocations, such as contract workers. The proportion of non-regular employees is high; however, this category includes master's and doctoral students who function in research assistant-type roles. These positions receive approximately two-thirds of standard compensation but do not include the Five Insurances and One Fund social security benefits. Looking ahead, non-regular employment salaries may increase, though this projection excludes social security benefits.

(6) WANG Zhenpo (Beijing Institute of Technology)

There are some differences in income, but overall the level is quite satisfactory. At the Beijing Institute of Technology, all scientific research personnel receive more than CNY 15,000, with the possibility of additional research project funds exceeding this amount. This exceeds the average income in first-tier cities.

There are few non-regular staff members, and most non-regular activities take the form of professors requesting assistance from students in their own research teams through project work. These are particularly master's and doctoral students under their supervision, and this situation cannot be evaluated solely from an income perspective. It serves as an opportunity for students to learn and develop and especially provides valuable chances for participation in practical social experience. Non-regular employment primarily consists of administrative department staff and some personnel handling miscellaneous duties.

Non-regular personnel are generally satisfied with their income and work responsibilities. However, there remains a significant gap between them and regular staff regarding welfare benefits, research opportunities, and chances for promotion. This also relates to the treatment of students being taught by professors within their own teams, which has long been criticized and even viewed as exploitation of cheap labor. This represents a one-sided perspective, as this process is about finding opportunities and learning, and many of the benefits cannot be easily measured in monetary terms.

(7) WANG Wei (Tsinghua University)

Overall, while compensation levels have risen, there remains a challenge with uneven resource distribution. Present salary structures follow a spindle distribution pattern, with resources concentrated among a select group of distinguished research scientists. These researchers receive both guaranteed research funding and institutional resource support. A significant number of young researchers who have not yet achieved notable prominence receive both state protection and institutional backing, along with reasonably favorable compensation packages. Those who have progressed beyond the early career phase can maintain satisfactory conditions, even in cases where their performance does not fully satisfy their organizations' baseline requirements.

The situation defies simple statistical analysis. While statistical data indicates that non-regular employees constitute more than half of Beijing's scientific research frontline staff, the actual proportion is approximately one-third. Some of these circumstances can be traced to historical factors. The lack of transparency in funding authority has resulted in some positions becoming purely nominal. These positions were partially created to utilize specific research funding allocations. However, this practice is undergoing steady improvement, with an expected decrease in such positions.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

The current situation has met with generally favorable reception. Over the past two years, Datang has implemented comprehensive salary reform measures. Research departments have seen salary increases that surpass Beijing's consumer price index growth by more than 105%, marking the highest growth rate across all departmental divisions.

Universities and research institutions maintain flexible ratios of non-regular research staff, with numbers primarily determined by project requirements. Master's and doctoral students predominantly staff standard projects and research initiatives. However, for government-funded research grants or interdisciplinary research projects, staffing solutions may include external contractors or temporary hires based on specific project requirements. The current market includes professional contracting firms that specialize in providing high-tech expertise for specialized projects. Consequently, the proportion of non-regular staff fluctuates primarily according to project volume.

The compensation differential between regular and non-regular employees remains modest. Non-regular staff typically receive approximately two-thirds of regular employee compensation. The most significant disparity exists in the area of welfare benefits.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

Research scientists' compensation structure consists of a base salary combined with research project fees. The project fees are separate from direct project expenses. Research institutes receive incentive funding ranging from 5 to 30% of total project funding, with these project amounts reaching considerable sums. In the context of Qingdao specifically, these compensation levels exceed those of civil servants.

Reform initiatives are currently underway regarding non-regular employment practices. These reforms are initially focusing on universities, with subsequent reforms at research institutions to be implemented based on the university outcomes. The Marine Chemical Research Institute currently maintains a non-regular employment rate of approximately 45%, and this percentage may increase in the future. Following the implementation of the Comprehensive Funding System, staffing structures are increasingly aligning with project-based models. While top-tier scientists remain exempt, outsourcing practices are expanding to encompass other positions, including administrative roles.

The disparity in base salaries remains relatively modest. The primary differences appear in welfare benefits, particularly regarding the Five Insurances and One Fund. These welfare disparities are especially pronounced, with state-owned enterprise research institutions offering notably comprehensive benefit packages, creating a substantial differential in total compensation.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

Some disparities may exist within private enterprises. Historically, national research institutions have served as the primary drivers of research and development activities. However, this landscape is expected to evolve as new systems emerge for commercializing research outcomes and implementing diverse research evaluation frameworks. As corporate research organizations assume a more central role in research activities, their compensation packages are likely to see gradual improvements, potentially reducing the current income differential with other research institutions.

While organizational reforms are being implemented across universities and research institutions, it is important to note that these reforms are not being uniformly applied across all provinces and research institutions. The reform strategy focuses on reducing the number of career staff positions, with all positions except those in education, research, and high-level personnel being reclassified as non-regular positions. This restructuring suggests a likely increase in the proportion of non-regular employment moving forward.

At present, non-regular personnel are classified into two distinct categories. The first category encompasses positions that mirror regular employment in all aspects except for public healthcare benefits. The second category offers income parity with regular employment but provides reduced statutory reserve funds and social security benefit bases compared to regular positions and excludes public healthcare coverage.

10. In China, while there has been substantial growth in both the number of researchers and research funding, how are these benefits being experienced at the research level? Can research funding from various sources—national and local governments, private enterprises, and foreign companies are combined for use?

(1) Hongyong ZHU (China Institute of Atomic Energy)

The nuclear power sector has experienced above-average annual growth in funding. This growth stems from nuclear power-related organizations and headquarters increasing their proportion of support funding each year, building upon the foundation of national support. Looking ahead, this proportion is expected to rise further as the economic benefits of nuclear power improve, leading to an overall optimistic outlook for the sector. At the frontline level, we are particularly witnessing an increase in external research initiatives and cross-industry projects across various fields. Notable among these is a significant rise in collaborative projects between universities and our research institute, particularly in the domains of fundamental physics and applied physics.

As a general rule, research funds from different sources cannot be combined. This is particularly true for external research projects, which cannot be merged with projects within the China National Nuclear Corporation and the Institute of Atomic Energy, as they differ significantly in their starting points, objectives, and research methodologies. However, there exists some flexibility when projects are closely related, particularly regarding the utilization of research personnel's performance compensation from indirect costs accrued in previous years. In such cases, combined usage may be permitted, subject to applications receiving approval from both the project management organization and the unified management department. It should be noted, however, that all such applications must receive formal approval to proceed.

(2) WANG Chengwen (Tsinghua University)

While funding from government sources has remained relatively constant, Tsinghua University has seen significant increases in funding for internal projects, joint scientific research projects with external organizations including private enterprises, and talent development initiatives. The proportion of research projects funded by government sources versus other sources stands at a ratio of 3:1, though in terms of actual monetary value, the distribution is approximately equal.

The combination of funds from different sources remains a gray area, with project management officially prohibiting such practices across the board. However, the practical implementation of funding usage during project execution tends to be less rigid. Notably, under the previous project budgeting system, research projects that had been approved were allowed temporary adjustments based on circumstances. This represents a particular management skill that project leaders must navigate effectively.

(3) XUE Lan (Tsinghua University)

The peak in researcher growth is projected to occur in approximately three years. Before 2019, both the number of researchers and their funding allocations were established according to average economic and social development benchmarks, with growth maintained at relatively modest levels. Following 2019, shifts in the international landscape combined with the effects of the COVID-19 pandemic precipitated a dramatic decrease in the proportion of students pursuing master's and doctoral degrees overseas. This led to a surge in applications to domestic master's and doctoral programs, with these students representing the next generation of scientific researchers who will need to be positioned at the forefront of research within the coming years.

Tsinghua University has recently experienced an acute shortage of laboratory internship positions, with even the institution's own graduates now subject to a lottery system for placement opportunities. This situation clearly demonstrates that funding increases have not maintained parity with the growth in personnel numbers.

The combination of funding from different sources remains prohibited, as such practices would compromise the fundamental intentions and objectives of individual research projects. While the government is anticipated to grant greater flexibility in the utilization of funds within specific research projects moving forward, the merging of funds across different projects, though not explicitly forbidden, presents substantial auditing complications. This is particularly pertinent in cases involving government-sourced funding.

(4) JIN Changqing (Chinese Academy of Sciences)

The impact of these developments is clearly evident. In our physics department, which concentrates on fundamental research, we have observed a significant increase in project numbers since 2018. At present, personnel at the researcher level within the Chinese Academy of Sciences must maintain a minimum of five national-level projects, with this figure representing the final count after the screening process and elimination of certain projects.

The combination of funding sources is prohibited in principle. This restriction extends even to projects under the Comprehensive Funding System, which otherwise provides the highest degree of operational flexibility. The only exemption applies to situations where project budget formulation and adjustment processes are not required.

(5) LIU Huijuan (Tsinghua University)

The growth rate in ecological and environmental protection projects has been exceptional. At present, the Chinese Academy of Sciences and Tsinghua University each have two doctoral researchers working in ecological and environmental protection. However, this staffing level does not correspond to a limitation of two ongoing projects per institution; in fact, the number of projects available for application is projected to increase this year. However, competition has become more intense, and when considering the impact of COVID-19, the current growth rate in projects may not keep pace with the increasing number of doctoral students. This disparity between project availability and researcher numbers is expected to widen further, leading to increasingly competitive conditions.

While the combination of funding sources remains prohibited in principle, project leaders retain discretionary authority to adjust funding allocations between individual sub-projects within a single major special project.

(6) WANG Zhenpo (Beijing Institute of Technology)

Research expenditure has increased steadily and significantly. This trend is particularly pronounced in scientific research projects funded by private enterprises, especially innovation-focused initiatives under corporate leadership. Our institute currently maintains collaborative projects with at least five new energy vehicle companies, with plans to establish partnerships with an additional two to three companies this year. This development clearly indicates that enterprises are now making substantial direct investments in scientific research.

There are no precedents for combining funding sources, and none of our current projects utilize combined funding.

(7) WANG Wei (Tsinghua University)

At Tsinghua University, national funding represents only a minor portion—approximately 20%—of total scientific research funding. The majority of funding derives from joint projects organized with relevant enterprises and companies, along with various other project-specific funding sources. Scientific research funding in 2021 totaled CNY 31.7 billion, with national funding projected to decrease relative to 2020 levels. For 2022, primary funding sources include substantial revenue from joint projects with several companies, including Huawei and Tencent. Our institute is indirectly participating in a project to establish a scientific research center in collaboration with Huawei, through which we secured a single support payment of CNY 360 million. This figure exceeds our institute's entire annual allocation of national funding.

While the combination of funding sources is generally not permitted, exceptions may be considered in cases where research projects demonstrate clear interdisciplinary elements and verifiable potential for resource overlap, subject to formal application and approval processes.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

The size of our scientific research staff is fundamentally determined by our company's scale of development, and no significant changes have occurred in the past two years. Nevertheless, the rate of staff turnover and replacement remains remarkably high. Over the past two years in particular, positions in big data analysis and intelligent computing have reached nearly full capacity. As a result, even front-line researchers have been dismissed if they lack knowledge and business experience in big data and intelligent computing.

Research funding has demonstrated clear and substantial growth. Specifically in terms of hardware investment, the frequency of State Key Laboratory applications, which was initially capped at three times per year, has now doubled to six times annually. All of this is financed through research funding allocations. The review period has been reduced from one month to three days, and requests for amounts under CNY 100,000 now require approval from only a single vice general manager. The efficiency of fund utilization has improved across all areas.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

Since the beginning of 2021, research funding from enterprises within Sinochem Group has increased by more than 50%. Government-sourced national-level funding has shown no significant changes. The Marine Chemical Engineering Research Institute has increased its investment in scientific research equipment, with this year's research investment in xenon lamp aging testers, electronic universal materials testing machines, and laser particle size testing equipment reaching tens of millions of yuan. This overall trend demonstrates the growth in scientific research funding.

The mixed usage of funds depends on the specific requirements of individual projects and research topics. As cross-disciplinary research topics and interdisciplinary studies continue to increase, mixed usage may present future challenges. Rather than imposing blanket prohibitions, these situations require case-by-case evaluation.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

Scientific researcher turnover occurs at a notably rapid pace, particularly among front-line research personnel. Research funding has experienced substantial growth, with basic research fields receiving increased investment not only from the government but also from large corporations and state-owned enterprises. The growth rate of research funding in this field has exceeded double digits.

Mixed usage of funds serves as an illustrative example, though it requires both application and approval. The supervising organizations and implementing organizations of research projects must establish formal cooperation agreements and related contracts.

11. What priority is given to basic research that requires long-term investment? Is funding being channeled toward areas promising short-term benefits? Within China, are there perspectives suggesting that principal investigators need greater discretionary authority, particularly given that national funding carries numerous restrictions that make it challenging to utilize funds dynamically in accordance with scientific principles?

(1) Hongyong ZHU (China Institute of Atomic Energy)

Smaller research institutions and corporate research institutes that depend primarily on external projects for their revenue typically gravitate toward short-term benefits, as they must operate within the constraints of their management structures and specific research project requirements. Research institutions under state-owned enterprises and central state-owned enterprises maintain dual responsibilities: they must pursue external projects while simultaneously conducting internal strategic research initiatives. These research activities collectively form crucial components of the scientific research landscape and are fundamentally oriented toward basic, long-term objectives.

The Ministry of Science and Technology implements annual reviews examining how central enterprises and directly affiliated research institutes utilize and allocate their research funding. These assessment findings are transmitted directly to the Minister's Office at the Ministry of Science and Technology. Several recurring issues identified over recent years have now been addressed, including streamlining budget preparation processes, transferring budget adjustment authority, and implementing performance-based compensation through indirect costs. The "Opinions of the General Office of the State Council on Reforming and Improving the Management of Central Budgetary Research Funding" [in Chinese],[87] released in August 2021, established that scientific research projects in talent development and basic research would adopt the Comprehensive Funding System. The document indicated that detailed project budget requirements would be discontinued, and discretionary authority would see gradual expansion. The pace and scale of this expansion in discretionary powers would be calibrated to meet the expectations and projections of frontline research personnel.

(2) WANG Chengwen (Tsinghua University)

In April 2020, the Ministry of Science and Technology, together with six departments of the State Council, jointly issued revised policies highlighting basic research. These policies established comprehensive guidelines encompassing the entire research process, from project selection through evaluation to the commercialization of research outcomes. This framework stands as the most comprehensive policy system to date, with many of its components demonstrating robust operational effectiveness. From its strategic direction to practical implementation, it demonstrates a strong commitment to basic research.

China's scientific and technological development began relatively late historically, with many technologies building upon foundations from the former Soviet Union and the United States through a process of introduction, digestion, absorption, and subsequent innovation. The proportion of truly fundamental and core technologies remains relatively modest. This historical context indirectly fostered an emphasis on practical applications of science and technology while diminishing focus on basic research. Many scientific and technological evaluations became purely quantitative

87 "国务院办公厅关于改革完善中央财政科研经费管理的若干意见"
(http://www.most.gov.cn/xxgk/xinxifenlei/fdzdgknr/fgzc/gfxwj/gfxwj2021/202108/t20210813_176373.html)

measures of guidelines and practical applications, leading to academic superficiality characterized by the Four Onlys (papers only, positions only, educational credentials only, or awards only). This resulted in disproportionate attention to immediate, short-term benefits. These challenges emerged from national circumstances and historical factors. The government has acknowledged these issues and is implementing comprehensive reforms. Policy adjustments span multiple areas, including policy frameworks, cultural aspects, and talent development, leading to progressive improvements in these areas.

Persistent calls have addressed the need for greater discretionary authority for principal investigators, particularly regarding budgetary systems, ratios between direct and indirect costs, labor expenses, and consulting fee limitations. The government has responded promptly and proactively through policy measures, implementing precisely targeted reforms. These changes have substantially satisfied the pressing demands of all stakeholders. Moving forward, the critical question centers on whether the scientific community can establish a self-regulating and credible system of integrity while the government continues to demonstrate increasing openness. This matter warrants careful attention.

(3) XUE Lan (Tsinghua University)

Basic research outcomes inherently belong to the public domain and require comprehensive oversight at the national level. China demonstrates particular strength in mobilizing resources for major initiatives, capable of addressing several key technological challenges within compressed timeframes—including improving citation rates for Chinese scientific publications—in alignment with its strategic phased development priorities. Notable examples such as the Beijing Electron Positron Collider and the Daya Bay Neutrino Experiment demonstrate the distinctive advancement of Chinese science and technology capabilities. Nevertheless, basic science research projects that have achieved substantial impact remain limited in number, and basic science research comprises a relatively small proportion of cited works. While the original National Key Basic Research Development Program (973 Program) maintained a clear focus on basic science, even after the systematic reorganization of the research and development framework, the emphasis on basic science remains inadequate. Since 2018, the nation has undergone a strategic reassessment of basic science's importance, particularly recognizing its role in strategic competition. Through various channels—from leadership addresses at numerous venues to policy formulation—basic research has effectively been elevated to the highest tier of national strategy. This elevation led to the establishment of funding mechanisms such as the National Natural Science Foundation, enabling systematic implementation of these prioritized policies.

The question of emphasis on short-term benefits remains a matter of degree, which the government continues to address through policy adjustments. Specifically, the enhanced focus on basic research, reforms to the scientific research evaluation system, and increased emphasis on talent development all represent policy adjustments designed to correct an excessive orientation toward short-term benefits. These challenges fundamentally stem from certain management systems and administrative review processes. Historically, the evaluation criteria for science and technology officials may have suffered from excessive generalization and short-term thinking. With the reform of the science and technology system, implementation of external competitive mechanisms, third-party evaluation systems, and diversified investment assessments, policies are expected to shift toward prioritizing the long-term accumulation of scientific research achievements.

The perspectives of scientific researchers can be consolidated into two primary concerns. The first concern addresses the funding application and utilization process, where an abundance of repetitive administrative tasks effectively reduces time available for actual research. The second concern relates to standardized evaluation criteria for professional positions and ranks, which have increased the burden on scientific researchers. Current professional position evaluations rely heavily on quantifiable metrics such as the number of published papers and technical achievement awards received. The government has demonstrated understanding of these two areas and has implemented remedial measures through policies including the "Opinions of the General Office of the State Council on Reforming and Improving the Management of Central Budgetary Research Funding" [in Chinese] and the "Opinions on Deepening the Reform of Project Evaluation, Talent Evaluation, and Institutional Assessment" [in Chinese].[88] As specific implementation guidelines are now being executed across all regions, these measures are expected to address researchers' concerns to some degree.

(4) JIN Changqing (Chinese Academy of Sciences)

In recent years, the government has continued to strengthen its emphasis on basic research. Basic research has historically represented China's greatest weakness, a situation stemming from the country's scientific structures and institutional systems. The national leadership has acknowledged this challenge, and directives from the highest levels have manifested in specific policies and high-level design initiatives across numerous sectors. Looking ahead, national policies that prioritize basic research are expected to exert influence over specific scientific research projects.

While projects oriented toward short-term benefits have always existed, they were particularly prevalent before 2018, primarily due to social and international conditions shaped by rapid economic development. Since 2018, both domestic and international environments have grown increasingly challenging. In response to these evolving circumstances, the State Council issued the ""Notice of the State Council on Several Measures to Optimize Scientific Research Management and Enhance Scientific Research Performance"" [in Chinese][89] in 2018. This document explicitly advocated for "optimizing the formation mechanism of central fiscal science and technology planning projects with a focus on major national strategic tasks." Following this directive, all regions made corresponding adjustments to their scientific research funding and project formation mechanisms. This effectively elevated basic research to a more prominent and significant position.

There are primarily two areas of concern here. The first involves funding shortages and authority usage. The host organizations for scientific research projects are fundamentally public institutions, where base salaries remain relatively low and performance-based compensation is restricted by indirect project management costs. Additional challenges include caps on total performance-based rewards and inadequate incentive mechanisms. The second concern relates to project evaluation methodology. Expert reviewers predominantly concentrate on written evaluations, applicants' educational backgrounds, and academic histories, while failing to give adequate consideration to the scientific value and innovative significance of the proposed projects themselves. This represents the much-criticized "Four Onlys" issue. Both these concerns have seen active reform promotion at the national level. The State Council addressed the first issue by implementing clear, practical solutions through the "Opinions of the General Office of the State Council on Reforming and Improving the Management of Central Budgetary Research Funding" in 2021. Regarding review and evaluation processes, the National Natural Science Foundation of China initiated the RCC

88 "中共中央办公厅 国务院办公厅印发《关于深化项目评审、人才评价、机构评估改革的意见》"
(http://www.gov.cn/zhengce/2018-07/03/content_5303251.htm)

89 "国务院关于优化科研管理提升科研绩效若干措施的通知"
(http://www.gov.cn/zhengce/content/2018-07/24/content_5308787.htm)

(Responsibility Credibility Contribution) review mechanism in 2020, which has already generated substantial positive feedback. Consequently, while researchers' authority continues to expand, this transformation cannot be achieved instantaneously.

(5) LIU Huijuan (Tsinghua University)

Basic research has gained increasing prominence as a national strategic priority. The nation's leadership has come to recognize the paramount importance of basic research, creating an unprecedented situation where emphasis on basic research resonates throughout all governmental levels.

The nation had previously deemphasized basic research for a period. Operating under the assumption that economic leverage and technology transfer could provide access to foreign developments, research funding was primarily directed toward frontier technologies capable of achieving technological breakthroughs, with emphasis placed on numerous projects promising short-term results. Changes in the international landscape and national economy over the past four to five years have elevated basic research to a fundamental pillar of national scientific research strategy. This shift has garnered funding support across the entire spectrum, from policy formulation through to specific scientific research evaluation systems and planning initiatives.

The "Four Expansions" outlined in the "Opinions of the General Office of the State Council on Reforming and Improving the Management of Central Budgetary Research Funding" emerged from comprehensive stakeholder input. However, following the delegation of autonomy to scientific research institutions, the question of authority distribution between researchers and their institutions may reemerge as a significant concern. The management of scientific research funds cannot be accomplished through administrative and project budgeting methodologies alone. Superior research outcomes can only be achieved through full adherence to scientific research principles and by granting financial autonomy to research organizations and their researchers. At present, scientific research organizations remain predominantly state-owned or administrative entities. The challenge of balancing respect for scientific principles while maximizing scientific benefits may receive heightened attention moving forward.

(6) WANG Zhenpo (Beijing Institute of Technology)

In response to President XI Jinping's emphasis on basic research and his directive for its strengthening at the 2021 Joint Conference of Members of the Chinese Academy of Sciences and Chinese Academy of Engineering, the importance of basic research has reached unprecedented levels, manifesting in both policy and concrete scientific research activities.

Scientific research projects typically span approximately three years. In the past, research outcome evaluation was constrained by the "four onlys" system, resulting in inadequate exploration and depth in scientific research outcomes. The prevailing approach to scientific research became rapid publication in academic journals. This situation inevitably fostered a focus on short-term formalism. Current reforms are addressing these issues by emphasizing basic research and constructing new scientific evaluation systems.

Demands for expanded discretionary authority continue to resonate strongly. Prior to the funding reforms, challenges such as unscientific budgeting processes and excessively detailed specialized tasks related to financial reporting created substantial administrative burdens, representing the most significant source of dissatisfaction. As scientific research funding reforms progress, these concerns have diminished. However, some voices suggest that the pace of liberalization might be too rapid, expressing concerns about potential disruption to the academic environment.

(7) WANG Wei (Tsinghua University)

Basic research has attained paramount importance in current policy. The Outline of the 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and Long-Range Objectives Through the Year 2035 proposes elevating basic research funding to exceed 8% of total research and development expenditure, marking a significant increase from the previous consistent level of approximately 6%. The 14th Five-Year Plan outlines specific measures and objectives for strengthening basic research, establishing tax incentives for enterprises conducting basic research and encouraging societal funding through various channels, including donations and foundation establishment, to create a sustainable and stable funding mechanism.

The project-based approach to scientific research and short-term performance evaluation management has turned scientific research into a short-term, profit-oriented task. At the same time, there is a tendency for incentives in the transformation of scientific and technological achievements to become short-term oriented. In response to this, the "Guiding Opinions of the General Office of the State Council on Improving the Mechanism for the Evaluation of Scientific and Technological Achievement" [in Chinese][90] (August 2021) stipulated that it is necessary to strengthen medium and long-term evaluation, post-completion assessment, and retrospective analysis of achievements to guide scientific research personnel to immerse themselves in research and pursue innovation. The document explicitly states that through hierarchical evaluation systems and third-party, financial, and market-based assessments, the utilitarian problem of pursuing short-term benefits should be corrected.

Under the current system, there is a transition underway to convert invoice expense management into a contract-based Comprehensive Funding System. Within the present academic environment and supervisory framework, this involves delegating and separating authorities to give researchers more control over their funding usage. Looking ahead, while oversight may intensify at both the project initiation and completion phases, the supervision of interim expense management is expected to gradually decrease. The pace of these reforms, the development of the academic environment, and the evolution of the supervision and evaluation system are all progressing in coordination. This represents a systems engineering approach.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

During China's 13th Five-Year Plan period, Datang Telecom Group articulated a strategic repositioning from a "chip-terminal-cloud" industrial chain configuration to an industrial arrangement that "clearly distinguishes between primary and secondary focuses," centered on the integrated circuit design industry. This shift demonstrates a concrete commitment to prioritizing basic research. Integrated circuits serve as both the foundation and core of the information and communications industry, occupying a strategic position where industry development aligns with national development interests. As an industry leader, state-owned enterprises must therefore place greater emphasis on advancing fundamental research.

The year 2016, which marked the commencement of the 13th Five-Year period, represented a pivotal transition point. The 13th Five-Year Plan explicitly outlined a shift in management policy from short-term performance metrics to sustainable development. The company's original focus was on improving efficiency and performance in segmented markets, aiming to lead demonstration projects and large-scale development as a leader in integrated circuits and

90 "国务院办公厅关于完善科技成果评价机制的指导意见" (http://www.gov.cn/zhengce/content/2021-08/02/content_5628987.htm)

segmented fields. Currently, with integrated circuits plus as their core technology, they provide chips, applications, and solutions to establish smart and reliable connections for Personnel (P), Vehicles (V), Machines (M), and Things (T). From both an industry-level and medium to long-term strategic perspective, they are expanding their focus to more comprehensive objectives.

At the policy level, the use of scientific research funds has become highly flexible, and the next challenge involves determining authority distribution between project management organizations and applicants (teams). Due to ambiguous regulations, applicants' influence varies by individual, necessitating more detailed implementation guidelines at the micro level.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

Marine coatings fall under applied basic research, with primary research areas including the study, manufacturing, and screening of several key raw materials, characteristic evaluation, development of core technologies, and engineering fundamentals. This research must address critical issues common across the industry. The industrialization of these research outcomes provides a reliable technological foundation. Both investment amounts and acquired funding in this field have shown yearly increases, reflecting through financial metrics the nation's emphasis on this type of basic research.

The Chemical Research Institute maintains particularly stringent oversight of research projects aimed at short-term results. As a research institution within the state-owned enterprise system, it prioritizes the execution of national missions and the achievement of national strategic objectives. Market-oriented short-term speculation has consistently faced criticism and opposition, and the Marine Chemical Research Institute has demonstrated strong performance in maintaining these standards.

The national reform initiative to delegate authority to scientific research personnel continues to gain momentum. The previously controversial issue of expense management authority has now been effectively delegated to the project management organizations. These organizations generally respect the viewpoints of individual scientific researchers in this domain. While they establish certain baseline academic ethical standards and prohibited activities, the fundamental authority over expenditure usage primarily rests with the applicants (project leaders). This arrangement has generated significantly less controversy compared to previous approaches.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

Currently, both government and private sectors have reached a consensus regarding the importance of basic research, which has begun to be reflected in both policies and scientific research activities. The National New Energy Vehicle Technology Innovation Center was specifically established to promote fundamental research across the entire industrial chain.

The distinctive features of basic research are emphasized in terms of goal orientation and quantifiable objectives. From a strategic perspective, careful attention is being devoted to developing rigorous scientific evaluation criteria for research outcomes at this stage. In previous approaches, there was a greater emphasis on horizontal comparisons, which influenced short-term results. Moving forward, there is a recognized need to increase vertical comparisons. Specifically, improvements in innovative capabilities and contributions to fundamental competencies are anticipated to serve as key benchmarks.

While individual proposals and opinions on this matter are expected, they have not yet developed into strong collective voices or organized opposition. This can be attributed to an institutional advantage within China's decision-making mechanism, which efficiently incorporates researchers' perspectives while maintaining swift decision-making processes. Consequently, current scientific research policies can be viewed as representative of mainstream academic opinion. As individual perspectives evolve from group consensus to industry-wide positions, decision-making organizations maintain various channels through which they can integrate these viewpoints into policy formation. Copy

12. Has there been a review of evaluation methods that emphasized the “Four Only” criteria (papers only, position only, educational background only, awards only)? Are funding project reviewers being appropriately selected? Are reviews conducted fairly, and is transparency ensured through the disclosure of results? Do foreign experts participate in these reviews?

(1) Hongyong ZHU (China Institute of Atomic Energy)

Scientific research management departments have taken numerous initiatives to reform and move beyond the “Four Only” criteria. In August 2021, the State Council issued and implemented the “Guiding Opinions on Improving the Scientific and Technological Achievement Evaluation Mechanism” [in Chinese]. This document addressed specific measures to overcome the “Four Only” approach by establishing a classified evaluation system for scientific and technological achievements and building evaluation mechanisms involving government, market entities, third-party institutions, and financial investment organizations, along with corresponding review and evaluation methods. Going forward, projects including those under the National Natural Science Foundation of China will serve as pilot projects for these new measures.

Regarding funding project reviews, I personally believe they are relatively transparent and fair. Similar to the National Natural Science Foundation of China's review process, reviewers are selected from an expert database comprising individuals whose projects have been approved by the Foundation. Additionally, project directors from the Foundation's Science Departments participate in project reviews, along with actively involved experts selected from corresponding fields. This process is relatively open and transparent, with information made public through the information center. Dedicated expert management regulations exist, and internal supervision, higher-level oversight, external monitoring, and reporting systems ensure fairness and transparency. Furthermore, reviewing experts evaluate each other during project reviews to assess the fairness of their peers' evaluations within the group. Fairness levels are categorized as A, B, or C, with statistical data and situation reports submitted to the Ministry of Science and Technology.

In the National Natural Science Foundation of China's Foreign Scholar Research Fund, foreign expert reviewers participate in specific project evaluations. Since one prerequisite for becoming a reviewer is project experience, there are few domestic projects with foreign reviewers. Generally, foreign involvement in project review is concentrated in the Foreign Scholar Research Fund.

(2) WANG Chengwen (Tsinghua University)

Substantial progress has been made across multiple areas. The initiative to move beyond the “Four Only” criteria has been implemented through a campaign-style approach to promotion and execution, which has quickly achieved fundamental consensus and reached all organizational levels. This campaign-style approach to promoting and implementing reforms represents a distinctive characteristic of China's system. Despite some debate, the approach has yielded immediate results.

Fund project administrators maintain specialized organizations for project review, selection, and management. These institutions conduct their selection and review processes through established expert databases. While they can now reach consensus on project support decisions through clear standards, the criteria for potential new expert databases remain under discussion, with considerable uncertainty around their development. As the system transitions from project guidelines to project orientation, the review process is expected to gradually evolve through the inclusion of experts from third-party evaluation agencies and market financial institutions. This progression aligns with China's broader social development. The fairness and transparency of reviews depend on both system implementation and appropriateness. While the supervision and review systems have become more systematic and refined, ongoing improvements address personal bias and extra-institutional factors in the implementation process. The nation currently maintains a zero-tolerance stance toward corruption and misconduct outside established systems. These influences extend throughout academic and scientific research communities.

Foreign expert participation in reviews currently remains limited in scope. For national-level projects, such as those under the National Natural Science Foundation of China, while foreign expert opinions may be considered during reviews and peer evaluations, domestic experts continue to serve as the primary implementing body.

(3) XUE Lan (Tsinghua University)

In July 2018, following the issuance of "Opinions of the General Office of the State Council on Reforming and Improving the Management of Central Budgetary Research Funding" by the General Office of the Communist Party of China Central Committee and the General Office of the State Council, the Ministry of Science and Technology and several other ministries and agencies issued a "Notice on Launching a Special Action to Clean Up the "Only Thesis, Only Title, Only Diploma, Only Award" Approach" [in Chinese].[91] This notice directed various departments and organizations to examine and address the "Four Only" problems (over-reliance on papers only, titles only, degrees only, and awards only) in accordance with its spirit. Specifically, they were instructed to eliminate any unreasonable "Four Only" requirements from evaluation systems and regulations at all levels. Although the "Four Only" issues are now largely under control, future development requires the addition of more quantifiable indicators to create a more scientific evaluation system. Recent attempts to implement new standards include the "Action Plan to Strengthen a '0 to 1' Approach to Basic Research" [in Chinese][92] and the "Ten Opinions" from the Shandong Academy of Agricultural Sciences.

The selection and certification of review committee members is typically determined by specialized project management organizations in accordance with project guidelines, subject to approval from the Ministry of Science and Technology. Under current conditions, this system is considered the most objective and fair approach available.

Reviews are generally conducted by specialized review institutions through relatively transparent processes, with procedural safeguards ensuring fair selection of review committees. Based on the number of feedback reports and complaints received over the past two years, most researchers have accepted the review results without dispute.

International expert collaboration currently centers on high-level planning activities, with a particular focus on strategic research and task structuring for national science and technology programs.

The National Key Research and Development Program has registered approximately 90,000 experts in total, including 1,260 foreign nationals representing about 500 institutions. In the evaluation process for scientific research projects, including the National Natural Science Award, review materials are occasionally sent to international experts for assessment. These external evaluations can serve as significant reference points for the review committee's deliberations. A pilot initiative launched in 2018 began inviting foreign experts to participate in Natural Science

91 "科技部 教育部 人力资源社会保障部 中科院 工程院关于开展清理"唯论文、唯职称、唯学历、唯奖项"专项行动的通知" (http://www.gov.cn/zhengce/zhengceku/2018-12/31/content_5446309.htm)

92 "科技部等部门印发《加强"从0到1"基础研究工作方案》"(http://www.cac.gov.cn/2020-03/04/c_1584872637385792.htm)

Award reviews. Drawing from the results of these pilot programs, consideration is being given to expanding foreign expert participation to include basic research proposal reviews as well.

(4) JIN Changqing (Chinese Academy of Sciences)

The State Council's "Guiding Opinions of the General Office of the State Council on Improving the Mechanism for the Evaluation of Scientific and Technological Achievement," which took effect in 2021, specifically addresses the reform of the "Four Only" system. The initiative seeks to dismantle the existing scientific and technological evaluation framework that emerged from the "Four Only" criteria, with the goal of building an entirely new mechanism for evaluating scientific and technological achievements that better reflects China's national circumstances. The scope of this reform extends beyond the systematic evaluation of scientific research, as it encompasses political considerations as well. The "Four Only" system, which draws heavily from Western evaluation methodologies, has not been effectively adapted or implemented within the Chinese context. This situation previously generated significant disruption across the scientific research community, leading to a period when research fabrication became prevalent. Currently, the fundamental challenge lies in China's absence of an independent literature database, which represents a crucial prerequisite for establishing an appropriate evaluation system. This development is widely regarded as the essential next step requiring national support.

The selection process for review committee members begins with university nominations, followed by appointments made in accordance with project management review procedures. Review committee members consist of well-respected authorities and highly regarded experts in their fields, with whom project management teams proactively maintain communication. The overall process is considered fundamentally fair. The Chinese Academy of Sciences, which functions as a third-party oversight and review body for the National Natural Science Foundation of China, has received general approval for this role.

Ensuring fair review assessments remains a technical challenge, and reaching definitive conclusions is not always straightforward. Nevertheless, both the scientific validity and objectivity of the evaluation system and its criteria continue to show steady improvement. No significant issues have emerged where transparency and institutional safeguards are in place.

Regarding international participation in the review process, several pilot projects have been conducted previously. However, due to foreign experts' limited understanding of China's domestic research capabilities, they have found it difficult to provide targeted, practical insights and opinions during specific project reviews. The National Natural Science Foundation rarely invites foreign experts to participate in project reviews, However, for projects aimed at foreign participants, there are cases where foreigners are requested to conduct the reviews. Based on personal observation, foreign experts can contribute meaningfully to discussions about macro-level policies, evaluation framework systems, and assessment criteria. However, for evaluating specific projects at the micro level, Chinese experts who understand the current state of scientific research within China are considered more appropriate reviewers.

(5) LIU Huijuan (Tsinghua University)

Substantial improvements have already been implemented in the evaluation system. The scientific research community has adopted the Chinese Academy of Sciences Model for evaluation, which incorporates both quantitative analysis under the "Four Only" criteria and qualitative categorization through expert peer review. This peer review model is now extensively used across scientific research programs, including those administered by the National Natural Science Foundation.

The selection of review committee members centers on the fundamental question of peer selection for peer review. Following incidents involving objections to the review process of major special projects, there is currently debate over issues including the definition of "peers" (i.e., colleagues in closely related fields [*xiaotongxing*] and colleagues in distantly related fields [*datongxing*])[93], expert qualifications, and problems of personal bias in academic circles formed by peers. It is believed these can be resolved through a combination of quantitative and qualitative approaches.

The fairness of review processes currently relies primarily on the academic knowledge and qualifications of the participating experts. While this methodology is not considered ideal, it has generally met with acceptance within the academic community. The system ensures comprehensive transparency through systematic oversight of all procedures and processes, with clear accountability measures in place.

The Chinese Academy of Sciences maintains its strong emphasis on international expert participation through their evaluation framework known as the "Two Key Points and One Foundation." Within this system, assessment and evaluation by international experts constitutes the first key point. This is then followed by itemized reviews conducted by domestic peer experts, alongside annual monitoring of key quantitative indicators. At the national level, different approaches are taken for different types of projects. For international cooperation projects, foreign expert participation is considered the first priority when determining the composition of expert committees. However, for domestic projects, merely emphasizing foreign expert participation is not sufficient; domestic experts continue to maintain their central role in the evaluation process.

(6) WANG Zhenpo (Beijing Institute of Technology)

Progress in moving beyond the "Four Only" evaluation criteria has been proceeding smoothly. This shift is evident not only in adjustments to national-level research projects but also in scientific research initiatives at the provincial, municipal, and university levels, where dependence on these criteria has markedly decreased.

The selection of review committee members constitutes a vital component of the evaluation process. Since the review system fundamentally relies on peer review, the selection of these reviewers holds particular significance. One current challenge lies in the excessive centralization of reviewer selection within specialized research project management organizations. A major point of contention within the scientific community is the absence of clear standards for establishing expert databases and conducting preliminary screenings. These challenges may require resolution through the integration of foreign institutional practices and field-specific characteristics into future evaluation system reforms.

The fairness of reviews and transparency in result announcements are both procedurally dependent matters that should not present significant difficulties when proper oversight mechanisms are in place. At present, based on evaluations from all stakeholders and public opinion, the situation appears largely manageable. Following the 18th National Congress of the Chinese Communist Party, the placement of supervisory committees within institutions at various levels has led to notable improvements in certain problematic practices.

93 *Xiaotongxing* refers to professionals in fields that are relatively similar in specialization. while *datongxing* encompasses those working in more distantly related specializations.

In general, during initial reviews, the opinions of foreign experts may be solicited to serve as important reference points for expert evaluation. However, direct participation by foreign experts in peer reviews and deliberations remains uncommon.

(7) WANG Wei (Tsinghua University)

In October 2018, five departments (the Ministry of Science and Technology, Ministry of Education, Ministry of Human Resources and Social Security, Chinese Academy of Sciences, and Chinese Academy of Engineering) issued a "Notice on Launching a Special Action to Clean Up the "Only Thesis, Only Title, Only Diploma, Only Award" Approach." Following this notice, all major research institutions have improved their "Four Only" indicators in project, talent, and institutional evaluations, fundamentally restructuring these criteria.

The reviewer selection issue revolves around choosing between reviewers from broadly related fields ("large peer group") or closely related specialties ("small peer group"). Since new classification and diverse evaluation systems have not been established, and peer review remains the likely predominant method, the composition of review committees has emerged as a critical discussion point during this transition period. Future discussions must address small and large peer groups, expert database development, evaluation criteria quantification, and detailed reforms. Given the constraints on systemic changes, maintaining transparency and fairness in institutional processes is essential. Specialized research project management organizations currently operate most review activities. The possibility of implementing third-party oversight and fair re-evaluation remains a topic for future discussion.

Based on National Natural Science Foundation project selection results, the scientific research community continues to acknowledge the fairness of outcomes. Information in the online sphere maintains relative transparency. Any significant irregularities in processes or results would likely receive considerable exposure through internet and new media channels. The fairness of scientific research selection has proven highly satisfactory from both expert and public perspectives. Discussions regarding technical accuracy may require progressive improvements and adjustments, as no unified solution has emerged.

For initial evaluations of funded projects, including the National Key Research and Development Program, opinions are sought from international counterparts through various channels, though this practice remains in its trial phase and is not fully developed.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

At the enterprise level, interdisciplinary research projects generally maintain a purpose-oriented approach and follow reference indicators for guidance. This formalistic evaluation methodology appears infrequently and tends to be practical in its implementation.

The reviewer selection process cannot claim absolute objectivity and fairness. Differing perspectives on expert requirements at national, enterprise, and individual levels present particular challenges for reform efforts. However, the system ensures procedural transparency and fairness, and improvements have been made in post-review accountability and oversight mechanisms. The state has implemented comprehensive institutional and environmental safeguards to protect academic matters from non-academic external influences. Debates surrounding reviewer selection have largely remained within the academic domain.

The process maintains relative fairness throughout its implementation, from internal reviews to external audits, with specialized project management organizations serving as the primary implementing bodies. Recent years have seen intensified investigations into misconduct and corruption at national institutions. However, this field has revealed few problems, and there exists general satisfaction with results and evaluations. Protest cases like that of the Shanghai Jiao Tong University professor remain uncommon. While others share his position, he has not received universal support. This matter represents an academic issue rather than one of institutional integrity or corruption.

Regarding foreign expert involvement in the review process, participation remains limited. While their opinions may be sought for reference purposes, direct participation as reviewers occurs very rarely.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

The reform of the "Four Only" criteria has been implemented thoroughly, with the Ministry of Science and Technology beginning its screening and review of national-level projects in 2018. In 2019, Sinochem Group initiated a screening system that uses the "Four Only" criteria as keywords when evaluating all research projects and positions. These criteria have been eliminated from all related regulatory documentation.

The reviewer selection process draws primarily from expert pools, ensuring both academic standards and fairness, thus constituting a relatively equitable selection mechanism.

The system demonstrates transparency through public disclosure of review opinions, results, and complete processes, supported by oversight systems, indicating that the current evaluation system functions effectively. The ongoing reform addresses evaluation criteria rather than the evaluation system itself, and the operational aspects of the evaluation system have shown improvement.

During the pre-review phase and throughout major peer reviews, project management organizations seek specific input from foreign experts and peers. These opinions are summarized and provided to reviewers as reference materials, serving a meaningful role in the process.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

China has transformed its scientific and technological evaluation system, establishing a new framework in its place. The "Four Only" criteria represented an evaluation methodology that required reform. Since 2018, following the State Council Office's release of policy documents including the "Opinions on Deepening Reform of Project Review and Assessment, Talent Evaluation, and Institutional Evaluation" and the "Notice of the State Council on Measures to Optimize Scientific Research Management and Enhance Scientific Research Performance"[94], national departments, including the Ministry of Science and Technology, have reorganized simplified quantitative methods affecting scientific and technological evaluation activities across projects, talent, academic disciplines, and research centers. For talent evaluation, they have established evaluation standards using honorary titles, including scientific research project leadership positions and project review expertise. The evaluation system since 2019 has concentrated primarily on reviewing representative work, applications, and mission statements themselves, marking substantial progress in the field.

All reviewers are drawn from expert databases maintained by specialized project management organizations within various ministries and committees. This system ensures representation of the highest industry standards. Discussions surrounding the selection system and the distinction between "large peer groups" and "small peer groups" remain

94 "国务院关于优化科研管理提升科研绩效若干措施的通知"(http://www.gov.cn/zhengce/content/2018-07/24/content_5308787.htm)

internal academic matters. These issues continue under deliberation, as no scientifically convincing criteria have been established internationally. The current reviewer selection methodology aligns with domestic academic standards and national conditions.

National policy dictates that future scientific research evaluation must establish a performance assessment system founded on innovation quality and contributions. This framework needs to develop diverse classification and evaluation mechanisms that encompass scientific, technological, economic, social, and cultural values. Scientific evaluation activities currently exist in a transitional phase. Policy measures ensure transparency throughout the process and provide post-evaluation oversight systems, while national scrutiny of industry misconduct continues to strengthen. These measures basically guarantee that expert reviews reflect the reviewers' scientific research knowledge and academic judgment.

Foreign experts bring advanced knowledge in frontier technologies and areas where China has technological gaps. China's scientific research process parallels the development experienced by many nations, and the country places considerable importance on foreign expert perspectives While domestic scientific research reviews, including those conducted by the National Natural Science Foundation, take relevant expert opinions into consideration, reviewers must understand domestic policy directions and specific developments within the scientific community. Consequently, foreign input serves an advisory function without direct participation in scientific research project reviews.

13. Do you believe an appropriate scientific review system exists for particularly ambitious projects, including the participation of suitable scientists (including foreign experts) in their evaluation?

(1) Hongyong ZHU (China Institute of Atomic Energy)

The state maintains an open and inclusive stance toward innovative projects showing future potential. Research projects in this category benefit from simplified application and review procedures, including a system allowing submissions at any time. A comprehensive scientific review system has been steadily established, encompassing multiple elements: diverse channels for project proposals including direct online access, selection mechanisms incorporating peer reviewers from related fields and industry experts and a liability exemption system for disruptive innovation activities currently under consideration.

(2) WANG Chengwen (Tsinghua University)

Nearly all domestic research project reviews currently rely on expert evaluation support. The expert review methodology operates through a peer review mechanism based on majority consensus. This framework compensates for limitations in government policy-making expertise while elevating the scientific standard of decision-making. The existing peer review mechanism faces certain constraints in identifying and selecting ambitious projects, with consensus projects falling within the category of knowledge chain extension projects. Reviewing ambitious research projects extends beyond conventional thinking and cognitive experience, utilizing peer review opinions as important reference points. The system employs cross-field deliberation and diverse evaluation metrics that include participation from market financial institutions. This approach represents the current reform direction for evaluating such projects, has achieved consensus, and requires implementation through policies and projects. Tsinghua University and the Chinese Academy of Sciences have initiated pilot programs for cutting-edge scientific research funding mechanisms. These mechanisms specifically advance projects through research, review, and funding phases, ultimately establishing projects based on new scientific research value. Tsinghua University is currently collaborating with the National Natural Science Foundation of China to develop mechanisms for sustained funding support for projects that yield original breakthrough results.

(3) XUE Lan (Tsinghua University)

China's current evaluation system fundamentally relies on existin g academic value consensus and the continuation of established academic data trajectories. The evaluation of ambitious projects requires a more scientifically robust evaluation system. The "Guiding Opinions on Improving Scientific and Technological Achievement Evaluation Mechanisms," issued in June 2021, established that a classified evaluation system should be adopted moving forward. For these research projects, international peer review by researchers in closely related fields will be employed, implementing evaluation criteria that combine both quantitative and qualitative assessments. Additionally, considering the advanced and innovative nature of ambitious research projects, evaluations may incorporate technological tools such as big data and artificial intelligence (AI), developing information-based evaluation tools for the review process. In December 2021, ten departments, including the Ministry of Science and Technology, Ministry of Education, and Ministry of Finance, launched a scientific and technological achievement evaluation reform pilot project. This initiative is divided into two categories: comprehensive pilot projects and special pilot projects. Ambitious projects fall within the comprehensive pilot projects category and will be implemented progressively at the provincial level moving forward.

(4) JIN Changqing (Chinese Academy of Sciences)

As I understand it, ambitious projects refer to innovation-oriented research initiatives, which the National Natural Science Foundation of China designates as "Creative Exploration Program Projects." These projects transcend conventional thinking and established cognitive frameworks, which creates significant disparities in the peer review process. This makes achieving consensus difficult and increases the likelihood of rejection. Reform initiatives and policy recommendations from various governmental bodies, including the State Council and the Ministry of Science and Technology, consistently encourage the optimization and enhancement of evaluation systems for projects that fall outside this category. The government is gradually introducing international peer review processes in select areas of frontier and basic sciences, incorporating classified reviews and third-party evaluations by financial institutions. They are also exploring non-traditional review and decision-making models. Policy reforms specifically target these challenges by emphasizing original innovation in research, while maintaining the existing requirements for preliminary groundwork and feasibility studies. The review mechanisms for such projects are undergoing continuous improvement.

(5) LIU Huijuan (Tsinghua University)

Systematic improvements are advancing primarily in terms of evaluation metrics and assessment frameworks. The General Office of the State Council issued the "Guiding Opinions of the General Office of the State Council on Improving the Mechanism for the Evaluation of Scientific and Technological Achievement" [in Chinese], which stipulates that science and technology evaluation criteria must emphasize several key elements: contributions to creativity in addressing major scientific challenges, the scientific value of research outcomes, technological innovation and integration capabilities, achievement of technological breakthroughs, and independent intellectual property rights. The document outlines plans to establish a needs-driven approach and advance the development of an innovation system through Strategic Open Recruitment and related mechanisms.

Regarding innovation projects in basic research fields, the State Council General Office's guidance recommends peer review by international experts in closely related disciplines, implementing an approach that combines quantitative and qualitative evaluations. The peer review system is currently under review, with the Chinese Academy of Sciences being consulted for their input. There is strong institutional support for incorporating foreign experts into scientific research innovation projects or delegating review processes to foreign institutions, though measures may be needed to prevent interference from political factors.

(6) WANG Zhenpo (Beijing Institute of Technology)

Based on my understanding, ambitious research topics are primarily innovation-oriented research initiatives characterized by their lack of consensus and disruptive qualities. Projects with stronger innovation orientation tend to generate considerable disagreement among experts within the same field. The current evaluation system for academic papers and projects predominantly relies on peer review mechanisms, which places projects lacking consensus at a distinct disadvantage during the assessment process. To support these innovative endeavors, the National Natural Science Foundation of China has implemented a specific approach for novel research topics and project applications that are either high-risk or controversial. This approach involves providing initial small-scale funding, typically with a one-year duration. After this initial period concludes, researchers may compile their findings and submit an application to the National Natural Science Foundation of China before reaching their final project conclusions. The Foundation's director then evaluates whether to extend funding for an additional year. The National Natural Science Foundation sets approximately 5% of its funding for small grants. This modest percentage reflects a broader issue: such research topics currently lack both institutional safeguards and sustainable long-term financial support. Even the government's efforts to establish a classification evaluation system represent merely an enhancement of existing frameworks rather than fundamental systemic change.

(7) WANG Wei (Tsinghua University)

All national-level scientific research programs, including the National Natural Science Foundation of China's "Creative Exploration Program Projects," are establishing scientific research evaluation systems focused on research and development quality as they actively explore assessment mechanisms for innovation-oriented research topics. However, the actual review criteria are not yet fully established. While adjustments are being made to the comparative weighting of short-term quantitative indicators such as number of papers, patent counts, and economic benefits, the new evaluation system remains inadequately developed.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

The Datang Telecom Group earned selection to the first cohort of the Ministry of Science and Technology's "National Hackerspace Specialization Demonstration Organizations." Datang Network Co., Ltd., operating under the Datang Telecom Group umbrella, represents a central enterprise subsidiary within the State Council's mixed economy reform initiative. The China Communications Enterprise Association has certified Datang Network Co., Ltd. as a "5G Innovation Enterprise." Datang Telecom Group maintains a leading position in China in both institutional structure and technological capability. The evaluation process for innovation-oriented research topics remains in an exploratory phase within China, with substantial ongoing debate regarding appropriate evaluation methodologies. This situation necessitates future improvements to system development. The Ministry of Science and Technology continues to examine these research topics. The current framework represents a transitional system that lacks both scientific rigor and appropriateness.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

The current review system's fundamental weakness lies in the absence of third-party perspectives from market participants and enterprises. This deficiency stands as the primary reason for the decreased industrial application of scientific research outcomes and their reduced social benefits. When experts from scientific research institutions conduct evaluations and reviews, their assessments tend to maintain an exclusively technical focus, emphasizing the advancement of technical parameters and indicators. This approach results in insufficient consideration of market demands and competitive potential, particularly when evaluating how innovation-oriented research topics contribute to these areas. The government is currently implementing reforms to these scientific research evaluation systems. Looking ahead, the assessment of innovative and ambitious research topics is expected to incorporate market and financial perspectives. These changes should lead to enhanced policies, improved evaluation systems, and higher quality outcomes for innovation-oriented research initiatives.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

Ambitious research topics possess inherent characteristics that make achieving consensus exceptionally difficult. Reviewer subjectivity plays a particularly prominent role when evaluating research topic design, scientific methodologies, and research outcome content. The existing peer review system proves inadequate for generating synchronized, scientifically sound opinions. Despite various governmental initiatives and trials, subordinate organizations, including the National Natural Science Foundation of China, have announced only two non-consensus projects. This reform effort, representing a crucial component of broader systemic changes, may require comprehensive clarification at both systematic and institutional levels rather than minor procedural modifications.

14. Are research outcomes being evaluated appropriately in terms of evaluation cycles and the selection of expert reviewers? To what extent do you believe research outcome evaluations and resource allocation decisions accurately reflect performance? What methods are employed for conducting follow-up assessments and post-completion evaluations to bridge basic research with industrial applications?

(1) Hongyong ZHU (China Institute of Atomic Energy)

While achieving absolute precision in evaluations remains an impossibility, the evaluation process continues to show positive development, particularly regarding specialization. Recent reform initiatives have garnered favorable responses, especially those aimed at dismantling the "Four Only" criteria and implementing classified review systems. The distribution of scientific research resources has largely fulfilled its fundamental objective of reflecting evaluation outcomes in an objective and equitable manner. Basic research fundamentally focuses on investigating natural laws and scientific methodologies, operating without specific directional targets in its research approach. Although basic research outcomes contribute to industrial validation, their fundamental value lies in their potential to generate novel industrial ecosystems through unpredictable pathways. As a result, the follow-up evaluation of industrial applications stemming from basic research constitutes a distinct evaluation framework based on practical and industrial perspectives. This process advances primarily through platforms connecting industry, academia, and research institutions, supported by incentive measures. Currently, no mature criteria exist for evaluating how effectively basic research translates into industrial applications. This form of evaluation centers primarily on assessing research institutions rather than individual projects.

(2) WANG Chengwen (Tsinghua University)

Perfect fairness is impossible. The current scientific research evaluation system adequately meets national standards for scientific, technological, and social development.

Two issues of inequity are currently being debated. The first concerns how achievements are distributed within projects. Interpersonal relationships sometimes prevent resources from being allocated based on project significance or individual contribution levels. This is particularly evident in patent application sequences and author ordering, where internal conflicts remain prominent and clear evaluation standards are still lacking. The second issue pertains to long-term usage rights for scientific research outcomes. This specifically involves the priority and long-term usage rights of scientific and technological achievements by professional researchers, as well as how these achievements are distributed between researchers and their affiliated institutions. While researchers face some disadvantages in this arrangement, pilot policies are actively expanding protections for researchers' achievements and showing greater respect for their work.

Basic research operates on a longer cycle than other research types. Throughout this extended research process, demonstrating a scientist's value presents significant challenges. The conversion period between scientific development, technological advancement, and practical application is becoming shorter, making the integration of basic and applied research increasingly crucial. These characteristics have made basic research evaluation a vital component of the scientific and technological achievement evaluation system. It has been integrated into a framework based on classified evaluation, encompassing basic research tracking, post-completion assessment, and the concrete realization of industrial applications. A fully developed scientific research achievement evaluation system incorporates evaluation indicators for all these elements and establishes its own evaluation standards.

(3) XUE Lan (Tsinghua University)

The evaluation of scientific and technological achievements must be grounded in their inherent scientific value, with this value serving as the fundamental core of the evaluation process. In this regard, China has taken an indirect approach and continues to implement ongoing corrections. The dismantling of the "Four Only" policy exemplifies this correction of past errors. The "Guiding Opinions on Improving the Scientific and Technological Achievement Evaluation Mechanism" [in Chinese] establishes the foundation for new evaluation standards. The current evaluation system integrates management and services from both market and planned economies, representing an evaluation methodology that aligns with China's present stage of social and scientific-technological development. This system is expected to evolve toward greater scientific rigor and service orientation. Several elements are anticipated to become crucial moving forward: an evaluation mechanism encompassing five values (scientific, technological, economic, social, and cultural), a classified evaluation framework for scientific and technological achievements, increased incorporation of financial investment and market factors in evaluating scientific and technological achievements, and evaluation by private third-party organizations.

Limited interest in basic research has created a risk within the scientific research achievement evaluation system of diminishing both achievements and resource allocation in basic research, though efforts to address this are underway. Within the comprehensive evaluation and resource allocation system, improvements are being made to address two issues: the sequence ordering between initial participants and team members and the limitation that only one project participant can submit patent applications.

Current implementation includes making science popularization a mandatory evaluation criterion for basic research projects within national-level scientific research projects under the National Key Research and Development Program. The pilot program system implements long-term evaluation, focusing on detailed study of basic research papers after publication, assessment of mid to long-term innovation performance, and post-implementation evaluation of achievement transformation. These pilot programs are primarily conducted through the Chinese Academy of Sciences and in the Shanghai region.

(4) JIN Changqing (Chinese Academy of Sciences)

The evaluation system is being improved incrementally and generally corresponds to China's current scientific research standards.

Under the previous management-centered scientific system, individual researchers' contributions to scientific research achievements lacked clarity and were undervalued, which resulted in insufficient authority and inequitable resource distribution. Against this backdrop, as reforms continue to advance, individual scientific researchers' contributions will receive heightened recognition. Furthermore, policies governing the distribution of benefits from scientific research achievement transformation will be enhanced, and economic incentives are expected to develop in parallel with these changes.

Basic research is distinguished by its focus on exploring natural laws and scientific methodologies rather than targeting specific applications and does not prioritize the development of technologies for industrialization or commercialization. In response to this characteristic, the state has implemented two measures to actively promote the industrialization of basic research. The first involves incorporating corporate and market evaluation elements into basic research assessment, while simultaneously encouraging enterprises to pursue their own basic research initiatives. Silicon Valley in the United States has achieved notable success in these areas, and China is currently studying and exploring these approaches.

(5) LIU Huijuan (Tsinghua University)

The Chinese Academy of Sciences has extensively modeled its evaluation system on that of Germany's Max Planck Society, allowing for active refinement of its evaluation system and methods according to strategic needs at different periods. This approach enables the Chinese Academy of Sciences to experience minimal external influence and modify its evaluation system more deliberately based on its development requirements. In contrast, universities face intensifying competition over various rankings. This ranking-based competition affects teachers, students, and parents while also influencing competition for development resources. Given these circumstances, a reform model aimed at reorganizing and standardizing national resources may not be feasible. While the state has proposed policy-based directions for improvement, evaluation processes may require ongoing refinement based on each project's scientific characteristics and current status. Throughout this process, establishing high-level expert teams and fostering a culture of integrity and credibility among scientific and technical personnel remains crucial.

Both evaluation outcomes and subsequent resource allocation form integral parts of enhancing the evaluation system. Going forward, the fairness of basic research evaluation combined with stable, long-term resource allocation is expected to gradually improve the alignment between resources and scientific research achievements. Moreover, reforms that reduce the proportion of indirect costs retained by project management organizations may progressively enhance resource distribution at the grassroots level. The "Guiding Opinions on Improving the Scientific and Technological Achievement Evaluation Mechanism" [in Chinese] explicitly states that evaluations of scientific and technological achievements, including basic research, should place greater emphasis on achievement transformation assessment. At the same time, the system will further enhance its three-part evaluation framework that emphasizes outcomes and socioeconomic development, utilizing user evaluations, market inspections, and third-party assessments as primary evaluation indicators. The system will also employ technology transfer contract values, market valuations, market share, and implementation status in major projects or leading enterprises as key evaluation metrics. Additionally, the effectiveness of industrial applications of scientific research achievements will serve as a vital indicator. Further detailed implementation work will be necessary moving forward.

(6) WANG Zhenpo (Beijing Institute of Technology)

Within the framework of current national conditions and the top-down project implementation system, institutions have maximized the scientific evaluation of research achievements. The evaluation systems for basic research projects and innovation-oriented research projects, along with evaluation standards for general projects, continue to show steady improvement and progress.

Research achievement evaluation and resource allocation remain fundamentally internal matters for project groups. Significant differences and challenges persist in establishing consensus and resource allocation standards between interdisciplinary fields and cross-industry research teams composed of interdisciplinary areas. These issues may require scientific clarification from a national policy perspective.

According to the "Notice of the State Council on Measures to Optimize Scientific Research Management and Enhance Scientific Research Performance" and the "Guiding Opinions on Improving the Scientific and Technological Achievement Evaluation Mechanism" [both in Chinese], evaluation of basic research and applied basic research projects occurs through peer review, emphasizing projects with substantial scientific value. The evaluation encompasses multiple dimensions: the significant originality and scientific value of new discoveries, principles, methods, and laws; effectiveness in addressing scientific challenges related to major economic and social development needs and national security; impact on supporting technology and product development; and the quality and level of scientific research achievements, including representative papers. For basic research achievements incorporating supporting technologies and product development, evaluation must assess the effectiveness of product development projects and applied demonstration projects. Performance tracking and evaluation take place within two to three years after completion. The process focuses particularly on the transfer and transformation of project achievements, their application and dissemination, and their resulting economic and social benefits. Looking ahead, the establishment of classified evaluation and diverse evaluation systems may incorporate third-party evaluations, including market and financial assessments, potentially leading to comprehensive reviews of industrialization evaluation.

(7) WANG Wei (Tsinghua University)

Under the current institutional and technological framework, the evaluation of scientific research achievements maintains fundamental objectivity and fairness. Since the 18th National Congress of the Chinese Communist Party, there has been decreased tolerance for domestic corruption. This has led to the curtailment and resolution of issues that previously affected academic integrity within academic circles, including "relationship-based evaluations," "academic faction culture," and "territorial culture." Present challenges focus on the scientific aspects of research achievement evaluation. Following the dismantling of the "Four Only" policy, there remains a need to explore incremental processes until a new grading evaluation system can be established.

Evaluation systems for research institutes and universities, including their frameworks for rewarding research achievements, have achieved relative maturity and face fewer issues. Implemented in 2020, the "Notice by Nine Departments Including the Ministry of Science and Technology of Issuing the Implementation Plan for the Pilot Program of Conferring the Ownership or Rights of Long-Term Use of Job-Related Scientific and Technological Achievements on Scientific Researchers" [in Chinese][95] has created policy impacts that will certainly increase the authority and benefits granted to scientific research personnel regarding their achievements. Current challenges primarily affect researchers in the corporate sector. Issues such as incomplete performance evaluation systems and inequitable distribution of scientific and technological achievements, including patent rights, reflect a certain degree of corporate underinvestment in research and development. Enterprises are steadily addressing these issues alongside the transformation of state research institutions, demonstration effects, and expanded personnel mobility mechanisms.

Basic research requires long-term research and development investment and continuous accumulation to develop independent technologies, characterized by an investment return rate pattern that is "slow at the beginning, fast at the end." Investment in basic research cannot be evaluated solely through short-term accounting measures. Development is underway for evaluation systems that include grading evaluation systems, medium to long-term evaluation cycles, and post-completion tracking mechanisms.

[95] "科技部等9部门印发《赋予科研人员职务科技成果所有权或长期使用权试点实施方案》的通知"
(http://www.gov.cn/zhengce/zhengceku/2020-05/19/content_5512908.htm)

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

The evaluation of scientific research outcomes has achieved relative sophistication and objectivity within the information and communications industry. This advancement has indirectly strengthened the nation's leading position in the global telecommunications network industry.

In terms of resource allocation, there exist notable differences between national research institutions and elite universities listed in the 985 and 211 projects. These differences both reflect concrete research achievements and align with national strategic considerations. In several middle and high-end fields, there are expectations for the development of premier research institutions. While the process of providing feedback to other research institutions based on these developments represents progress, the supporting institutional frameworks require further refinement.

The system for evaluating scientific research outcomes, including basic research, is undergoing reform. One key aspect of these reforms involves the implementation of long-term tracking and evaluation of basic research applications. At present, this initiative remains primarily limited to the expansion of laboratory work and data collection, with heavy reliance on logical analysis and expert assessment. Moving forward, this may evolve into a comprehensive system encompassing medium to long-term tracking evaluation in practical applications, along with mechanisms for funding implementation and follow-up procedures.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

Research outcomes cannot be evaluated through a one-size-fits-all approach, making it essential to advance a differentiated evaluation system. In the wake of abolishing the "Four Only" criteria, we find ourselves in a transitional period of analysis before implementing a new evaluation system. The current adjustment phase presents numerous challenges in evaluation methodology, particularly regarding peer review protocols. Although the peer review system is regarded as objective and fair in practice, there remains significant scope for refinement and enhancement.

For our research institute, the most pertinent issue currently centers on the ownership and usage rights of intellectual property generated through the work of scientific research personnel. The existing framework implements a distribution principle where ownership and usage rights are allocated between individual researchers and the research institute at a ratio of 3:7. This distribution ratio has remained unchanged for nearly a decade. However, as national policies increasingly emphasize the achievements of scientific researchers, this balance is expected to shift progressively in favor of the researchers. The initial phase of this transition is scheduled to commence in 2025, introducing an equal distribution between parties as the basic principle, with provisions for special circumstances to be addressed through consultation and subsequent reforms. Survey findings indicate that researchers express dissatisfaction with this proposed plan. This matter requires further detailed examination going forward.

Regarding the evaluation and practical application tracking of basic research, while no definitive systems or standards are currently in place, the Ministry of Science and Technology's growing emphasis on basic research and its practical applications will necessitate the implementation of a two to three-year tracking mechanism. However, no pilot programs have been initiated at this time. Moving forward, it will be necessary to identify key project implementation points and proceed with policy advancement.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

The current evaluation system operates primarily under state leadership, with relevant organizations within various ministries and committees taking principal responsibility for implementation. This institutional structure ensures the highest level of objectivity and fairness. This foundation presents opportunities to incorporate market elements that could address gaps in the government-led evaluation framework. The system demonstrates both scientific rigor and practical effectiveness in terms of industrializing research outcomes and generating economic benefits.

Distribution remains the primary challenge, specifically regarding the relatively low proportion of incentives within indirect costs. This particularly affects early-career and mid-career researchers, who constitute the backbone of scientific research yet receive comparatively modest economic incentives. Future evaluations of scientific research outcomes must be integrated with reforms to the merit-based system. The National New Energy Vehicle Technology Innovation Center has implemented a third-party evaluation system for assessing researcher contributions, distributing incentives based on these assessments. Financial institutions and third-party market organizations conduct approximately 50% of these evaluations, employing diverse assessment methods to ensure equitable distribution of research outcomes.

Tracking evaluations focus primarily on goal-oriented applied basic research projects. The State Council's "Notice of the State Council on Measures to Optimize Scientific Research Management and Enhance Scientific Research Performance" stipulates that these project categories may undergo performance tracking evaluations with feedback within two to three years of completion. These evaluations specifically emphasize the transfer and transformation of project outcomes, their practical application and dissemination, and their resulting economic and social benefits. The classified evaluation system reform, launched in 2022, provides similar guidance for evaluating such research categories, bringing enhanced policy clarity.

15. Has the evaluation of research paper quality, rather than impact factors and publication counts, produced positive results? Have recent reforms in journal submission practices, including the increased emphasis on domestic Chinese-language journals, yielded positive effects on research implementation?

(1) Hongyong ZHU (China Institute of Atomic Energy)

This represents one component of dismantling the "Four Only" policy framework. Following the April 2020 implementation of "Measures for Eliminating the Undesirable Trend of 'Relying Solely on Papers' in Science and Technology Evaluation (Trial Implementation)"[96] [in Chinese], scientific research evaluations across various fields have demonstrated leadership in enhancing academic impact and achieving practical applications, making substantial contributions to economic and social development as well as national security. The emphasis placed on publication quantity has significantly diminished. This shift represents a meaningful reduction in superficial metric adherence and signals a return to an authentic academic evaluation system that maintains both persuasive authority and the capacity to advance technological progress. The increased attention to Chinese-language journals offers distinct advantages: it lowers submission barriers and reduces unnecessary labor associated with English translation. This shift enables focused analysis from a professional perspective rather than mere procedural review. From personal experience, this approach reduces the overall workload by one-third.

(2) WANG Chengwen (Tsinghua University)

This matter fundamentally concerns the direction of academic research. Quality academic papers require a rigorous scholarly approach, profound individual scientific inquiry, and substantial investment of energy. In earlier examinations of publication practices, many students, including doctoral candidates, concentrated on factors that would influence successful publication. Although universities and other institutions offered accelerated publication courses, these have been substantially reduced. Students are now dedicating increasingly more time to in-depth consultations with their academic advisors. In my current role supervising three doctoral students, our weekly paper discussion sessions have extended by approximately three hours compared to previous practices. These discussions concentrate purely on academic substance rather than tracking trends in academic journals.

The emphasis on Chinese-language domestic journals has enabled research to be grounded in solving domestic issues, allowing for selection from a broader range of topics, with a notable increase in research projects focused primarily on domestic research content. The peer review process for domestic core journals proceeds at a more deliberate pace, necessitating research proposal submissions approximately one month earlier than before. With regard to domestic Chinese-language journal publications, there has been increased overlap in research directions and topics, resulting in heightened competition. This situation demands that research be grounded in scientific fundamentals and principles, rather than merely processing straightforward comparative analyses or implementing adapted technological approaches. Additionally, more critical consideration of funding issues and their solutions indirectly promotes the advancement of students' scientific research capabilities.

96 "科技部印发《关于破除科技评价中"唯论文"不良导向的若干措施(试行)》的通知"
(https://news.sciencenet.cn/htmlnews/2020/2/436125.shtm)

(3) XUE Lan (Tsinghua University)

This development marks a positive return to fundamentals, reflecting the evaluation system's restoration of genuine scientific merit as its core value. In the current environment, scientific researchers have moved away from the blind pursuit of quantitative metrics, instead devoting themselves authentically to their specialized work. This shift has strengthened the academic atmosphere supporting scientific research beyond previous levels. Earlier evaluation practices were characterized by an inflated research style that relied heavily on personal connections for publication opportunities. This approach has now diminished, with scientific research operations increasingly concentrating on addressing concrete research challenges.

We must draw a clear distinction between emphasizing Chinese-language journals and emphasizing domestic journals, as these represent fundamentally different approaches. I endorse the emphasis on Chinese-language journals, viewing it as an essential tool for establishing international academic discourse authority. This represents a critical component in the chain of international scientific and technological competition, where academic discourse authority enables engagement with international standards and helps shape academic direction. This stands as a strategic objective in international competition and represents a critical challenge that China must address in its development trajectory. On the matter of emphasizing domestic journals, I maintain certain reservations. I have consistently expressed objections in various contexts, primarily due to what I perceive as excessive influence from political factors.

(4) JIN Changqing (Chinese Academy of Sciences)

The evaluation of academic achievements has shifted from formalism back to judgments based on intrinsic academic value, improving both the quality of evaluations and scientific research outcomes. This transformation has fundamentally addressed the problem of overly ornate academic writing styles.

In 2016, President XI Jinping emphasized that "the majority of scientists and technologists should write their papers on their homeland's soil." The Ministry of Science and Technology has been actively encouraging publication in domestic academic journals whenever possible. The domestic academic community has responded to these critical observations with both anticipation and support. The best research outcomes were not submitted to Chinese-language journals. This used to be a typical phenomenon, and an established fact The primary reason for this was that Chinese-language journals were unable to meet the needs of scientific researchers. This was particularly true in innovative fields where China lacked authoritative standing. In these areas, publishing papers essentially served as a means of promoting one's academic achievements, with researchers hoping to gain recognition in academic circles. The academic community operates within a hierarchical structure, with top-tier institutions leading the way and the majority following their lead. In fields where China does not hold a leading position, researchers must publish in journals recognized by high-level academic circles. This represents an established academic protocol. Naturally, the academic standards of domestic journals have been steadily rising, with core journals elevating their requirements year after year. Furthermore, compared to the Science Citation Index (SCI) and similar indices, domestic journals' review criteria tend to place greater emphasis on practical applications. As the industrial chain evaluation system improves and technological standards advance, there may be a return to domestic publication. This represents a process that the domestic academic community comprehends and can adapt their research strategies accordingly. At present, the more concrete change lies in making every effort to submit papers to both domestic and international journals simultaneously, and while this increases the workload, it is a transitional phase.

(5) LIU Huijuan (Tsinghua University)

The quantitative evaluation system known as the "Four Onlys" is in a transitional phase, and until a new evaluation system is fully established, the assessment of published papers continues to serve as a critical indicator. Since 2020, research projects, including those under the National Natural Science Foundation of China, have shifted their focus from mere paper counts to emphasizing the practical problem-solving capabilities demonstrated in research papers. This reverse incentive has effectively addressed the issue of professional paper writers across various fields. In the medical field, for instance, this has led to improvements in practices such as the "paper machine" phenomenon, where researchers would test a single gene against all types of tumors. The prevalence of publishing papers through personal connections, relationship building, and monetary payments has decreased significantly, and the tendency toward hasty research pursuits has been somewhat curbed. Certain highly practical positions, such as clinical physicians, have eliminated paper quantity requirements entirely.

In relation to these policies, it should be noted that among the five papers submitted for science and technology achievement applications, more than one-third were published in domestic journals (distinct from Chinese-language journals). Among papers submitted this year, there has been a marked increase in those demonstrating practical achievements in technology transfer and concrete contributions to social development.

(6) WANG Zhenpo (Beijing Institute of Technology)

With greater emphasis being placed on paper quality, researchers are now paying more attention to original, direct experimental data than they did previously. This shift extends beyond simply writing papers based on publication and presentation prospects. The focus of paper writing has returned to the exploration of fundamental scientific research questions, marking clear progress.

The new emphasis on Chinese-language journals has encouraged researchers to pay greater attention to domestic academic standards and the research findings of their Chinese colleagues. Specifically, the identification and comparative analysis of published domestic scientific research can more effectively promote the continuity of scientific research within China.

(7) WANG Wei (Tsinghua University)

The transformation of academic styles has yielded significant benefits. In the past, project team meetings centered on discussing presentation techniques, networking strategies, and tactical approaches—all of which represented speculative academic behavior. Now, research team discussions have refocused on core academic disciplines, and invited experts are more freely sharing their accumulated expertise. This represents the beginning of a virtuous cycle.

The quality of Chinese-language journals currently varies considerably, and changes made solely on the basis of language may not result in substantive improvements. Real progress requires both reform of the journals themselves and elevation of their standards. At present, efforts are focused on promoting and encouraging these changes, and further discussion may be needed regarding whether specific quantitative metrics and numerical indicators should be used for evaluation.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

The impact continues to be substantial, particularly on scientific research activities at the grassroots level, where researchers employ specific strategies and techniques for publication that extend beyond the scientific content of the papers themselves. Online platforms now offer intensive short-term training programs focused on publishing in Science Citation Index (SCI) journals, which represents one of the negative outcomes of systemic distortions in the academic system. Currently, there is a gradual shift back toward mainstream academic standards, with an increased focus on the quality of scholarly discourse. This development marks positive progress in the field.

While the emphasis on publishing in Chinese-language journals serves as a double-edged sword, it plays a progressively important role in preserving domestic technological knowledge and building internal systems. However, placing excessive emphasis on the status and function of Chinese-language journals leaves the academic sphere vulnerable to political influences from outside the scholarly community. A noticeable gap still exists between the overall quality of Chinese-language journals and mainstream publications such as those indexed in SCI. Until this disparity is eliminated completely, it may continue to impede cross-disciplinary technological comparisons and international collaborative efforts.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

In terms of position evaluation, the focus has shifted away from quantitative metrics. The current system, which evaluates representatives' bodies of work, places greater emphasis on research outcomes than previous approaches, signaling a return to fundamental scientific principles. This shift enables researchers to dedicate more effort to specialized research and studies within their areas of expertise.

Regarding recent reforms in journal submission policies, there has not been significant impact. In the past, publications from the Institute of Marine Chemical Technology were predominantly in domestic Chinese-language journals, with relatively few international publications.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

The National Innovation Center for New Energy Vehicles is currently implementing reforms to its annual researcher evaluation system by adopting an approach modeled after the representative evaluation systems used in universities. Under this system, researchers' annual technological contributions are assessed based on their most valuable scientific and technological achievements. This evaluation methodology goes beyond merely listing scientific activities and published papers.

Although Chinese-language journals do not possess the same level of influence or authority as SCI publications, they are firmly rooted in China's practical circumstances, and their contributions to humanities and social sciences have attracted considerable attention. Contemporary evaluation of scientific research outcomes places greater emphasis on their potential for practical application and the economic and social benefits they generate. This approach is anticipated to advance both the industrialization and development of scientific research outcomes while strengthening the collaborative relationships between industry, academia, and research institutions.

16. Please list China's future priorities in the field of R&D or in the science management system.

(1) Hongyong ZHU (China Institute of Atomic Energy)

The authority over scientific research project applications, fund utilization, and other research activities has been extensively delegated, with numerous administrative powers transferring from national management departments to project-implementing organizations. However, implementing organizations, applicants, and project leaders lack clear policy guidance regarding project application authority and the use and management of funds. There are irrational factors and systems that constrain researchers' activities, which need to be improved in subsequent phases according to the specific nature of scientific research institutions.

(2) WANG Chengwen (Tsinghua University)

A critical issue concerns the establishment of a system to ensure honest and credible scientific researchers. The reforms in China's scientific research sphere predominantly emphasize marketization and service orientation. The central challenge lies in establishing a highly autonomous academic atmosphere founded on scientific principles. This transformation requires not only the dedication of scientific research personnel but also institutional and cultural safeguards.

(3) XUE Lan (Tsinghua University)

It is to rapidly establish a classification and evaluation system for scientific research results. The priority is to swiftly establish a classified evaluation system for scientific research outcomes. From a foundational standpoint, this system can address not only the undervaluation of basic research but also provide solutions to several issues, including the significant potential for subjective bias in the evaluation system, insufficient scientific rigor, limited market impact of scientific research outcomes, and low rates of patent commercialization.

(4) JIN Changqing (Chinese Academy of Sciences)

The primary focus is on establishing a system and management oversight mechanisms to ensure honest and credible scientific research personnel. The main trajectory of current reforms in China centers on delegating authority to scientific researchers and maximizing respect for academic freedom in scientific research, as the institutional framework in science and technology transitions from a management-oriented to a service-oriented approach. The success of this transition, particularly for researchers accustomed to the previous system, in shifting promptly to authentic research work and adapting effectively to their new roles depends fundamentally on the supporting mechanisms that ensure honesty and credibility.

(5) LIU Huijuan (Tsinghua University)

The establishment of a system ensuring honest and credible scientific research has become a priority. Since 2017, numerous manuscript retractions have occurred frequently, damaging the image of Chinese scientists and adversely affecting them internationally. Specifically, academic misconduct concentrated in the medical field has emerged as a significant obstacle to reforming scientific research management systems. While implementing the delegation-supervision-service approach, the state must simultaneously foster the development of an appropriate scientific research environment and establish an honest and credible academic system.

(6) WANG Zhenpo (Beijing Institute of Technology)

The comprehensive reform of scientific and technological systems and mechanisms—encompassing technology management, research evaluation, research integrity and credibility, and technological incentives—remains incomplete in its implementation. The reform process is currently focused on adjusting departmental interests, with the immediate priority being fundamental changes to several management systems and enhancement of certain services. This aligns with researchers' primary expectations.

(7) WANG Wei (Tsinghua University)

The insufficient emphasis on basic research and core technologies has led to a scarcity of original achievements and critical technological challenges. Given the anticipated long-term strategic tensions between China and the United States, addressing these areas holds profound significance not only for scientific and technological advancement but for the nation's overall trajectory.

(8) MA Weiguo (Datang Telecom Technology & Industry Group)

Talent team development is crucial, particularly fostering the emergence of world-class scientists and technologists. This requires sustained generational effort combined with stable institutional support. The current emphasis on and increased investment in domestic basic research, coupled with the stable existing system, will inevitably produce such leaders in the future.

(9) WANG Bo (Marine Chemical Research Institute Co., Ltd.)

The enhancement of independent innovation systems remains a priority. Despite state efforts to position enterprises as primary innovation drivers, policy implementation remains incomplete. Local research organizations such as ours, which depend on state-owned enterprises, face challenges as group headquarters and local governments fail to coordinate on tax and finance policy implementation. Furthermore, some localities' non-compliance with policy directives has undermined both innovation mechanism efficiency and researcher motivation.

(10) YUAN Chengyin (National New Energy Vehicle Technology Innovation Center)

China must assume a global leadership role in establishing new standards across pioneering fields, particularly in areas such as charging specifications and next-generation intelligent driving standards. With advancing capabilities in basic research and technological innovation, China anticipates achieving the smart stage of new energy vehicles around 2025 and the ecological development stage by approximately 2035. These globally leading fields require not only technological accumulation but also institutional integration to secure leadership in international standard-setting. The implications extend beyond industrial development to influence outcomes in international strategic competition.

8 Comments on Survey Results by Japanese Experts

We received reviews from the following experts regarding the survey findings, including questionnaire results, to highlight differences with Japan and identify potentially beneficial insights for Japan.

Name (in Japanese syllabary order, honorifics omitted)	Affiliation
OHAMA Takashi	Director, Department of Research Project Promotion, Japan Science and Technology Agency
KUNITOMI Kazuhiko	Team Leader, HTGR Practical Application Research Cooperation Promotion Project Team, Fast Reactor and Advanced Reactor R&D Division, Japan Atomic Energy Agency
TAKAGI Toshiyuki	Professor Emeritus, Tohoku University Vice Director, Tohoku Forum for Creativity, Organization for Research Promotion, Tohoku University, Specially Appointed Professor
NARABAYASHI Tadashi	Specially Appointed Professor, Laboratory for Zero-Carbon Energy, Institute of Innovative Research, Tokyo Institute of Technology
MATSUOKA Shunji	Professor, Graduate School of Asia-Pacific Studies, Waseda University
YOSHIKAWA Hidekazu	Professor Emeritus, Kyoto University

OHAMA Takashi (Japan Science and Technology Agency)

As professionals engaged in science and technology, we, myself included, naturally maintain a strong interest in understanding the factors driving China's remarkable scientific and technological advancement. While Japanese-language overview materials about China's research and development systems can be found in public sources, resources offering detailed insights into actual conditions remain limited. My own fragmentary understanding and impressions have centered on an evaluation system disproportionately focused on publication metrics, emphasis on practical development, and rigid management under national directives. However, reading this survey report has revealed that these characteristics belonged to previous systems, and rapid evolution continues to take place.

As reported here, China has been introducing a series of significant policies in recent years to reform its research and development system, including changes to funding systems, R&D project management, and research evaluation methodologies. These reforms address various issues that have emerged from both the existing R&D system and Chinese social conventions, incorporating academic expertise while implementing new recommendations and measures.

Whether characteristic of China's approach or not, new frameworks are first implemented on a trial basis in specific areas, their effectiveness is evaluated, and then they are applied comprehensively. This process proceeds rapidly. The ten Chinese experts (researchers from public research institutes, universities, and corporations) who contributed to this research report (hereinafter referred to as "experts") highly regard all these reforms as generally heading in the right direction and explain that they are beginning to yield tangible results.

This research report is not simply a Japanese summary of Chinese documents available online and elsewhere but is compiled based on specific questionnaire responses from the experts. As such, it serves as valuable documentation in which experts provide frank explanations and assessments from an R&D field perspective regarding the motivations behind these new policies and programs, reforms in science and technology management methods, and the practical effectiveness of these new measures.

From my position as someone responsible for designing and operating R&D funding systems, I will share below what I found particularly interesting in this research report and my observations.

▪ On the Position of the Ministry of Science and Technology (MOST)

Given that MOST and the Ministry of Finance (MOF) jointly approve science and technology-related budgets and settlements, collaborate on important R&D policy considerations such as the National Key R&D Program, and that MOST chairs inter-ministerial meetings on science and technology, it appears that MOST maintains strong cross-ministerial coordination authority in science and technology matters.

Since science and technology inherently intersect with all areas of administration, it is natural for agencies overseeing science and technology policy to have cross-cutting functions. This represents a crucial mechanism for achieving both the creation of new industries and the resolution of social issues through science and technology.

▪ Shift to Emphasis on Basic Research

While China has historically focused on technology transfer from abroad and practical development yielding short-term results, basic research is now emphasized to such an extent that one expert in this report describes it as an unprecedented situation, with basic research becoming a crucial pillar of the nation's scientific research strategy. The recent focus on basic research appears to be partially in response to intensifying global competition in science and technology. However, there seems to be a shared understanding among China's leadership, including top government officials, that original scientific and technological achievements are essential for long-term economic and social development. In terms of support for young researchers who will be conducting basic research over the long term, China is actively pursuing both domestic development and international recruitment simultaneously.

▪ Reform of Research Evaluation Systems

The "Four Only" evaluation system for scientific research that began in the 1990s—focusing solely on papers, positions, academic credentials, and awards—has been dismantled after being criticized for issues such as its emphasis on short-term formalism, and new evaluation systems are being introduced on a trial basis. One of these is the Classification Evaluation System, which involves evaluation mechanisms by government, market, third-party organizations, and financial investment institutions. While this is very interesting, this research report does not provide details (such as which programs it applies to or what the main indicators are). I would welcome follow-up research on this topic. Multiple experts note that an evaluation system to replace the Four Only approach has not yet been established. The development of future evaluation systems and indicators in China, as well as their effectiveness, will be of particular interest.

▪ The Strategic Open Recruitment System (for Selecting the Best Candidates)

The model for the Strategic Open Recruitment (Ch. *jie bang gua shuai* 揭榜挂帅) system derives from ancient Chinese history. It is a system that allows anyone to apply without any conditions (such as age, academic credentials, or position requirements for principal investigators), selecting only the most capable individuals from among the applicants.[97] While it aims to draw out enthusiasm from young researchers, research topics are not necessarily based on researchers' free ideas; rather, it appears to be a system strongly focused on innovation, targeting breakthrough core technologies. It would be interesting to learn what kinds of researchers are being selected and what projects are being implemented.

▪ Simplification of R&D Project Management, Reduction of Burden on Researchers (Research Institutions), and Expansion of Autonomy

Based on Premier LI Keqiang's proposed Green Channel and the State Council's Fang Guan Fu Reform (combining administrative simplification and power delegation, integration of delegation and management, and service optimization), it appears that various significant simplifications in research project management procedures, streamlining and networking of research funding applications, and expansion of research institution autonomy have substantially reduced the burden on researchers and research institutions, effectively contributing to more efficient research project operations.

In addition to the above, this research report introduces numerous examples of how China's R&D system is rapidly evolving in effective and efficient directions. These reforms appear to be becoming a major driving force for China's continued growth in scientific and technological capabilities.

While Japan, like the United States, has been tightening restrictions to prevent the outflow of advanced technologies overseas, science and technology is inherently an open system, and access to excellent knowledge worldwide, including from China, remains essential for Japan's scientific and technological development. Understanding and benchmarking how overseas counterparts think and what programs they implement forms the foundation for maintaining communication channels and building cooperative relationships. For this reason as well, surveys like this one are considered important.

97 Science Portal China, "Beijing News [21-038] National Key R&D Program Introduces Recruitment System That Does Not Consider Principal Investigators' Positions" [in Japanese]

KUNITOMI Kazuhiko (Japan Atomic Energy Agency)

Tsinghua University in China has been conducting research and development on high-temperature gas reactors for over 20 years. High-temperature gas reactors are extremely safe as they use inert helium gas rather than water for reactor cooling, preventing water-related hydrogen explosions. Even in cases of helium gas loss due to pipe rupture or power loss, core meltdown does not occur. An additional characteristic is that high-temperature heat can be extracted from the reactor, making it useful not only for power generation but also for hydrogen production and high-temperature steam supply. In Japan, a research test reactor called HTTR with world-leading performance has been completed. Meanwhile, China has completed a demonstration reactor called HTR-PM and is preparing for full-power operation. China acquired its high-temperature gas reactor technology foundation from Germany and is proceeding with domestic production based on this technology. Some technology has also been introduced from Japan.

Regarding high-temperature gas reactor technology, while HTTR can extract heat at 950°C, China's reactor operates at 750°C. The technological level required for materials and equipment used at 950°C is extremely high compared to 750°C, and Japan maintains superiority in such advanced technologies. While quantitative assessment is difficult due to insufficient information about the quality and reliability of Chinese-made components in China's high-temperature gas reactor, comparing the scattered information available with the quality and reliability of Japanese products suggests the gap remains quite significant. However, regarding control and monitoring systems, they have clearly adopted superior modern technology compared to HTTR, which was completed about 20 years ago. As economics will be an important factor in future commercialization, it is currently unclear which high-temperature gas reactor has the advantage. However, while China has designated high-temperature gas reactors as strategically important technology with substantial budgetary support, Japan lacks such backing. Going forward, it is expected that Japan's advantage in high-temperature gas reactors will continue to decrease.

Regarding the research and development environment for high-temperature gas reactor technology, I believe conditions are not conducive to producing innovative and novel technologies. The reason for this is that to catch up with and overtake the technological leaders—Japan, Europe, and America—products must be commercialized quickly, leaving no time to advance technological development from basic research. It is difficult to balance methodical development from basics over time with achieving rapid social implementation, and China prioritizes the latter. In the nuclear field, I do not believe the innovation-fostering environment described in the report is functioning effectively.

Moreover, the inability to produce innovation also stems from the unique nature of nuclear technology, which requires proven technology for safety assurance. In Japan as well, there are strong concerns about using new technology in reactor systems, and development motivation is diminished because innovative technologies cannot be implemented even if developed.

Regarding researcher capabilities, almost all current leaders of the high-temperature gas reactor project earned their doctorates studying in the United States or Germany, then were called back to their home country to assume key positions. Through exposure not only to academic and technical knowledge but also to advanced countries' superior research and development environments, they clearly recognize both China's advantages and those of advanced foreign countries. However, mid-career researchers have limited overseas study experience and, having grown up in a developed China and working under policies that regard China as a powerful nation, tend to undervalue the superior aspects of foreign technology and research development environments. There is also a growing number of people who are not interested in the depth of Japanese technology with its superior quality and high reliability. During the bubble period, Japan was caught up in rhetoric such as "Japan as Number One," and as a result of misjudging the underlying strength of Europe and America, it has fallen behind the rest of the world in many fields. If China continues with this inward-looking attitude, it is highly likely to face a similar future.

The organizational structure is also similar to Japan's. The generation following those who could not receive education due to the Cultural Revolution became leaders at a young age in their early 40s. That generation still remains in leadership positions. Having the same system in place for about 20 years is a major problem for maintaining young researchers' motivation for R&D and generating outstanding innovation. However, implementing such organizational changes will likely prove challenging.

Many of the issues faced by China and Japan are fundamentally the same. As China has essentially pursued economic development by following the Japanese model, it is natural that similar problems would emerge. In Japan, we have been unable to stop the long-term decline in scientific and technological capabilities, and no effective solutions have been discovered. I believe China will encounter similar circumstances to Japan. This may represent the limitations of the Japanese model.

Nevertheless, there are major differences in the current situation. In Japan, there exist democratic and diverse opinions that cannot be disregarded. Consequently, it is difficult to strategically select promising technologies and advance technological development under government leadership. Furthermore, concerns about national fiscal insolvency make it impossible to implement bold budget expenditures. While the Ministry of Economy, Trade and Industry aims to develop nuclear technology through shared investment and risk between government and private sector like the United States, private companies expect nuclear technology development to continue with government funding and risk-bearing as before, revealing a significant gap in perspectives. Meanwhile, China continues to experience economic growth and can inject substantial budgets into numerous fields. As long as this situation persists, the gap in technological capabilities between Japan and China is expected to widen.

However, China will inevitably enter a low-growth period like Japan and face increased social security expenditures, for which they have no solutions. They will undoubtedly encounter the same problems as Japan. The policies outlined in the report are short-term in nature, and I believe a strategy with a longer-term vision is necessary.

TAKAGI Toshiyuki (Tohoku University)

China has been producing numerous scientific and technological research achievements. In my related research fields (maintenance engineering, non-destructive evaluation, etc.), the improvement in both quantity and quality of papers has been remarkable. Several Chinese international students and research students have studied in my laboratory. After obtaining their degrees and continuing research in Japan as faculty members or postdoctoral researchers, they returned to Chinese universities where they have achieved success. About ten years ago, after returning to China, they began purchasing experimental equipment similar to what we use in our laboratory and establishing their research environments. Since then, many researchers have secured substantial funding within China and are advancing their research in expanded forms. With each visit to their laboratories, I have observed increases in their laboratory spaces, experimental equipment, and the number of graduate students under their supervision. While this research progress is certainly due to their own efforts, they have successfully adapted to China's research support system to obtain research funding and space.

The primary reason for this research advancement appears to be the State Key Laboratory system described in Section 5.4 of the report. Laboratories designated as State Key Laboratories receive abundant budgets and sufficient research space. Many graduate students can conduct research on various projects under their supervisors' guidance.

The second reason appears to be the secondary effects of the State Key Laboratory designation. Beyond the direct budget of the State Key Laboratory itself, this designation has helped them secure funding from local governments and university support. In terms of education, laboratories affiliated with State Key Laboratories send graduate students abroad under the National Construction of High-level University Graduate Student Dispatch Program, and my laboratory has hosted such students. In terms of personnel, while I initially heard concerns about being unable to hire technical staff to operate the purchased equipment, they now have more staff members, possibly through university support. In terms of research funding, they receive grants from other government departments and from international projects such as ITER. Some laboratories simultaneously receive multiple research grants, with doctoral students serving as key project members. I hear they face challenges regarding doctoral students' degree completion.

The third reason is their utilization of international networks. They invite many researchers from abroad for both short and medium-to-long-term stays, with universities providing such mechanisms. I find it impressive to see students eagerly discussing research problems with visiting international researchers. They also actively send faculty and students abroad to present their findings at international conferences. Furthermore, they host international conferences and invite overseas researchers. At these events, they demonstrate their role as a core hub in China's domestic research and development network by facilitating substantial participation from domestic researchers and industry engineers.

China's rapid scientific and technological development appears to be related to the horizontal relationship between the Ministry of Science and Technology and the Ministry of Finance, which differs from Japan's structure. In Japan, even after the Ministry of Education, Culture, Sports, Science and Technology (MEXT) submits budget requests, these are frequently rejected by the Ministry of Finance. While it is certainly rational to consider the national budget with the Ministry of Finance at the pyramid's apex, applying this same approach to science and technology budgets is questionable. As described in Section 1.3 of the report, China's system, where the Ministry of Science and Technology and Ministry of Finance cooperate to implement policies approved by the National People's Congress, appears to be contributing to China's scientific and technological development. Japan's current method of allocating science and technology budgets seems likely to widen the gap with China further.

Regarding the evaluation system for faculty appointments at Chinese universities, I understand they evaluate research (number of papers), research funding acquisition, education (teaching load, student supervision), and international experience (overseas research experience), among other factors. I also hear they use a point system. In this sense, it seems clear-cut as the target points are explicit. However, perhaps to earn points, some are forcing submissions to journals with impact factors. There are cases where content that should be published as a single paper is divided into multiple papers. Particularly, since doctoral students must publish in journals with impact factors to obtain their degrees, they sometimes appear to be submitting underdeveloped papers prematurely. This is likely one of the issues with the "Four Only" system mentioned in the report.

As described in this report, while China's science and technology policies continue through trial and error, substantial budgets are being invested, and several research fields have reached world-class levels. Even with high-speed railways and nuclear power plants, they have continued to improve imported technologies domestically until developing them into export industries. Significant research and development funding is being invested in universities and research institutions. When national goals are established, administrative agencies can proceed uniformly without uncertainty. Research outcomes are expected to continue increasing. However, technological development inevitably has negative aspects, including ethical and legal challenges. Japan is addressing these through comprehensive knowledge that integrates humanities and sciences. While this report does not address this point, it would be interesting to see how China will address these potentially problematic challenges.

NARABAYASHI Tadashi (Tokyo Institute of Technology)

(1) Policy Recommendation Process and Achievements of the China Association for Science and Technology

The following point deserves attention:

"The China Association for Science and Technology (CAST) leverages its unique organizational advantages and academic influence to unite numerous scientific and technological workers. It actively conducts consulting activities for policy decisions related to scientific and technological innovation, supports party and government scientific policy formulation, and serves as a think tank for scientific and technological innovation."

This differs significantly from Japan's Science Council, which tends to avoid making recommendations that would benefit the administration, thus lacking the driving force to cooperate in national strategic science and technology development as China does.

(2) Reform of Launch and Organizational Management Methods for Key Science and Technology Projects

Reform of administrative procedures and services: Through promoting administrative simplification, authority delegation, integration of delegation and management, and service optimization, they are reforming the launch and organizational management methods for key science and technology projects. They are implementing systems such as Strategic Open Recruitment System[98] and the Competitive Project Selection ("Horse Racing") System[99] for core technologies and promoting a technical supervisor system. Other noteworthy developments include granting research and development personnel ownership and long-term usage rights to scientific and technological achievements obtained through their duties, and establishing due diligence for the transformation of scientific and technological achievements, along with negative lists and fault-tolerance mechanisms for exemptions.

Under the "Law of the People's Republic of China on Scientific and Technological Progress" [in Chinese] (Standing Committee of the National People's Congress, December 2021), the government strengthens basic research and national strategic scientific and technological capabilities, improves the national innovation system, promotes breakthroughs in core technologies, and optimizes regional innovation deployment. Japan's administration appears to lack this system where government officials with science backgrounds from Tsinghua University concentrate heavily on basic research.

(3) Basic Core Fields Related to National Security and Development

Eight priority frontier fields have been identified: artificial intelligence (AI), quantum information, integrated circuits, life and health sciences, brain science, biological breeding, space science and technology, and deep earth/deep sea exploration. These strategic national key science and technology projects with future potential appear to be common priority science fields in Japan as well. The following priority fields are outlined, which are also important technologies and national projects that should be promoted in Japan:

98 4.4 See the National Key Research and Development Program's Strategic Open Recruitment system.

99 Competitive Project Selection ("Horse Racing"): see footnote 37.

1) Artificial Intelligence (AI); 2) Quantum Information; 3) Integrated Circuits; 4) Genetic and Biotechnology; 5) Brain Science and Brain-Inspired Intelligence Research; 6) Clinical Medicine and Health; 7) Deep Earth, Deep Sea, and Polar Exploration; and 8) Space Science and Technology

(4) Positive Approach to Receiving Global Expertise

In July and September 2019, the Ministry of Science and Technology held two International Expert Consultation Meetings on National Medium and Long-term Science and Technology Development Planning Research at the Beijing Friendship Hotel. Fourteen experts from countries including the United States, Belarus, Germany, and Japan attended the first meeting. Subsequently, many experts, including Nobel laureates, from the United States, Ukraine, France, Russia, Switzerland, and Germany attended and provided recommendations. They reportedly received international advice regarding academic evaluation mechanisms, inter-university competition and cooperation, importance of basic science, international exchange and cooperation, scientific and technological fields that could significantly impact human society, application of digital technology, and the International Thermonuclear Experimental Reactor (ITER) project. Such international consultation is also necessary for Japan. Currently, Japan lags behind China in many fields of science and technology. While mechanisms are being implemented to encourage active participation of doctoral students and postdoctoral researchers in projects, Japan faces a critical issue where talented researchers do not remain at universities because assistant professors have five-year terms with no status guarantee afterward. This continues to be a factor in the significant decline of university research capabilities.

(5) Development of Large Advanced Pressurized Water Reactors (PWR) and Acquisition of International Competitiveness

Below are my observations regarding light water reactors, my area of specialization.

Since its launch in 2008, the major special project for large advanced pressurized water reactors (PWR) and high-temperature gas reactor power plants (major special nuclear power project) has completed its first unit, despite ongoing construction delays at the U.S. Vogtle plant. This was achieved through developing, constructing, and testing the industrial foundation for the complete AP1000 technology from Westinghouse-Toshiba, which represents the world's most advanced nuclear power technology, aiming to achieve strategic development in global cutting-edge nuclear power generation. While Toshiba's engineers contributed by supporting Westinghouse in overall commissioning, it is a significant loss for Japan that Toshiba had to relinquish its manufacturing rights due to massive losses approaching JPY 2 trillion from AP1000 construction with Westinghouse in the United States. China developed the CAP1000 model based on the AP1000. The CAP1000 fully absorbed the original AP1000 technology, established equipment manufacturing and construction capabilities, and enhanced China's safety review system. This led to the development of the "C"-branded CAP1000 as a Chinese domestic product, which was then scaled up to the CAP1400 at 1.4 million kW, achieving strong economic efficiency. It has strong international price competitiveness and, together with the 1 million kW HPR1000 known as "Hualong One" [in Chinese], is prepared for domestic construction and overseas export.

During this period, Japan's nuclear power manufacturers have unfortunately declined due to lack of government support, delayed reviews by the Nuclear Regulation Authority, and economically unreasonable excessive safety measures.

MATSUOKA Shunji (Waseda University)

(1) Overall impressions

This report, "Research Report | Study on the Mechanism of Discovery and Promotion of the Excellence in China's Research and Development System," provides detailed coverage of China's science and technology policy-making processes, including medium to long-term strategies such as the "National Medium and Long-term Science and Technology Development Plan Outline (2021–2035)" [in Chinese] and the "National Key Research and Development Program" [in Chinese], extending to research and development systems and funding structures. This is an exceptionally well-crafted systematic and comprehensive report on Chinese science and technology policy.

Furthermore, the detailed survey records included at the end of the report, comprising nearly 80 pages of responses to 16 items from interviews with 10 leading Chinese experts in the science and technology field, capture these experts' "raw voices" and represent an invaluable resource.

Below, I will offer observations focusing on three points from my perspective as a researcher who has conducted innovation studies from a social science standpoint.

(2) Science and Technology Policy Decision-Making Process and the Role of Experts

First, let us examine the formulation process of the "National Medium and Long-term Science and Technology Development Plan Outline (2021–2035)" [in Chinese] to understand the position and role of experts in science and technology policy decision-making. According to pages xx-yy of this report, the process unfolded as follows:

On June 24, 2019, the Ministry of Science and Technology held discussions with more than 60 experts invited from various State Council departments, local governments, industries, universities, research institutions, and key enterprises. On July 28, 2019, they convened a forum with 15 academicians and over 40 experts from 7 high-tech fields: energy, transportation, information, advanced manufacturing, materials, space technology, and modern service industry. Furthermore, on September 27, 2019, the Ministry of Science and Technology held a high-level expert symposium on the National Medium and Long-term Science and Technology Development Plan strategy, gathering prominent experts from science, technology, economics, and industrial fields.

Additionally, exchanges with international experts were held on September 27 and September 29, 2019, involving discussions with many experts, including Nobel laureates, from Japan, the United States, Norway, Ukraine, France, Russia, Switzerland, and Germany.

The "National Medium and Long-term Science and Technology Development Plan Outline (2021–2035)" [in Chinese] was developed based on these staged discussions with diverse experts. China's science and technology policy decision-making process demonstrates a dynamic approach combining top-down and bottom-up methods. According to the report (p.xx), China's "policymaking process has activated three key drivers of policy innovation—central government, local government, and the general public—establishing a decision-making system that fundamentally combines top-down and bottom-up interactions among these three entities.'

This has been a recurring point of discussion in Japan's science and technology policymaking process as well. While there is a common misconception in Japan that Chinese policymaking follows a centrally-driven top-down process, it seems that Japan's science and technology policy decisions could benefit from greater reference to Chinese science and technology policymaking examples.

However, in the expert survey, WANG Chengwen of Tsinghua University responded that "while current national policies have established channels for expert input, these channels primarily target elite and top-tier experts. Many frontline researchers' opinions fail to influence policies, creating a disparity in policy consultation." (this report, p. xx). LIU Huijuan, also from Tsinghua University, noted that "there is a need to further reflect the opinions of ordinary and frontline young researchers into policy." (p. xx).

These observations are particularly interesting as they indicate that, as in Japan, a select group of elite researchers exercises strong influence over policy formation in China.

(3) Research Evaluation Systems

Discussions surrounding Japan's declining research capabilities following the early 1990s bubble collapse and the 2004 incorporation of national universities have highlighted issues with the standardization of evaluating Japanese researchers and research outcomes. Specifically, there is concern that by emphasizing simple metrics like the number of peer-reviewed papers in high-impact-factor journals and external funding amounts, Japanese universities and research institutions may be losing the diversity that serves as the foundation for innovation.

From this perspective, China's moves to break away from the uniform evaluation system known as the "Four Onlys" (papers only, position only, educational background only, and awards only) deserve attention, as seen in measures such as "Measures for Eliminating the Undesirable Trend of 'Relying Solely on Papers' in Science and Technology Evaluation (Trial Implementation)" [in Chinese].

Regarding specific new evaluation systems, this report states that 'The "Guiding Opinions on Improving Scientific and Technological Achievement Evaluation Mechanisms,' issued in June 2021, established that a classified evaluation system should be adopted moving forward. For these research projects, international peer review by researchers in closely related fields will be employed, implementing evaluation criteria that combine both quantitative and qualitative assessments." (p.xx).

However, the report also notes that "a robust evaluation system has not yet been established" (p.xx), suggesting the need for continued monitoring of China's new research and researcher evaluation systems.

Furthermore, since highly innovation-oriented projects often face significant disagreement among experts in the same field, and the current project review system employs peer review, this includes the challenge of how to evaluate "non-consensus" science and technology projects that may be disadvantaged in project reviews. These points could provide valuable insights when considering the future direction of research evaluation in Japan.

Furthermore, regarding China's Strategic Open Recruitment system, a mechanism that breaks from traditional evaluation systems to promote young researchers, the report states that it "was formally implemented at the national level in May 2021, with the Ministry of Science and Technology working on comprehensive pilot projects" (p.xx) and has been "widely implemented in more than 20 provinces nationwide" (p.yy).

However, given Japan's serious situation of declining doctoral program enrollment since 2003, more detailed information about China's Strategic Open Recruitment system would be valuable.

(4) Innovation and Integrated Knowledge

Finally, Japan's Science, Technology and Innovation Basic Plan, approved by the Cabinet on March 26, 2021, emphasizes the importance of "comprehensive knowledge (integrated knowledge combining specialized knowledge from natural sciences, technology, humanities and social sciences with local knowledge)" for creating innovation that can solve trans-scientific social issues in a sustainable and resilient way.

The report states on p.xx that "interdisciplinary science is becoming a major trend in future science and technology development. Whether in quantum computing, nanomaterials, biopharmaceuticals, autonomous driving, or financial technology development, all rely on the close integration of multiple fields, and interdisciplinary science must be emphasized in the country's medium- and long-term science and technology development." It would be desirable to learn more about what constitutes interdisciplinary science in China and how it relates to the concept of comprehensive knowledge discussed in Japan's science and technology policy debates.

YOSHIKAWA Hidekazu (Kyoto University)

(1) Introduction

After DENG Xiaoping's speeches during his inspection tour of southern Chinese cities in January–February 1992 (Southern Tour Speeches) proposing a shift toward reform and opening up, China declared itself a socialist state with a capitalist economy, advancing the introduction of foreign technology and promotion of domestic industry. As a result, by the 2000s, China's economy had developed steadily to the point of being called the world's factory. In 2010, China surpassed Japan, which had previously held the world's second-largest nominal GDP, to become the second-largest economic power after the United States. Current Chinese President XI Jinping, in his second term, is working to establish an economic zone through the Belt and Road Initiative that extends from China through Central Asia and the South China Sea in two directions toward West Asia and Africa.

To catch up with industrial technology, which had significantly lagged behind the West and Japan, China first ① sent students to study abroad and invited foreign experts to teach, ② attracted foreign companies to China to learn, digest, and absorb their technology for domestic production, then independently built factories and managed manufacturing and facility operations. Recently, however, due to policy changes by the United States, which has grown wary of China, there have been obstacles to introducing knowledge and technology as before. Consequently, China is now attempting to shift its research and development approach to ④ independently creating original knowledge and advancing production technology innovation on its own. As a result, there has been increasing emphasis on basic research in R&D, and independent innovation promotion has become prominent.

Meanwhile, Japanese universities have gradually been declining in global university rankings and now trail behind Chinese universities in Asia. According to recent statistics, China has surpassed not only Japan but also the previously top-ranked United States in the number of research papers, and China now leads the world in paper citations as well. Japan continues to decline in this area.

Japan continues to decline in this area. Based on my experience in China, I aim to examine how China has grown to lead the world in research paper output (which demonstrates achievements in basic research), what methods they employed, and study China's institutional practices to learn from their successful aspects. After retiring from Kyoto University, I spent over ten years engaged in education and research at Chinese universities. Drawing from these experiences and insights, I would like to introduce potentially relevant aspects when comparing educational and research environments between Japan and China.

(2) Suggestions from Educational and Research Experience in China

During my working life, I conducted long-term research in nuclear reactor instrumentation, control, and human interface, contributing to global nuclear safety improvements in these areas. After retiring from the Graduate School of Energy Science at Kyoto University in 2006, I was invited to the College of Nuclear Science and Engineering at Harbin Engineering University in Heilongjiang Province, China in 2007. From 2008 to 2018, I formally participated in the college's education and research as an overseas academic master in the 111 Project (a Ministry of Education project aimed at internationalizing Nuclear Safety and Simulation Technology. The project recruits leading experts from the world's top 100 universities, forms teams of 10 related experts from within and outside China centered around that person, and internationalizes research levels on specific themes through activities such as workshops, with each period lasting five years). During this time, my responsibilities encompassed all aspects of graduate-level education and research. In examining China's research and development system, I will discuss differences from Japan that may be linked to characteristics worth referencing.

Here, I will discuss points that differ from Japan which should be considered as notable characteristics when examining China's research and development system.

A. The doctoral education and supervision system at Chinese universities differs significantly from that of Japanese universities.

① Graduate schools that award master's and doctoral degrees in China are called research institutes (研究院 *yánjiūyuàn*). China has national, provincial, municipal, and private universities. What are known as university departments in Japan are termed colleges (学院 *xuéyuàn*) in China, with their primary function being professional education and training. While master's and doctoral degrees in Japan are awarded by graduate schools, in China these are conferred by research institutes. Research institutes exist not only at universities but also at national research institutions. For instance, in Japan, institutions such as RIKEN and the Japan Atomic Energy Agency have graduate schools with professors who accept and supervise students and award doctoral degrees. This means that graduate schools awarding doctoral degrees are not exclusively affiliated with universities. In China, most national and provincial research institutions have research institutes that are equivalent to Japanese graduate schools.

② The Chinese degree-conferring system follows Western standards. As in South Korea, doctoral students must publish several papers as first authors in internationally recognized high-level journals, collectively known as "SCI," before they can apply for their degree. (Without numerous SCI publications, one cannot secure a faculty position or advance in their academic career as a university professor. This same requirement exists in neighboring South Korea.) For doctoral degree reviews (and faculty hiring), the government employs a peer review system requiring evaluation from two external experts outside the candidate's university. This criterion aligns with global standards. In contrast, Japan allows universities to set their own standards, which are generally more lenient than global standards and more vulnerable to misconduct. Shouldn't the Ministry of Education provide guidance to universities to strengthen degree review standards at the national level to match global standards?

B. Chinese national universities are overseen by multiple government agencies

During my time at Kyoto University, it was initially a national university under MEXT but transformed into the National University Corporation Kyoto University in 2004 as part of government administrative reforms. While still under MEXT's oversight, the university has faced increasing financial challenges since becoming a national university corporation due to annual reductions in government operational grants. Prior to the incorporation that occurred during my tenure at Kyoto University, we established a three-year endowed chair funded by an electric power company. The Kyoto University Faculty and Staff Union (a voluntary membership organization of university faculty and staff) responded by erecting protest signs at the main gate opposing "endowed chairs from power companies" and distributed flyers throughout campus. They opposed this on grounds that research conducted in collaboration with private industry violated principles of academic freedom, specifically arguing that an endowed chair potentially supporting nuclear power promotion by electric power companies was unacceptable at Kyoto University. However, I believe that endowed chairs have now become standard practice, with donations being welcomed due to universities' financial circumstances.

After leaving Kyoto University, I worked at Harbin Engineering University, which was originally established as a military technical university directly under the Chinese People's Liberation Army. It later separated from the military and is now a national university under the Ministry of Industry and Information Technology. Tsinghua University, an elite Chinese university, falls under the Ministry of Education. There are also universities under the Ministry of Science and Technology, as well as universities under provincial governments (in China, a ministry-level 部 bù corresponds to a Japanese ministry, and some Chinese provinces have areas larger than the entirety of Japan). The administrative structure of Chinese universities and research institutes involved in research and development is complex, with oversight distributed among central government ministries, provincial governments, the Chinese Academy of Sciences, the Chinese Academy of Engineering (both national research institutions), and state-owned enterprises. This broad administrative structure creates an extensive foundation for human resource development and financial support in research and development. In Japan, at the national level, the Ministry of Finance provides fiscal oversight, while MEXT supports basic research at universities, and other ministries such as the Ministry of Economy, Trade and Industry support applied research and development at national research institutes and in the private sector. Given Japan's limited financial resources including tax revenue, if the Ministry of Finance must reduce government research and development funding, shouldn't we implement mechanisms to attract more private sector donations and investment in basic research?

C. The conditions for establishing academic societies and publishing academic journals differ entirely between Japan and China

① In China, academic societies must receive government approval, and it is impossible to arbitrarily establish similar societies. Conversely, in Japan, academic societies can be established so readily that there is a saying that there are as many societies as there are professors. After establishment, these societies register with the National Institute of Informatics. Upon registering with the Science Council, members recommended by these societies can become members of the Science Council of Japan. In Japan, particularly in the humanities, there are many societies with similar names that have only a few dozen members.

② Here I address the matter of the Science Council of Japan. The Science Council of Japan is a government agency. In China, members of the Science Council of Japan are mistakenly equated with Chinese academicians (院士 *yuànshi*), and Council members are therefore believed to be extremely distinguished experts. This misunderstanding is actually widespread within Japanese society as well.

③ Let me explain China's academician system. There are two types of Academicians: those of the Chinese Academy of Sciences and those of the Chinese Academy of Engineering. The government annually appoints Academicians from experts selected through a two-stage review process. The Chinese Academy of Sciences and the Chinese Academy of Engineering are national research institutes comprised of experts in basic sciences and industrial technology fields, respectively. Their academicians serve lifetime appointments and participate in policy planning, project development, and evaluation of basic science and industrial technology initiatives planned by the Chinese government. For this reason, Academicians in China command great respect as experts of the highest standing. In contrast, Science Council of Japan members serve fixed terms and are divided into three sections: Section I (Humanities and Social Sciences), Section II (Life Sciences), and Section III (Physical Sciences and Engineering). Until now, the government had automatically appointed members recommended by the Science Council following consultations with the numerous academic societies affiliated with each section. It is said that once appointed as a member, one gains the right to recommend future members. The Science Council's role is to make recommendations to the government and society from an academic and specialist perspective. In any case, regarding the advancement of basic sciences and the planning and evaluation of industrial applications of scientific and technological research and development, Science Council of Japan members play a markedly different role from that of Chinese academicians. Furthermore, the current nomination system, where candidates are recommended by numerous competing academic societies based on their individual interests and then coordinated among themselves, does not appear suitable for such purposes.

D. University College Rankings

In China, university applicants are placed in departments at national universities according to their scores on the national unified examination conducted in early June each year. This effectively determines the course of a student's life. Students who cannot enter their desired university department due to poor performance can choose to study abroad at universities in Europe, America, or Japan if their parents are wealthy. While the situation may have changed now due to COVID-19 and other factors, students who completed their studies abroad were known as "sea turtles" and received preferential treatment in employment. This is where university college rankings become significant when students choose their preferred universities based on their common examination scores. In China, the government periodically releases rankings of university colleges within the same specializations. The higher a department's ranking, the more it attracts top-scoring students from the national university entrance examination, receives increased government funding, and gains more government projects. These government policies and evaluation criteria are effectively determined by the Academicians. As a result, universities strive to produce their own Academicians and work to improve their departmental performance to meet these standards. When I inquired about the ranking of the College of Nuclear Science and Technology at Harbin Engineering University in 2018, I learned it had advanced from fourth to third place. Specifically, Tsinghua University ranked first, University of Science and Technology of China ranked second, while Shanghai Jiao Tong University and Harbin Engineering University shared third place. In Japan, while MEXT oversees university education systems, there appears to be less emphasis on higher education systems and measures that would contribute to effectively educating and developing human resources for national advancement in basic and applied sciences. Furthermore, the Science Council of Japan, as a government organization, does not appear to be expected to make policy recommendations in this direction.

(3) Impressions from Reading This Survey Report

After reading the Japan Science and Technology Agency (JST) survey report "Study on the Mechanism of Discovery and Promotion of the Excellence in China's Research and Development System," I understood why I was invited to the university in Harbin and what was expected of me. This was due to the following factors during the invitation period (primarily the first half of the 12 years from 2007–2018): China's limited experience in hosting international conferences; the emphasis placed on overseas study for researcher career development; the difficulty in gaining approval for domestic academic journal publication, the requirement for doctoral candidates to publish papers as first authors in SCI journals; and the importance of the "Four Only" criteria (papers only, position only, educational background only, and awards only) in evaluations for employment, promotion, and project applications. According to this report, while China has recently reconsidered its overemphasis on SCI papers and is moving toward more rational standards, peer review is widely used despite acknowledgment of the difficulties in establishing fair and appropriate evaluation criteria for departments, projects, and personnel.

Reading Chapter 3 "National Medium and Long-term Science and Technology Development Planning Guidelines"

(2021–2035) and Chapter 4 "National Key Research and Development" of the survey report reveals that China, against the backdrop of changes in U.S. policy toward China, has established medium and long-term national goals for self-reliant development. To enhance its research and development capabilities, China aims to place greater emphasis on basic research and promotion, and advance scientific and technological innovation through industry–academia–research collaboration. The country is pursuing comprehensive institutional reforms, including improving research evaluation and project review methods that eliminate the formal "Four Only" criteria; simplifying administrative tasks for project leaders (which had become time-consuming bureaucratic formalities); reorganizing the 522 "National Key Laboratories" established at universities and research institutes nationwide through the "985" and "211" projects into "State Key Laboratories" based on the "National Key Research and Development" during the 13th Five-Year Plan period (2016–2020); increasing the number of key laboratories for new projects; and enhancing support for doctoral students and postdoctoral researchers.

China, with its capitalist-socialist system based on democratic centralism under Communist Party leadership, and Japan, founded on liberal democracy, have fundamentally different political systems across many aspects. Directly applying China's historically top-down planning guidelines (comprehensive, long-term guidelines) to Japan would be extraordinarily difficult, if not impossible, not only in light of Japan's current fiscal austerity but also due to the various impacts and friction it would likely generate across multiple sectors. Nevertheless, there appear to be many aspects of China's strategic and systems management approach that Japan should consider emulating, including long-term research and development program formulation; goal setting and its breakdown; role allocation among universities, industry, and national and private research institutions; project planning involving both long-term and short-term collaborative efforts and plans for individual organizational execution; consistency in implementation, evaluation, auditing, and human resource development; and financial backing from national and provincial governments and private enterprises. For example, MEXT is tasked with developing Japan's higher education system. In recent years it has been promoting "independent, interactive, and deep learning" (active learning) as a central concept in revising curriculum guidelines for primary and secondary education, including high schools. When considering mechanisms for discovering and promoting excellence in Japan's research and development system, one could approach it from the concept of active learning. However, practical implementation is not solely a matter for MEXT. Even if the Cabinet establishes a council to consider these matters, observing the deliberations of the repeatedly revised Basic Energy Plan raises concerns about whether the council system can function effectively. In Japan's liberal democracy, shouldn't this be an issue for the Diet, the highest organ of state power, to address in order to raise national consciousness about the country's future?

Appendix

Key Projects During the 14th Five-Year Plan Period (2021–2025) Research Projects and Budget, December 15, 2021

No.	Major Project Name	Project Name	Managing Organization	Implementation Period (Years)	Budget (in CNY 10,000)
1	Science and Technology for the Winter Olympics	Research, Development and Application Verification of Ice-Making Equipment	Ouyue Ice and Snow Investment Management (Beijing) Co., Ltd.	August 2009–December 2010	8,000 (total)
2	Science and Technology for the Winter Olympics	Core Technologies for Construction, Operations and Maintenance of Beijing Winter Olympics Temporary Facilities	Beijing University of Civil Engineering and Architecture	2	
3	Science and Technology for the Winter Olympics	Core Technologies for Summer-Winter Training Integration of Current and Potential Snow Sport Advantages	Shenyang Sport University	2	
4	Science and Technology for the Winter Olympics	Olympic Athlete Mental Health Protection	Peking University Sixth Hospital	2	
5	Science and Technology for the Winter Olympics	Research on Core Technologies and Standards for Public Testing of Ice and Snow Sports Equipment	Hebei Provincial Institute of Product Quality Supervision and Inspection	2	
6	Science and Technology for the Winter Olympics	Research and Application Verification of Core Technologies for High-end Speed Skate Development	Qiqihar Heilong International Ice and Snow Equipment Co., Ltd.	2	
7	Active Health and Aging Technology Response	Research on Evaluation and Intervention Technologies for Pelvic Floor Dysfunction in Elderly Women	West China Hospital, Sichuan University	3	17,000 (total)
8	Active Health and Aging Technology Response	Research and Development of Exercise-Promoted Precision Health Monitoring Technology and Dedicated Chips	China Sporting Goods Federation	2	

9	Active Health and Aging Technology Response	Research on Comprehensive Prevention and Control Technologies for Elderly Prostatic Hyperplasia with Precise Risk Assessment and Application Verification of Individual Prevention and Treatment Measures	Chinese PLA General Hospital	2	
10	Active Health and Aging Technology Response	Development, Application and Verification of Smart, Accessible, Healthy and Livable Environmental Systems for the Elderly and Disabled	Guangdong Second Provincial General Hospital	2	
11	Digital Medical Equipment Research and Development	Research and Development of New Invasive Ventilators and Their Core Components	Shenzhen Anbao Technology Co., Ltd.	3	3,400 (total)
12	Digital Medical Equipment Research and Development	Research and Development of High-Performance Non-invasive Medical Ventilators Based on Dynamic Precise Control	Hunan Mingkang Zhongjin Medical Technology Development Co., Ltd.	3	
13	Digital Medical Equipment Research and Development	Research and Development of Intelligent Robots for Mobile Medical Examination Rooms	Beijing Shuimu Dongfang Medical Robot Technology Innovation Center Co., Ltd.	3	
14	Digital Medical Equipment Research and Development	Research and Development of Intelligent Robot Systems for Intensive Care	Shenyang SIASUN Robot & Automation Co., Ltd.	3	
15	Green Biomanufacturing	Intelligent Design and Catalytic Applications of Industrial Enzymes	Hubei University	3	Dynamic (Budget Declaration System)
16	Green Biomanufacturing	Construction of General High-efficiency Expression Systems for Industrial Enzymes	Institute of Animal Science (IAS), Chinese Academy of Agricultural Sciences (CAAS)	3	
17	Green Biomanufacturing	Enzyme Generation and Catalysis in Pharmaceutical and Food Industries	East China University of Science and Technology	3	

18	Green Biomanufacturing	Molecular Design of Core Enzymes and Intelligent Manufacturing of Enzyme Preparations in Light Industry	Tianjin University of Science & Technology	3	
19	Green Biomanufacturing	Design Principles and Methods for Efficient Microbial Cell Factories	Shandong University	3	
20	Green Biomanufacturing	Infrastructure Development and Adaptability Optimization in Microbial Pharmaceutical Industry	Shanghai Jiao Tong University	3	
21	Green Biomanufacturing	Construction and Application of Next-generation Network Models for Pathogenic Microorganisms	Beijing University of Chemical Technology	3	
22	Green Biomanufacturing	Artificial Transposition Technology for Industrial Pathogenic Microorganisms	Tianjin University	3	
23	Green Biomanufacturing	Modification and Industrial Verification of Important Amino Acid Industry Pathogenic Microbial Systems	Jiangnan University	4	
24	Green Biomanufacturing	Core Technologies for Raw Drug Industry Pathogenic Microbial Modification and Industrial Verification	Zhejiang University of Technology	4	
25	Green Biomanufacturing	Bioreactors and Smart Biomanufacturing	East China University of Science and Technology	3	
26	Green Biomanufacturing	High-efficiency Membrane Separation Technology and Integrated Equipment for Bioethanol Production	Nanjing Tech University	3	
27	Green Biomanufacturing	Core Technologies for Efficient Sugar Production and Comprehensive Utilization of Lignocellulosic Biomass	Shanghai Jiao Tong University	3	
28	Green Biomanufacturing	High-efficiency Biomanufacturing Technology for Artificial Meat	Jiangnan University	3	

29	Green Biomanufacturing	Biomanufacturing Technology for Natural Enzyme-containing Products	Northwest University	3	
30	Green Biomanufacturing	Cellulosic Ethanol Biorefinery and Industrial Verification	South China Agricultural University	4	
31	Green Biomanufacturing	Green Manufacturing and Industrial Verification of Complete Biosynthetic Biopolymers	Nanjing Tech University	4	
32	Green Biomanufacturing	Efficient Green Production and Industrial Verification of Bio-based Polyamide Monomers and Materials	Institute of Microbiology, Chinese Academy of Sciences	4	
33	Green Biomanufacturing	Development and Industrial Verification of New Bio-based Polyurethane Polyols and Their Green Manufacturing Technology	Nanjing Tech University	4	
34	Green Biomanufacturing	Green Biomanufacturing and Industrial Verification of Chiral Chemical Substances	Tianjin Institute of Industrial Biotechnology, Chinese Academy of Sciences	4	
35	Green Biomanufacturing	Industrial Verification of API Biomanufacturing for Major Disease Prevention and Management	Zhejiang University of Technology	4	
36	Green Biomanufacturing	Verification of Efficient Treatment and Resource Recovery Technology for High-salt Organic Wastewater	Jiangnan University	4	
37	Green Biomanufacturing	Creation and Catalysis of Industrial Enzymes for Medical and Food Functional Carbohydrates	Tianjin University	3	
38	Green Biomanufacturing	Molecular Design and Efficient Production of Key Oxidoreductases for Light Industry	Institute of Animal Science (IAS), Chinese Academy of Agricultural Sciences (CAAS)	3	
39	Green Biomanufacturing	Design Principles and Manipulation Methods for Large-segment DNA from Industrial Microbial Genome	Tianjin University	3	

40	Green Biomanufacturing	Industrial Platform Development for Filamentous Fungi and Optimization of Critical Drug Biosynthesis Pathways	Qingdao Institute of Bioenergy and Bioprocess Technology, Chinese Academy of Sciences	3	
41	Green and Livable Technology Innovation	Integration and Demonstration of Quality and Efficiency Improvement Technologies for Advantageous and Characteristic Industries in the Dashishan Area of Guangxi Zhuang Autonomous Region	Guangxi University	2	
42	Green and Livable Technology Innovation	Integration and Demonstration of Quality and Efficiency Improvement Technologies for Meat Sheep in Liangshan Prefecture, Sichuan Province	Sichuan Agricultural University	2	
43	Green and Livable Technology Innovation	Integration and Demonstration of Quality and Efficiency Improvement Technologies for Advantageous Characteristic Industries in the Karst Mountain Areas of Guizhou Province	Guizhou Academy of Sciences	2	
44	Green and Livable Technology Innovation	Integration and Demonstration of Quality and Efficiency Improvement Technologies for Characteristic Agriculture on the Yunnan Plateau	Institute of Tropical and Subtropical Economic Crops, Yunnan Academy of Agricultural Sciences	2	30,000 (total)
45	Green and Livable Technology Innovation	Integration and Demonstration of Quality Improvement and Efficiency Enhancement Technologies for Dominant Industries in Gansu and Ningxia	Gansu Academy of Agricultural Sciences	2	
46	Green and Livable Technology Innovation	Integration and Demonstration of Quality Improvement Technologies for Dominant Characteristic Industries in Xinjiang	Xinjiang Agricultural University	2	

47	Research on Reproductive Health and Prevention/Control of Major Congenital Defects	Development of New Technologies for Long-term Carrier Screening of Single-gene Diseases: Evaluation of Clinical Applications and Establishment of Rescue Systems	Chinese PLA General Hospital	2021–2024	7,600 (total)
48	Public Safety Risk Prevention, Management, and Emergency Technical Equipment (Special Judicial Mission)	Research on Core Judicial Blockchain Technology and Typical Application Demonstrations	Information Technology Service Center of the People's Court	1.5	3,000 (total)
49	Solid Waste Resource Utilization	Core Technologies for Full Consumption and Harmless Disposal of Urban Waste	Hunan University	3	7,000 (total)
50	Solid Waste Resource Utilization	Core Technologies for Advanced Purification and Recycling/ Remanufacturing of Copper and Aluminum Waste from High-end Sectors	University of Science and Technology Beijing	3	
51	Solid Waste Resource Utilization	Integration and Demonstration of Collaborative Utilization of Representative Solid Waste in the Water Conservation Functional Areas of Beijing, Tianjin, and Hebei	Hebei Ruizhou Solid Waste Engineering Technology Research Institute Co.	3	
52	Soil Contamination: Causes and Management Technologies	Integrated Pollution Prevention and Treatment Technology and Engineering Demonstration for Northwest Coal Chemical Industrial Site	Shaanxi Institute of Environmental Science	4	9,300 (total)
53	Soil Contamination: Causes and Management Technologies	New Ecological Environment Management System and Demonstration Applications Based on Artificial Intelligence and Blockchain Technology	Beijing Ecological Environment Monitoring Center	3	
54	Soil Contamination: Causes and Management Technologies	Quantification Methods for Environmental Capacity and Carrying Capacity of Site Soil	Institute of Soil Science, Chinese Academy of Sciences	3.5	
55	Soil Contamination: Causes and Management Technologies	Integrated Research on Site Soil Pollution Management Technology System and Risk Management	Zhejiang University	3	

56	Gravitational Wave Detection	Research on Frequency Pre-stabilization Control Technology for Satellite-mounted Lasers	Innovation Academy for Precision Measurement Science and Technology, Chinese Academy of Sciences	5	50,000 (total)
57	Gravitational Wave Detection	Research on Frequency Stabilization Technology for Satellite-mounted Laser Locking Arms and Time Delay Interference Technology	University of Chinese Academy of Sciences	5	
58	Gravitational Wave Detection	Research on Satellite-mounted Telescope System Design with Ultra-stable and Ultra-high Stray Light Suppression Capabilities	Beijing Institute of Space Mechanics and Electricity	5	
59	Gravitational Wave Detection	Research on Manufacturing, Installation, and Adjustment Technology for Satellite-mounted Telescopes	Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences	5	
60	Gravitational Wave Detection	Research on Performance Measurement, Testing, and Evaluation Technology for Ultra-high Precision Satellite-mounted Telescopes	Institute of Optics and Electronics, Chinese Academy of Sciences	5	
61	Gravitational Wave Detection	Design, Development, and Testing Technology for Ultra-low Disturbance Inspection Quality	Huazhong University of Science and Technology	5	
62	Gravitational Wave Detection	Design, Development, and Testing Technology for Ultra-stable Capacitor Plate Frames	Beijing Institute of Technology	5	
63	Gravitational Wave Detection	Mass Charge Inspection Control Methods and Technology Research	Huazhong University of Science and Technology	5	
64	Gravitational Wave Detection	Study on Multi-Reference Mass Drag Control Methods and Techniques for Space Gravitational Wave Detection	Innovation Academy for Microsatellites, Chinese Academy of Sciences	4	
65	Gravitational Wave Detection	Research on Calibration Methods and Techniques for High-Reliability Submicron Thrusters	Lanzhou Institute of Physics, CAST	5	

66	Gravitational Wave Detection	Research on Development and Performance Testing Technology for High-precision Thruster Rating Systems	Institute of Mechanics, Chinese Academy of Sciences	4	
67	Gravitational Wave Detection	Semi-physical Simulation Research on Space Gravitational Wave Detection Formation Systems	Harbin Institute of Technology	5	
68	Gravitational Wave Detection	Template Library and Signal Recognition Technology for Space Gravitational Wave Detection	Hangzhou Institute for Advanced Study, UCAS	5	
69	Gravitational Wave Detection	Interdisciplinary Research on Primordial Gravitational Wave Theoretical Science and Observation Site Atmospheric Science	University of Science and Technology of China	5	
70	Gravitational Wave Detection	Research on Primordial Gravitational Wave Ground Observatories and Their Environment	National Astronomical Observatories, Chinese Academy of Sciences	5	
71	Gravitational Wave Detection	Development of Primordial Gravitational Wave Telescope Control Systems and Final Assembly Test Platforms	Institute of High Energy Physics, Chinese Academy of Sciences	5	
72	Gravitational Wave Detection	Research and Development of Focal Plane Detectors and Antenna Core Technology for Primordial Gravitational Wave Telescopes	Institute of High Energy Physics, Chinese Academy of Sciences	5	
73	Gravitational Wave Detection	Research on Real-time Control of Large-aperture Radio Telescope Surface Shapes and Core Technologies for Ultra-wideband Pulsar Signal Processing	Xinjiang Astronomical Observatory, Chinese Academy of Sciences	5	
74	Gravitational Wave Detection	Research on Environmental Load Measurement and Electromechanical Coupling Control Technology for High-precision Pulsar Timing Array Systems	Xidian University	5	

75	Synthetic Biology	Design, Construction, and Functional Research of Artificial Chromosomes in Eukaryotic Organisms	Peking University	5	35,000 (total)
76	Synthetic Biology	Design, Synthesis, and Functional Research of Non-Natural Bases and Non-Natural Cells	Institute of Cancer and Basic Medicine, Chinese Academy of Sciences	5	
77	Synthetic Biology	Design and Construction of Microbial Chassis Cells for Special Environments	Shanghai Jiao Tong University	5	
78	Synthetic Biology	Rational Design and System Engineering of Microalgae-Based Chassis Cells	Henan University	5	
79	Synthetic Biology	Rational Design and System Engineering of Microalgae-Based Chassis Cells	Qingdao Institute of Bioenergy and Bioprocess Technology, Chinese Academy of Sciences	5	
80	Synthetic Biology	Construction and Applications of Nano-Artificial Hybrid Biological Systems in Tumor Immunotherapy	Zhejiang University	5	
81	Synthetic Biology	Nano-Artificial Hybrid Biological Systems for Early Pancreatic Cancer Diagnosis and Treatment	East China University of Science and Technology	5	
82	Synthetic Biology	Biosensing Systems for Precise Diagnosis and Monitoring of Major Diseases Including Malignant Tumors	Zhejiang Cancer Hospital	5	
83	Synthetic Biology	Research on Synthetic Biological Sensor Systems for Food Safety Testing	Guangdong Institute of Microbiology, Guangdong Academy of Sciences	5	
84	Synthetic Biology	Efficient Processing Systems for Landfill Leachate Using Synthetic Microbiota	Guangdong Institute of Microbiology, Guangdong Academy of Sciences	5	
85	Synthetic Biology	Design and Construction of High-Energy Sugar-Based Batteries	Tianjin Institute of Industrial Biotechnology, Chinese Academy of Sciences	5	
86	Synthetic Biology	Combinatorial Biosynthesis for Constructing Artificial Products with Novel Scaffolds	Huazhong University of Science and Technology	5	

87	Synthetic Biology	Chromosome Engineering of Specialized Yeast Chassis Cells	Fudan University	5	
88	Synthetic Biology	Fundamental Principles of Biological Pattern Formation and Synthetic Biology Research on Artificial Control	Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences	5	
89	Synthetic Biology	Design, Construction, and Application of Non-Natural Photoautotrophic Organisms	Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences	5	
90	Synthetic Biology	Design and Synthesis of Pathogen Tracer Compound Marking Systems	Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences	5	
91	Synthetic Biology	Design and Construction of Biological Carbon Chain Extension and Energy Storage Cells	Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences	5	
92	Synthetic Biology	Design and Synthesis of Non-Natural Artificial Phages	Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences	5	
93	Synthetic Biology	Synthesis and Application of High-Efficiency Preparations for *Pseudomonas aeruginosa* Bacteriophages	The Third Military Medical University of Chinese People's Liberation Army	5	
94	Synthetic Biology	Design and Synthesis of Genetic Circuits for Drug-Resistant Bacteria Diagnosis and Treatment	Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences	5	
95	Synthetic Biology	Design of Biochemical Reactions and Construction of Efficient Biosynthesis Systems for Novel Nitrogen-Containing Molecules	Fudan University	5	
96	Synthetic Biology	Design of Biochemical Reactions and Construction of Efficient Biosynthesis Systems for Novel Nitrogen-Containing Molecules	Tianjin Institute of Industrial Biotechnology, Chinese Academy of Sciences	5	
97	Synthetic Biology	DNA Information Storage in the Immune Microenvironment of Bladder Cancer	Shenzhen University	5	

98	Synthetic Biology	Design and Mechanistic Research of T Helper Cell-Targeted Tumor Environmental Immunotherapy	Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences	5	
99	Synthetic Biology	Novel Combination Immunotherapy Research on "Secondary Reprogramming of Tumor Microenvironment" Using Oncolytic Virus Bispecific Antibodies	Sun Yat-sen University	5	
100	Early Warning and Preparedness Monitoring for Major Natural Disasters (Special Task for the Protection and Utilization of Cultural Heritage)	Critical Technologies for Detection and Prevention of Seepage in Sandstone Cave Fissures (Special Theme Task for Cultural Heritage Protection and Utilization)	Fudan University	3	6,000 (total)
101	Early Warning and Preparedness Monitoring for Major Natural Disasters (Special Task for the Protection and Utilization of Cultural Heritage)	Critical Technologies for Early Warning Systems of Safety Risks in Large-Scale Ming and Qing Dynasty Architectural Complexes	Palace Museum	3	
102	Key Scientific Issues in Innovative Technologies	Research on Lunar Internal Structure and Evolution	National Astronomical Observatories, Chinese Academy of Sciences	5	63,700 (total)
103	Key Scientific Issues in Innovative Technologies	Theory and Methods of On-Orbit Intelligent Multi-Satellite Data Fusion	Tsinghua University	5	
104	Key Scientific Issues in Innovative Technologies	Monolithic High-Integration Self-Curling Technology for Basic 3D Passive Components	Hefei University of Technology	5	
105	Key Scientific Issues in Innovative Technologies	Theoretical and Systems Research on High-Resolution Electromagnetic Vector Imaging	Shanghai Jiao Tong University	5	
106	Key Scientific Issues in Innovative Technologies	Infrared Differential Systems and Silicon-Based Monolithic Integrated Detection Chip Technology	Shanghai Institute of Technical Physics, Chinese Academy of Sciences	5	
107	Key Scientific Issues in Innovative Technologies	Novel Ferroelectric-Controlled Functional Devices for Semiconductor Integration	Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences	5	

108	Key Scientific Issues in Innovative Technologies	Critical Scientific Issues in Room-Temperature Preparation of Biologically-Inspired Ceramic Materials	Wuhan University of Technology	5	
109	Key Scientific Issues in Innovative Technologies	Thermal Protection C/C Composites for Large Special-Shaped Components and Their Manufacturing Technology	Northwestern Polytechnical University	5	
110	Key Scientific Issues in Innovative Technologies	Research on Theory and Technology of In-Situ Regulation and Management for Groundwater Quality Improvement	China University of Geosciences (Wuhan)	5	
111	Key Scientific Issues in Innovative Technologies	Formation Mechanisms, Distribution Characteristics, and Resource Assessment of Deep High-Temperature Geothermal Energy in Eastern China	Peking University	5	
112	Key Scientific Issues in Innovative Technologies	Research on Mars Habitability and Life Signal Detection	Shanghai Astronomical Observatory, Chinese Academy of Sciences	5	
113	Key Scientific Issues in Innovative Technologies	Basic Research on Microgravity Combustion in Energy Power Systems and Space Fire Prevention	Tsinghua University	5	
114	Key Scientific Issues in Innovative Technologies	New Material Processing Principles and Specialized Forming Technology in Space Environments	Northwestern Polytechnical University	4	
115	Key Scientific Issues in Innovative Technologies	Novel Methods for Semiconductor Device Manufacturing Based on Van der Waals Epitaxy-Peel Transfer	Peking University	5	
116	Key Scientific Issues in Innovative Technologies	Antenna Miniaturization Technology Based on Novel Acoustic Principles	Sun Yat-sen University	5	
117	Key Scientific Issues in Innovative Technologies	Modular Mobile Terminal Technology with Open Extension Architecture	Tsinghua University	5	
118	Key Scientific Issues in Innovative Technologies	Basic Research on Ultra-Diffusion Droplet Manipulation Technology for Efficient Pesticide Utilization	Institute of Chemistry, Chinese Academy of Sciences	5	

119	Key Scientific Issues in Innovative Technologies	Research on Key Technologies and Applications of Distributed Optical Fiber Seismic Imaging and Inversion	Institute of Geology and Geophysics, Chinese Academy of Sciences	5	
120	Key Scientific Issues in Innovative Technologies	Seismological Research and Application Demonstration for High-Speed Railways	Xi'an Jiaotong University	5	
121	Key Scientific Issues in Innovative Technologies	Essential Technologies for High-Throughput Microbial Culture Screening and Health-Related Microorganism Identification	Institute of Microbiology, Chinese Academy of Sciences	5	
122	Key Scientific Issues in Innovative Technologies	Studies on Earth-Moon Transportation Networks and High Fault-Tolerant Control Systems	Northwestern Polytechnical University	5	
123	Key Scientific Issues in Innovative Technologies	Research on Fundamental Scientific Issues in Large-Scale In-Situ Mining of Lunar Water Ice Resources	Peking University	5	
124	Key Scientific Issues in Innovative Technologies	Four-Dimensional Tomography and Smart Forecasting of Space Weather in the Ionosphere	Fudan University	5	
125	Key Scientific Issues in Innovative Technologies	Research on Ultra-Low Power Devices for Carbon-Based Sub-10nm Nodes	Peking University	5	
126	Key Scientific Issues in Innovative Technologies	Design Theory and Implementation Technology for Multifunctional Millimeter-Wave Common-Aperture Passive Packaged Components	Beijing Jiaotong University	5	
127	Key Scientific Issues in Innovative Technologies	Carbon-Based and Quantum Dot Composite Technologies for On-Chip Integrated Infrared Sensors	Beijing Institute of Technology	5	
128	Key Scientific Issues in Innovative Technologies	Research on Reconfigurable Optoelectronic Fusion Operators and Interconnection Architectures Based on Silicon Photonics	Nanjing University	5	

129	Key Scientific Issues in Innovative Technologies	Research on Deep Ultraviolet Nonlinear Optical Crystals and Laser Frequency Conversion Performance	Xinjiang Technical Institute of Physics & Chemistry, Chinese Academy of Sciences	5	
130	Key Scientific Issues in Innovative Technologies	Flexible TFT Materials for "Sense-Memory-Computing" Integration Devices in Artificial Vision Systems	Tianjin University	5	
131	Key Scientific Issues in Innovative Technologies	Research on Intelligent Identification of Summer Heavy Rainfall Precursor Mechanisms in the Yangtze River Basin	National Meteorological Center, China Meteorological Administration	5	
132	Key Scientific Issues in Innovative Technologies	Metal Isotope Tracing Technologies and Principles for Earth-Early Life Coevolution	Nanjing University	5	
133	Key Scientific Issues in Innovative Technologies	Metal Stable Isotope Technologies for Tracking Earth's Habitability Evolution During the Mesoproterozoic Era	University of Science and Technology of China	5	
134	Developmental Programming and its Metabolic Regulation	Epigenetic Modification Control of Intestinal Immune System Development and Homeostasis	ShanghaiTech University	5	30,000 (total)
135	Developmental Programming and its Metabolic Regulation	Regulatory Mechanisms of Secretory Proteins in Energy Homeostasis	Tsinghua University	5	
136	Developmental Programming and its Metabolic Regulation	Cardiac-Brain Inter-Organ Metabolic Regulation	University of Science and Technology of China	5	
137	Developmental Programming and its Metabolic Regulation	Cardiovascular Regeneration and Repair Mechanisms and Interspecies Differences	Southwest University	5	
138	Developmental Programming and its Metabolic Regulation	Impact of Glycolipids and Their Metabolic Intermediates on Major Tissue and Organ Development and Homeostasis	Sun Yat-sen University	5	
139	Developmental Programming and its Metabolic Regulation	Genetic Foundations and Pathogenesis of Hereditary Ataxia-Related Movement Disorders	Xiangya Hospital, Central South University	5	

140	Developmental Programming and its Metabolic Regulation	Research on Neural Development Mechanisms in Huntingtin Gene Knock-in Pigs	Jinan University	5	
141	Developmental Programming and its Metabolic Regulation	RNA m6A Modification in the Regulation of Intestinal Development Programming	Southern Medical University	5	
142	Developmental Programming and its Metabolic Regulation	Functions and Mechanisms of Liver Secretory Proteins in Regulating Adipose Tissue Metabolism and Homeostasis	Zhongshan Hospital (Shanghai Medical College, Fudan University)	5	
143	Developmental Programming and its Metabolic Regulation	Mechanisms and Functions of Gut Microbiota Metabolic Remodeling in Tissue Homeostasis, Tumor Formation, and Development Regulation	Zhejiang University	5	
144	National Quality Infrastructure Systems	Core Technology Research and System Establishment for Digital Quality Infrastructure Based on D-SI	National Institute of Metrology of China	3.5	9,000 (total)
145	National Quality Infrastructure Systems	Technical Research on Key Metrological and Measurement Testing for AI Multimodal Sensing	National Institute of Metrology of China	3	
146	National Quality Infrastructure Systems	Core Technology Research on Quality Assurance for 5G Industrial Applications	Instrumentation Technology and Economy Institute (ITEI)	3	
147	National Quality Infrastructure Systems	Research and Application of Core Digital Standards for Emergency Response in Typical Disaster Scenarios	Standardization Administration of China	3	
148	National Quality Infrastructure Systems	Research on Core Technologies for High-Precision Quantitative Characterization and Measurement of Multidimensional Stress Fields	Beijing Institute of Technology	3	
149	National Quality Infrastructure Systems	Energy Efficiency Evaluation of Representative Combustion Equipment Under Complex Conditions	China Special Equipment Inspection and Research Institute	4	

150	National Quality Infrastructure Systems	Research on Critical Measurement Technologies for Novel Biofunctional Material Structures	National Institute of Metrology of China	3.5	
151	National Quality Infrastructure Systems	Quality Inspection and Measurement Traceability Technologies for Protein Biological Products	China Jiliang University	4	
152	National Quality Infrastructure Systems	Research on Cantilever Waveguide Bio-Nano Dimensional Measurement and Intelligent Detection Technologies	Shanghai Institute of Measurement and Testing Technology	4	
153	National Quality Infrastructure Systems	Research and Application of Quality-Based Coordinated Control Technology Systems for Leading Industries in Carbon Peak Management	Huazhong University of Science and Technology	5	
154	National Quality Infrastructure Systems	Research and Application of Core Technologies for Defect Detection, Risk Prevention and Control in In-Service New Energy Vehicles	Standardization Administration of China	3	
155	National Quality Infrastructure Systems	Research and Application of Quality Inspection and Identification Technologies Using Spectroscopic Analysis and Microscopic Imaging	Shanghai Maritime University	4.5	
156	National Quality Infrastructure Systems	Research on Critical International Standards for UAV Autonomy in Technical Leadership	China Aerospace Studies Institute	3	
157	National Quality Infrastructure Systems	Research on Common Technologies for Machine-Readable and International Standards in Key Fields	Instrumentation Technology and Economy Institute, PRC	3	
158	National Quality Infrastructure Systems	International Standards Research and Application for Strategic Essential Mineral Materials and Associated Testing Methods	China Metallurgical Standardization Research Institute	3	

159	National Quality Infrastructure Systems	International Standards Research for Sustainable Urban Development (Phase I)	Standardization Administration of China	3	
160	National Quality Infrastructure Systems	Research on Essential and Fundamental Common International Standards for Maritime Equipment	China Productivity Center for Machinery Co., Ltd.	3	
161	National Quality Infrastructure Systems	International Standards Research on Core Technologies in Advanced Computing and Digital Infrastructure (Phase I)	China Academy of Information and Communications Technology	3	
162	National Quality Infrastructure Systems	International Standards Research on Agricultural Food Product Quality Control and Classification	General Administration of Quality Supervision, Inspection and Quarantine	4	
163	National Quality Infrastructure Systems	Research on Quality Assurance Systems and Essential Technologies in Housing Construction	China Building Standard Design Research Institute Co., Ltd.	3.5	
164	National Quality Infrastructure Systems	Research on Core Technologies for Testing Tampering and Quality Assessment in Forensic Video Portrait Identification Systems	Material Evidence Identification Center of Ministry of Public Security	3	
165	National Quality Infrastructure Systems	Quality Assurance Throughout the Complete Life Cycle of Urban Rail Transit	China Certification and Accreditation Technology Research Center, State Administration for Market Regulation	3	
166	National Quality Infrastructure Systems	Large Gas Turbine Manufacturing	Dongfang Turbine Co., Ltd., Dongfang Electric Corporation	3	
167	National Quality Infrastructure Systems	Integration, Application and Demonstration of Core Technologies for Smart Inspection, Monitoring and Quality Assurance in Large Gas Turbine Manufacturing and Mineral Processing	Mining and Metallurgy Technology Group Co., Ltd.	4	
168	National Quality Infrastructure Systems	Integration, Application and Demonstration Research of Core Technologies for Toxicological Analysis Quality Assurance	Material Evidence Identification Center of Ministry of Public Security	3	

169	National Quality Infrastructure Systems	Integration, Application and Demonstration of Core Technologies for Rapid Customs Clearance and Quality Enhancement of Critical Strategic Inbound Materials	China Customs Science and Technology Research Center	3.5	
170	National Quality Infrastructure Systems	Research and Demonstration Application of Core Technologies for Driving Safety Inspection of Assisted Driving Vehicles	Traffic Management Research Institute, Ministry of Public Security	3	
171	National Quality Infrastructure Systems	Development and Research of Cutting-edge Nucleic Acid Detection Equipment and Technology Platform for Port-based Monitoring of Critical Livestock and Poultry Pathogens	Hangzhou Customs Technology Center	4	
172	National Quality Infrastructure Systems	Integration, Application, and Demonstration of Core Quality Assurance Infrastructure Technologies for Advanced Manufacturing of Medical Electronic Devices	Shenzhen Academy of Metrology and Quality Inspection		
173	National Quality Infrastructure Systems	Research, Application, and Demonstration of National Quality Infrastructure Core Technology Systems for the High-precision High-speed Bearing Industry	China Productivity Center for Machinery Co., Ltd.	3	
174	National Quality Infrastructure Systems	Environmentally-friendly Insulation Gas Systems for Modern Power Industry	Nanjing University of Aeronautics and Astronautics	3	
175	National Quality Infrastructure Systems	Aircraft Engine Assembly Coaxial Alignment Technology Based on Dual-axis Integration	Harbin Institute of Technology	3	
176	National Quality Infrastructure Systems	Next-generation Laser Wavelength Quantum Standard Research Based on Optical Frequency Combs	National Institute of Metrology of China	3	

177	National Quality Infrastructure Systems	Research on Online Monitoring and Quality Assurance Technologies for Performance Parameters of Precision-machined Core Components	Instrumentation Technology and Economy Institute (ITEI)	3	
178	National Quality Infrastructure Systems	Research on Biological Aptamer Measurement Methodologies Using Micro-nano Optical Scale Technology	Harbin Institute of Technology	3	
179	National Quality Infrastructure Systems	Research on Key Technologies for Nanodosimetric Measurement of Radiation Biological Effects in Precision Radiotherapy	National Institute of Metrology of China	3	
180	Networked Collaborative Manufacturing and Smart Factories	System-level Modeling Language Design and Software Development for Industrial Edge Computing	Shanghai Jiao Tong University	2	11,000 (total)
181	Networked Collaborative Manufacturing and Smart Factories	Core Technologies for Blockchain-based Trusted Industrial Internet	Beijing University of Posts and Telecommunications	3	
182	Networked Collaborative Manufacturing and Smart Factories	Theory and Methods for Scenario-driven Spatial Design of Product Ecological Data	Chongqing University	3	
183	Networked Collaborative Manufacturing and Smart Factories	Theory and Methods for Intelligent Product Quality Management and Control Based on Industrial Big Data	East China University of Science and Technology	3	
184	Networked Collaborative Manufacturing and Smart Factories	Multi-dimensional Data Space and Service Theory for Manufacturing Product Lifecycle Value Chain	Southern University of Science and Technology	3	
185	Networked Collaborative Manufacturing and Smart Factories	Integrated Intelligent Design Methodology for Complex Products Driven by Engineering Knowledge and Data Fusion	Beijing Institute of Technology	3	
186	Networked Collaborative Manufacturing and Smart Factories	Integrated Geometry-driven Full-scale Modeling, Analysis, and Optimization Technologies and Tools for Complex Surface Components	Huazhong University of Science and Technology	3	

187	Networked Collaborative Manufacturing and Smart Factories	Core Technologies for Human-Computer Interaction and Autonomous Coordination Control Methods in Intelligent Production Units	Tianjin University	3	
188	Networked Collaborative Manufacturing and Smart Factories	Theory of Data/ Model Hybrid-driven Intelligent Production Line Collaboration and Autonomous Decision-making	Beijing Institute of Technology	3	
189	Networked Collaborative Manufacturing and Smart Factories	Core Technologies and Algorithms for Augmented Reality-based Visual Intelligent Assembly of Advanced Aircraft Equipment	Xi'an Jiaotong University	3	
190	Networked Collaborative Manufacturing and Smart Factories	Big Data Analytics Technology for Precise Operation and Maintenance of Intelligent Equipment in Cloud-Edge Environments	Beijing Institute of Control Engineering	3	
191	Networked Collaborative Manufacturing and Smart Factories	Ultra-lightweight Intelligent Design Technology and Software for Ultra-large Structures with Extreme Service Functions	Nanjing University of Science and Technology	3	
192	Networked Collaborative Manufacturing and Smart Factories	Theory and Methods for Agile Development of Industrial Intelligent Software	Tsinghua University	3	
193	Networked Collaborative Manufacturing and Smart Factories	Construction of Unified Information Models, Intelligent Recognition and Dynamic Integration Methods, and Implementation Tools for Intelligent Manufacturing Execution Systems	National Machinery Intelligent Technology Research Institute Co., Ltd.	2.5	
194	Networked Collaborative Manufacturing and Smart Factories	Topology Optimization and Tool Development for Structures with Coupled Physical Phenomena in Laser Additive Manufacturing	Shanghai Jiao Tong University	3	

195	Networked Collaborative Manufacturing and Smart Factories	Research on Core Technologies and Software Development for High-precision Modeling and Optimization of Large-scale Complex Particle-fluid Systems	Southeast University	3	
196	Networked Collaborative Manufacturing and Smart Factories	Knowledge Integration, Safety Control, and Service Technologies for Smart Factories	Xi'an Jiaotong University	3	
197	Networked Collaborative Manufacturing and Smart Factories	Manufacturing Resource Automatic Adaptive Dynamic Integration Methods and Optimal Operation Support Technology for Discrete Intelligent Workshops	Beijing Institute of Technology	3	
198	Networked Collaborative Manufacturing and Smart Factories	Theory and Methods for Equipment CAE Open Source Software Supporting Incremental Integration	Hunan University	3	
199	Networked Collaborative Manufacturing and Smart Factories	Design and Intersection Theory and Methods for Free-form Curves and Surfaces	Academy of Mathematics and Systems Science, Chinese Academy of Sciences	3	
200	Networked Collaborative Manufacturing and Smart Factories	Rapid Development Methods for Intelligent Manufacturing Management Software in Industrial Interconnection	Inspur General Software Co., Ltd.	2	
201	Social Management and Smart Society Science and Technology Support Projects	Core Technology Research for Independent Development and Controllable Applications of DNA Testing Core Equipment	First Research Institute, Ministry of Public Security	3	19,000 (total)
202	Social Management and Smart Society Science and Technology Support Projects	Research and Application of System Design Methods for Complex Systems in Social Management	Beijing Institute of Technology	3	
203	Social Management and Smart Society Science and Technology Support Projects	Research and Application Demonstration of Core Technologies for Digital Network Management at the Grassroots Level	Zhejiang University	3	

204	Social Management and Smart Society Science and Technology Support Projects	Research and Application Demonstration of Core Technologies for Urban Social Management Collaboration	RoboSense Technology Group Co., Ltd.	3	
205	Social Management and Smart Society Science and Technology Support Projects	Research and Application Demonstration of Analysis and Resolution Technologies for Multiple Conflicts and Conflict Sources	University of Science and Technology of China	3	
206	Social Management and Smart Society Science and Technology Support Projects	Research and Application Demonstration of Detection and Processing Technologies for Financial Fraud and Payment Acceptance Market Violations	Fudan University	3	
207	Social Management and Smart Society Science and Technology Support Projects	Research on Genetic Facial Feature Inference Technology Based on DNA Biological Evidence	Material Evidence Identification Center of Ministry of Public Security	3	
208	Manufacturing Foundation Technology and Core Components	Inspection and Measurement Technology for Basic Physical Parameters of Rolling Bearings	Xi'an Jiaotong University	3	18,000 (total)
209	Manufacturing Foundation Technology and Core Components	Rolling Bearing Assembly Fundamentals and Intelligent Assembly Methods	Wafangdian Bearing Group Co., Ltd.	3	
210	Manufacturing Foundation Technology and Core Components	Life Prediction and Life Extension Design for High Power Density Axial Piston Pump/ Motor Friction Pairs	Beijing Institute of Technology	3	
211	Manufacturing Foundation Technology and Core Components	Online Monitoring and Intelligent Control of High-performance Hydraulic Valve Performance	Nanjing University of Science and Technology	3	
212	Manufacturing Foundation Technology and Core Components	Multidimensional Information Recognition and Intelligent Operation and Maintenance of Gear Transmission Systems	Chongqing University	3	
213	Manufacturing Foundation Technology and Core Components	Flexible Strain Sensor Arrays Based on Two-dimensional Materials	Xi'an Jiaotong University	3	

214	Manufacturing Foundation Technology and Core Components	High-sensitivity Magnetoresistive Sensors	Aerospace Information Research Institute, Chinese Academy of Sciences	3	
215	Manufacturing Foundation Technology and Core Components	High-sensitivity MEMS 3D Electric Field Sensors	Aerospace Information Research Institute, Chinese Academy of Sciences	3	
216	Manufacturing Foundation Technology and Core Components	Silicon-based Thick Metal Film Manufacturing Process Fundamentals	Tsinghua University	3	
217	Manufacturing Foundation Technology and Core Components	Research on Key Technologies for Distributed Independent Electrohydraulic Control Systems for Excavators	Sany Heavy Machinery Co., Ltd.	3	
218	Manufacturing Foundation Technology and Core Components	Core Technologies for High-precision Silicon-based Pressure Sensors for Industrial Measurement and Control	Chongqing Chuanyi Automation Co., Ltd.	3	
219	Manufacturing Foundation Technology and Core Components	Core Technologies for Industrial Robot Reducer Condition Monitoring Sensors	Central South University	3	
220	Manufacturing Foundation Technology and Core Components	Safe and Reliable Technologies for Open Numerical Control Systems	Huazhong University of Science and Technology	3	
221	Manufacturing Foundation Technology and Core Components	Research and Application of Safety Integration Enhancement Technologies for Industrial Control in Intelligent Networks	Zhejiang Supcon Technology Co., Ltd.	3	
222	Manufacturing Foundation Technology and Core Components	Core Technologies for Information Security Protection in Representative Process Industries	Hangzhou Hollysys Automation Co., Ltd.	3	
223	Manufacturing Foundation Technology and Core Components	Development and Demonstration Application of Control Safety Sensors for Power Battery Units	East China Institute of Photoelectronic Integrated Devices	3	
224	Manufacturing Foundation Technology and Core Components	Development and Demonstration Application of Key Sensors for Medical Imaging Equipment	Beijing University of Posts and Telecommunications	3	

225	Cyberspace Security Management	Design Theory and Analysis Technology for Post-quantum Cryptography Systems	Institute of Software, Chinese Academy of Sciences	3	25,500 (total)
226	Cyberspace Security Management	Research on Post-quantum Computing Encryption Systems and Security Mechanisms	The 30th Research Institute, China Electronics Technology Group Corporation	3	
227	Cyberspace Security Management	Research on Fundamental Theories of Privacy Computing and Security	Institute of Information Engineering, Chinese Academy of Sciences	3	
228	Cyberspace Security Management	Research on Fundamental Theories of Privacy Computing and Security	Nanjing University of Aeronautics and Astronautics	3	
229	Cyberspace Security Management	Theoretical Research on Knowledge Atlas Construction for Network Pollution Management	National University of Defense Technology (NUDT)	3	
230	Cyberspace Security Management	Theoretical Research on Knowledge Atlas Construction for Network Pollution Management	Institute of Information Engineering, Chinese Academy of Sciences	3	
231	Cyberspace Security Management	AI-based Security Defense and Evaluation Technology	Nanjing University of Aeronautics and Astronautics	3	
232	Cyberspace Security Management	AI-based Security Defense and Evaluation Technology	National University of Defense Technology (NUDT)	3	
233	Cyberspace Security Management	Core Technology Research for Comprehensive Security Evaluation of Nanoscale Chip Hardware	National Center for Computer Network and Information Security Management	3	
234	Cyberspace Security Management	Research and Development of Distributed Power Supply Protocols and Equipment for Internet Source Address Verification Tables	Huawei Technologies Co., Ltd.	3	
235	Cyberspace Security Management	Research on Core Technologies for Secure Big Data Utilization in Open Environments	Xidian University	3	

236	Cyberspace Security Management	Analysis, Detection Technology, and Application Demonstration of Privacy Collection Behaviors in Mobile Applications	Fudan University	3	
237	Cyberspace Security Management	Research on Personal Rights Protection in Privacy Data	Institute of Information Engineering, Chinese Academy of Sciences	3	
238	Cyberspace Security Management	Research on Detection, Behavior Recognition, and Disposal of Network Pollution in Encrypted Traffic	Institute of Information Engineering, Chinese Academy of Sciences	3	
239	Cyberspace Security Management	Lightweight Security Protection for Heterogeneous Networks in Smart Vehicles	Beijing Institute of Technology	3	
240	Cyberspace Security Management	Security Protection Technology for Industrial Control Programming Platforms Based on Domestic Cryptographic Algorithms	Beijing Hollysys System Engineering Co., Ltd.	3	
241	Cyberspace Security Management	Multilayer Defense and Secure Processing Technology for Industrial Control Systems in Intelligent Network Scenarios	State Grid Liaoning Electric Power Co., Ltd.	3	
242	High-Performance Manufacturing Technology and Major Equipment	Mechanical-Electrical-Intelligent Integrated Design for Flexible Piezoelectric Composite Drive Smart Rotors	Nanjing University of Aeronautics and Astronautics	3	28,300 (total)
243	High-Performance Manufacturing Technology and Major Equipment	Research on Thermal Protection Structures and Surface Drag Reduction Technologies for Hypersonic Aerospace Morphing Vehicles	Beijing Institute of Technology	3	
244	High-Performance Manufacturing Technology and Major Equipment	Research on Flexible High-performance Manufacturing Technologies for Hard, Brittle Thin-walled Special-shaped Components	Zhejiang University	3	

245	High-Performance Manufacturing Technology and Major Equipment	Research and Application of Key Technologies for High-temperature Corrosion-resistant Transmission System Bearings	Luoyang LYC Bearing Co., Ltd.	3	
246	High-Performance Manufacturing Technology and Major Equipment	Research and Application of Key Technologies for Internal Curve Hydraulic Motors	Zhejiang University	3	
247	High-Performance Manufacturing Technology and Major Equipment	Core Design, Manufacturing, and Application Technologies for High-performance Aviation Hydraulic System Seals	Guangzhou Mechanical Engineering Research Institute Co., Ltd.	3	
248	High-Performance Manufacturing Technology and Major Equipment	Core Technologies for Comprehensive Testing Platforms of High-speed Train Transmission System Bearings	China Academy of Railway Sciences Corporation Limited	3	
249	High-Performance Manufacturing Technology and Major Equipment	Manufacturing Technologies and Core Equipment for High-strength Ultra-thin Copper Foil	Xi'an Taijin Industrial Electrochemical Technology Co., Ltd.	3	
250	High-Performance Manufacturing Technology and Major Equipment	Precision Forming Technologies for Large-scale Space Thin-walled Aluminum Alloy Monolithic Cylinder Sections	Shanghai Aerospace Precision Machinery Institute	3	
251	High-Performance Manufacturing Technology and Major Equipment	High-performance Hot Rolling Forming Technologies for Extra-large H-beam Steel	Zhongzhong Science & Technology (Tianjin) Co., Ltd.	3	
252	High-Performance Manufacturing Technology and Major Equipment	High-reliability Brazing Technologies and Equipment for Large Titanium Alloy Plate-fin Heat Exchangers	Zhengzhou Mechanical Engineering Research Institute Co., Ltd.	3	
253	High-Performance Manufacturing Technology and Major Equipment	Digital Frozen Sand Mold Green Casting Technologies and Equipment	Nanjing University of Aeronautics and Astronautics	3	
254	High-Performance Manufacturing Technology and Major Equipment	New MOCVD Technologies for Micro LED	Advanced Micro-Fabrication Equipment Inc. (AMEC)	3	
255	High-Performance Manufacturing Technology and Major Equipment	Core Technologies and Equipment for Deep-sea Seabed Drilling Systems	China University of Petroleum (East China)	3	

256	High-Performance Manufacturing Technology and Major Equipment	Core Technologies and Equipment for 1000-meter Shaft Hard Rock Full Section Roadheaders	China Railway Construction Heavy Industry Corporation Limited (CRCHI)	3	
257	High-Performance Manufacturing Technology and Major Equipment	Research on High-performance Silicon Carbide Single Crystal and Epitaxial Equipment and Processing Technologies	NAURA Technology Group Co., Ltd.	3	
258	Blockchain	Construction Design Theory and Methods for Novel Blockchain Systems	East China Normal University	3	11,600 (total)
259	Blockchain	Design Theory and Methods for Highly Reliable and Elastic Blockchain Architecture	Wuhan University	3	
260	Blockchain	Research on Core Technologies for Network-Safety-Reliability Integrated Blockchain Performance Models and Multi-level Sustainable Cooperative Optimization	Beihang University (the former Beijing University of Aeronautics and Astronautics)	3	
261	Blockchain	Research on Blockchain Evaluation and Measurement Technology Systems	China Academy of Information and Communications Technology	3	
262	Blockchain	Research on Core Technologies for Blockchain Ecosystem Safety Supervision and Management	Hangzhou Yunxiang Network Technology Co., Ltd.	3	
263	Blockchain	Research on Core Technologies for Blockchain Ecosystem Safety Supervision and Management	Hainan University	3	
264	Blockchain	Research on Basic Theory and Methods for High-concurrency Scalable Blockchain Storage	Huazhong University of Science and Technology	3	
265	Blockchain	Research on Asynchronous Blockchain Scalability Technologies Supporting Layering-Folding-Aggregation	Hefei Institutes of Physical Science, Chinese Academy of Sciences	3	

266	Blockchain	Blockchain Security Threat Recognition and Forensic Investigation	Nanjing University of Information Science and Technology	3	
267	Blockchain	Blockchain Security Threat Recognition and Forensic Investigation	Tsinghua University	3	
268	Industrial Software	Research on Theory and Methods for Device-Edge-Cloud Interconnection Integration in OT and IT Integration	Beijing University of Posts and Telecommunications	3	19,200 (total)
269	Industrial Software	Research on Theory and Methods for Device-Edge-Cloud Interconnection Integration in OT and IT Integration	Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences	3	
270	Industrial Software	Intelligence Theory and Methods for Industrial Data Throughout the Discrete Manufacturing Process	Nanjing University of Posts and Telecommunications	3	
271	Industrial Software	Intelligence Theory and Methods for Industrial Data Throughout the Discrete Manufacturing Process	Beihang University (the former Beijing University of Aeronautics and Astronautics)	3	
272	Industrial Software	Basic Theoretical and Technical Research for Next-generation Industrial Internet of Things Data Management	Tsinghua University	3	
273	Industrial Software	Research and Software Implementation of Embedded Field Isogeometric CAE Theory and Computational Methods	Dalian University of Technology	3	
274	Industrial Software	Digital Ecosystem Theory Research for Group Enterprise Value Chains	Harbin Institute of Technology	3	
275	Industrial Software	Digital Ecosystem Theory Research for Large-scale Manufacturing Network Structure Value Chains	Sichuan University	3	
276	Industrial Software	Research on Theory and Methods for Reliable Traceability in Large-scale Manufacturing	Northeastern University	3	

277	Industrial Software	Research on Frontier Technologies for Next-generation Field-level Industrial Internet of Things Integration Networking and Deployment	Chongqing University of Posts and Telecommunications	3	
278	Industrial Software	Research on Digital Security Integrated Management and Control Theory and Methods for Smart Factories in Process Industries	Beijing University of Chemical Technology	3	
279	Industrial Software	Research on Data-driven Manufacturing Process Closed-loop Control Analysis and Optimization Methods	University of Science and Technology Beijing	3	
280	Industrial Software	Research on Theory and Methods for Intelligent Production Line Management and Control Based on Cloud-Edge Device Collaboration	Nanjing University of Aeronautics and Astronautics	3	
281	Industrial Software	Research on Basic Theory and Methods for Edge Control and Real-time Simulation Based on MEC	Shenyang Institute of Automation, Chinese Academy of Sciences	3	
282	Industrial Software	Research, Development, and Application of Industrial Internet Operating System Core Components for Discrete Industries	Beijing Institute of Technology	3	
283	Industrial Software	Development and Application of Integrated Platforms for Design/Manufacturing/Operation and Maintenance of Large Engineering Equipment in Complex Construction Environments	China Railway Construction Heavy Industry Corporation Limited (CRCHI)	3	
284	Industrial Software	Research, Development, and Application of Industrial Internet Platforms for Large-scale Manufacturing Industries	Gree Electric Appliances, Inc. of Zhuhai	3	

285	Industrial Software	Research, Development, and Application of Industrial Internet Platforms for Customized Industries	Guangzhou MINO Automotive Equipment Co., Ltd.	3	
286	Industrial Software	Research, Development, and Application of Industrial Internet Platforms for Distributed Factories	Shanghai Aircraft Manufacturing Co., Ltd.	3	

Note: Amounts are not final.
Source: National Science and Technology Management Information System Public Service Platform (as of December 15, 2021)

Profiles of Authors and Survey Respondents (in no particular order, honorifics omitted)

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Survey Respondents

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Research Planning

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