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ARTICLE

Multi-Dimensional Analysis and Trend Prediction of China's Scientific Research Service Industry using the PEST Model

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Abstract

As China pushes ahead with its innovation-driven development initiatives against the backdrop of growing shifts in the global innovation landscape, its scientific research service (SRS) sector has grown from its infancy towards maturity. With increased interactions between China and other countries in scientific research, China's SRS industry transitions from an input-driven model of development towards one centered on building an innovation ecosystem. In this study, the PEST model is employed to examine the political, economic, social, and technological impacts on the construction of an innovation ecosystem in China's SRS industry, provide a glimpse into the current dynamics of this industry, and unveil the causes for problems within. Some recommendations are proposed to improve this innovation ecosystem. The research here aims to lay a foundation for developing an independent and controllable innovation ecosystem for research support service and provide a decision-making basis for research support service providers in China.

Keywords: Scientific Research Service Industry; PEST Model; Development Trend

1. INTRODUCTION

As the competition for technological superemacy intensifies across the globe in these years, nations are turning to science and technology (S&T) innovation for more national strength and global clout. Against this backdrop, the scientific research service (SRS) industry, which is a crucial part of China's innovation ecosystem construction initiative, now stands primed to thrive and expand on a tailwind of national economic growth and increased investments into S&T innovation. However, behind the boom lurk concerns—lingering dependence on foreign service providers in the high-end market, structural imbalance in R&D investment, and regional inequality in the industry development.

The PEST model, a classical macroeconomic environment analysis framework proposed by Johnson G. and Scholes K. in 1999, allows organizations to assess external factors and their impacts through political, economic, social, and technological prisms [1]. In this study, a theoretical framework based on political, economic, social, and technological (PEST) analysis is constructed to examine the macroenvironment of China's SRS industry, and recommendations are proposed accordingly for improvement. The objectives of this study are to provide a decision-making basis for the industry stakeholders, lead China's SRS industry toward quality development despite the vagaries in the market, and improve China's technological self-reliance and global competitive edge.

2. ENVIRONMENTAL FACTORS OF CHINA'S SRS INDUSTRY AND THEIR IMPACTS

2.1. Political factors

2.1.1. Ongoing Updating of Policies for Scientific Research: Systematic Restructuring of the Innovation Ecosystem

China's national strategy propels fundamental research into high gear. The "*The Outline of the 14th Five-Year Plan for Economic and Social Development (2021–2025) and Long-Range Objectives*

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through the Year 2035" approved in the Fifth Plenary Session of the 19th CPC Central Committee mandates the establishment of national high-end platforms for scientific research publication and technological information exchange. This endeavor plays a pivotal role in improving China's technological strength and enhancing research data sharing and service infrastructure. In addition, the central authority, considering fundamental research the cornerstone in the nation's ambition to achieve S&T self-reliance, stipulates in its 14th Five-Year Plan that fundamental research funding should take up 8% of overall R&D investment by 2025[1]. The "*Guiding Standards for Imported Products Procurement Review"*, issued by the Ministry of Finance, imposed minimum domestic procurement quotas across categories of research instruments, and provincial governments followed suit by tightening governmental procurement of imported equipment, providing a tailwind to the rapid expansion of domestic alternatives[2]. Encouraging both goal-oriented research and curiosity-driven exploratory studies, the national policy framework aims to forge a closer link between fundamental research and new productive forces by restructuring state laboratories and initiating major scientific & technological programs [2,3].

Reforms of the evaluation mechanism have alleviated "involutionary" competition (or zero-sum competition) within the research circle. Through pilot reforms in six provinces and cities (including Shanghai and Shandong) and 21 research institutes and universities, China's Ministry of Science and Technology tried to promote the new evaluation model featured by "landmark achievement-based evaluation" and "long-cycle evaluation", a model that prioritizes the researchers' contribution to original theories and high-quality publications in the assessment of researchers. Meanwhile, some pioneering regions like Shanghai have started establishing "fundamental research special zones", where two disruptive mechanisms—negative list management and independent budgeting—are adopted, mandating the allocation of over 60% of research funds to R&D activities and granting principal investigators the decisive authority over the technical pathway of research [4].

The establishment of pilot "fundamental research special zones" optimizes resource allocation. As the "fundamental research special zones" pioneered by Shanghai gained traction nationwide, provinces like Guangdong and Sichuan followed suit, which significantly increased the flexible research fund utilization rate (from 35% to 60% in some programs)[3] and allowed researchers to decide the research priorities and allocate funds on their own. As stipulated by the Ministry of Science and Technology, these special zones need to strive for "zero-to-one" breakthroughs, and implement the "lump-sum" funding management model to have more autonomy in budget planning, slash bureaucratic overhead in financial planning, and maximize the researchers' autonomy in research work, thereby unleashing scientists' instinct to explore and innovate.

2.1.2. Escalating Global Technology Race: Multi-Front Contest under Rule Overhauls

The world is experiencing a systematic escalation of constraints on cross-border technology sharing. The key US agencies—its Department of Energy, National Institutes of Health (NIH), Department of Defense, and National Science Foundation—have issued a flurry of restrictions[4] in an attempt to curb research collaborations and academic exchange with Chinese institutions. Likewise, the European Union has rolled out "ProtectEU: Internal Security Strategy", compelling participants in its Horizon Europe program to undergo technology sovereignty risk evaluation and imposing strict controls over programs in 12 critical fields like artificial intelligence (AI) and quantum computing, while accelerating supply chain diversification to cut reliance on China for critical raw materials.

Divergent tactics have reshaped the global battle for talents. Per reports from the US Department of State, the F-1 visa rejection rate for US-bound students rose to a decade high of 41% in the 2023–2024 fiscal year. The EU, on the contrary, has rolled out a kaleidoscope of policy campaigns (issuing

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[1] Source: "*Proposals for Formulating the 14th Five-Year Plan (2021–2025) for National Economic and Social Development and the Long-Range Objectives Through the Year 2035"*, Section 2.3.

[2] Source: https://www.cn-healthcare.com/articlewm/20211018/content-1275030.html

[3] Source: "*Several Opinions of the General Office of the State Council on Reforming and Improving the Management of Central Government Scientific Research Funds*"; https://www.gov.cn/zhengce/2021-09/01/content_5634633.htm.

[4] "*Science & Technology Policy*" issued by National High-end Think Tank of Chinese Academy of Sciences (CAS) on September 5th, 2019; https://www.casisd.cn/zkcg/ydkb/kjzcyzxkb/2019/kjzcxkb201909/202001/P020200116524250467441.pdf.

blue cards, for instance) to attract highly-qualified scientists and specialists to live and work in an EU country. Statistics from the Chinese Academy of Sciences (CAS) reveal that from 2020 to 2024, China has witnessed a sharp growth (1.2 times higher than the preceding five years) in the number of highly-qualified talents it has drawn from abroad, among whom are postdoctors and professors from Harvard, MIT, and Oxford.

The rule-making dominance grows to the focus of the global technology race. Through the "Digital Belt and Road" (DBAR) initiative, China has joined hands with 59 nations to build a global Earth data-sharing network in support of the sustainable development goals. The EU, through its €95.5 billion "Horizon Europe" program, planned to cement its rulemaking authority by doubling its research funding by 2024 and establishing standards for domains like green and digital technologies. The US followed suit and enforced biomedical data sovereignty protocols to restrict cross-border access to NIH and NIC databases, which compels China to build its own databases.

2.1.3. China's Improved S&T Governance Capacity: Towards Multi-Party Collaboration in Ecosystem Construction

China has seen growing collaborations between its central and regional governments in building an innovation network. As of 2024, special funds have been launched in several provinces across China for fundamental research programs to explore a model of multi-party engagement. Guangdong and Jiangsu pioneered the "horse-racing model", in which competing teams pursue different roadmaps within shared research domains, while individual researchers or institutions are exempted from liability for unmet objectives (excluding scenarios involving misconduct) to encourage bold experimentation and embrace risks in R&D[5].

A novel nationwide innovation system is underway in China. China's "Innovation 2030" initiative adopts the centralized command model characterized by "chief architect accountability". The "Brain Science and Brain-inspired Technology" project is a fine example: directed by the Central Science and Technology Commission, the project integrates resources from the National Health Commission and CAS to build a inter-departmental collaboration network, and run in a "demand-oriented" closed-loop structure involving the demand party (the National Health Commission), the supplier (research institutes), and the application party (enterprises or hospitals), it has enabled remarkable breakthroughs in neurodegenerative therapeutics and biomaterials R&D. When translating research findings in the project to real-world solutions, the accountablity system featured by "open-challenge grants" and "performance-bound commitment" is implemented for enhanced oversight.

Alignment with the global research ethics is strengthened. As stipulated in the "*Measures for the Review of Science and Technology Ethics (Trial)*" jointly released by the Ministry of Science and Technology and other authorities in China in 2024, research institutes must set up ethics committees and establish codes of ethics for cutting-edge research domains like gene editing and AI [6]. In response to this evolution, Shenzhen piloted the "S&T collaboration review mechanism", and by issuing the "Implementation Plan for Strengthening the Governance of Science and Technology Ethics", the city mandated the establishment of a collaborative review system across institutions and regions, incorporating Hong Kong and Macau into the joint effort of constructing a collaborative S&T ethics governance network[7].

2.2 Economic Factors

2.2.1. Expanded Industry Scale: Foreign Capital-Dominated High-End Market Coexisting with the Upgrading of Domestic Mid/Low-End Local Alternatives

Industrial chain synergy has fueled robust growth in China. Table 1 compares the revenues of sub-sectors in the SRS industry in 2018 and 2023.

As Table 1 shows, in 2023, China's SRS industry yielded a revenue totalling 8.6 trillion yuan, where 14% (1.2 trillion yuan) was from the research and experiment development service

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[5] Source: "*New Technology Innovation Regulations of Guandong", "Action Plan for Jiangsu to Strengthen Basic Research*", and "*Administrative Measures on Special Funds for Science and Technology Plan in Jiangsu*".
[6] Source: "*Measures for the Review of Science and Technology Ethics (Trial)*".
[7] Source: "*Notice for Strengthening the Governance of Science and Technology Ethics in Shenzhen*", issued by General Office of Shenzhen Municipal People's Government.

subsector. Compared with 2018, this subsector witnessed a 132.5% revenue growth, and the main growth driver was the surging R&D need in the biopharma and semiconductor fields. The S&T commercialization service subsector generated a revenue of 2.3 trillion yuan in 2023, 126.2% higher than in 2018, indicating accelerated translation of scientific findings into market solutions[8].

Table 1. Revenue of Subsectors in China's SRS Industry in 2018 and 2023[9]

Sub-Sectors	Revenue in 2018 (trillion yuan)	Revenue in 2023 (trillion yuan)	Growth Rate (%)
Research and experiment development services	0.51475	1.19698	132.5
Specialized technical services	2.93412	5.09845	73.8
S&T commercialization and application services	1.0207	2.30921	126.2
Sum	4.46957	8.60464	92.5

Barriers to the high-end market remain, but mid- and low-end services keep upgrading as alternatives. Table 2 shows the structure of China's SRS service market and the market share taken by foreign capital.

According to research and analysis conducted by Zero Power Intellgence Group, currently, in the high-end segments of China's scientific research instrument market, such as analytical instruments and optical instruments, the localization rate has increased from 22% in 2020 to 38% in 2024. In fields like spectrophotometers and atomic fluorescence spectrometers, the localization rate has reached over 50%. However, in the segment of top-tier instruments such as mass spectrometers and electron microscopes, the import dependency remains as high as over 85%[10], driven by a command released by the Ministry of Finance in 2023 mandating that research institutions procure instruments from domestic providers, and this triggers a surge in the demand for domestic mid- and low-end instruments. Meanwhile, the "Major Technology Instrument R&D Initiative", led by the Ministry of Science and Technology, encourages breakthroughs in R&D of key research instrumentation like mass spectrometry and spectroscopy, with a vision to shape a development pattern powered by two engines—substitution for imports and independent innovation.

Table 2. China's SRS Market Structure and Market Share Taken by Foreign Capital in 2019–2023

Year	Actual foreign capital usage in China	Scale of foreign capital	Market share of foreign brands (research instruments/reagents)	Data source
2019	138.14 billion USD	**Revenue of foreign enterprises:** Thermo Fisher Scientific: 2.752 billion USD Merck: 2.294 billion USD Danahe: 2.308 billion USD **Market scale** 251.6 billion yuan (foreign capital accounting for 90%, around 226.44 billion yuan)	> 90% (80%–90% high-end reagents were imported from abroad)	FDI Statistics from the Ministry of Commerce, reports from China International Capital Corporation (CICC), China Scientific Research Services Market Analysis Report

[8] Source: "*Communiqué on the Fifth National Economic Census*", released by National Bureau of Statistics.
[9] Source: "*Communiqué on the Fourth National Economic Census*" and "*Communiqué on the Fifth National Economic Census*" released by the National Bureau of Statistics.
[10] Source: 2025-2030 China Scientific Research Instruments Industry Market Panoramic Research and Trend Outlook Report.

Table 2. China's SRS Market Structure and Market Share Taken by Foreign Capital in 2019–2023 (continued)

Year	Actual foreign capital usage in China	Scale of foreign capital	Market share of foreign brands (research instruments/reagents)	Data source
2020	144.37 billion USD	**Foreign capital for high-tech services:** 50.14 billion USD **Market scale:** 251.6 billion USD (foreign capital taking up 90%, reaching 226.44 billion yuan)	90% (domestic bioreagents took up a share below 10%)	2022 Statistical Communiqué released by the Ministry of Commerce, CICC reports
2021	173.48 billion USD	**Foreign capital for high-tech services:** 50.14 billion USD (close to the figure in 2020, not separately disclosed); **Market scale:** 276.8 billion yuan (foreign capital taking up 88%–90%)	88%–90% (90% tool compounds were imported)	2022 Statistical Communiqué and Industry Forecasts released by the Ministry of Commerce, Industry
2022	189.13 billion USD	**Foreign capital for high-tech services:** 50.14 billion USD **Growth in foreign capital for R&D and design services:** 57.1%	85%–88% (over 80% research instruments were imported)	2023 Statistical Communiqué released by the Ministry of Commerce, Statistics from the Haikou Municipal Bureau of Commerce
2023	158.47 billion USD	**Foreign capital in the high-tech industry :** 59.16 billion USD (37.3% of the total) **Growth in foreign capital for R&D and design services:** 4.1%	80%–85% (domestic alternatives grew and breakthroughs were seen in the mid- and low-end market)	2024 Statistical Communiqué released by the Ministry of Commerce; reports from regional technological authorities

2.2.2. Structural Imbalance in R&D Investment: Dual Challenges from Scale Expansion and Efficiency Improvement

Domestic investments into R&D initiatives have been increasing, but gaps remain with the global technology powerhouses like the US and the EU. Figure 1 shows the volume of R&D investment in China and the R&D investment intensity (measured by the percentage it takes in the nation's GDP), and Figures 2 and 3 show the comparison between several nations in their R&D expenditure.

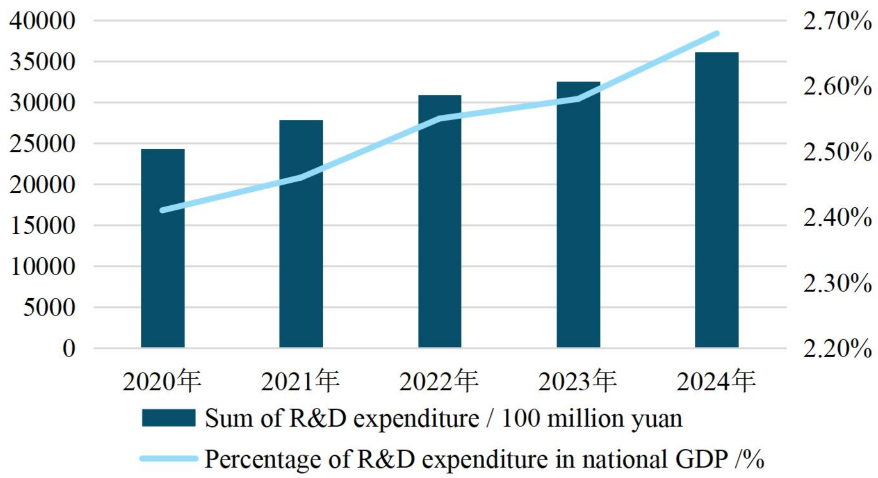

Figure 1. Volume and Intensity of R&D Inputs in China in 2020–2024[11]

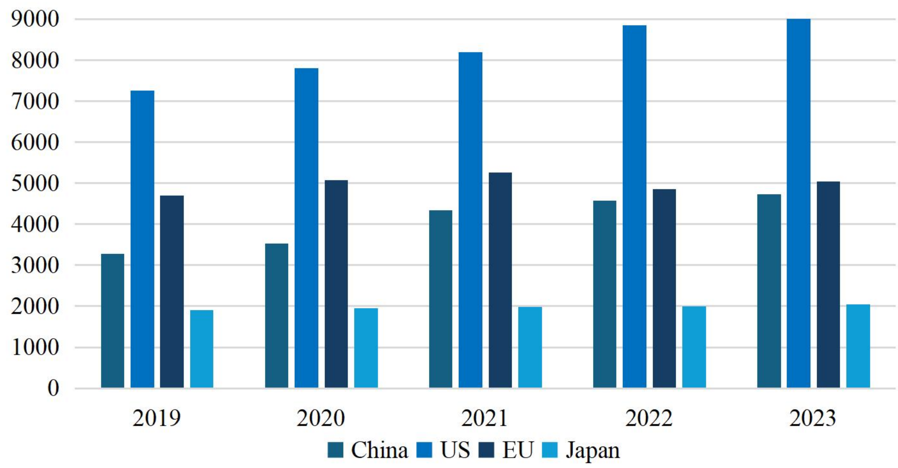

Figure 2. R&D Expenditure of Different Countries in 2019–2023

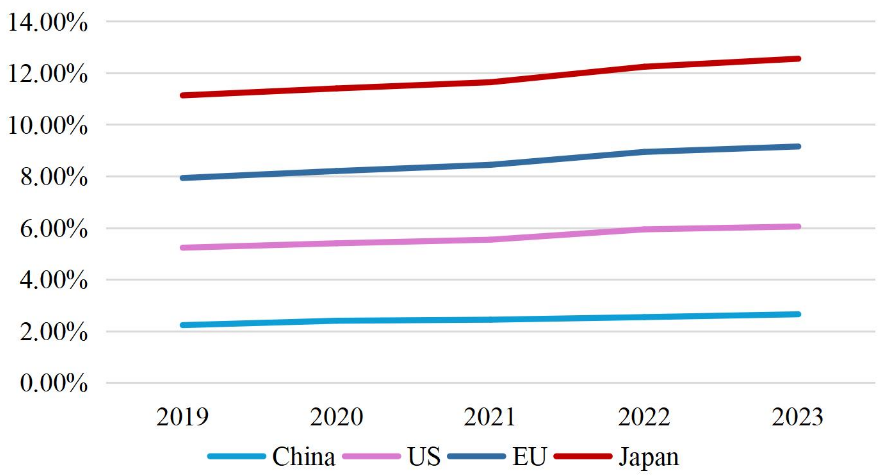

Figure 3. Comparison of R&D investment Intensity in Different Countries in 2019–2023

As Figures 1–3 show, from 2020 to 2024, China's R&D inputs have grown steadily from 2.44 trillion yuan to 3.6 trillion yuan, a 47.5% cumulative growth with an annual growth of around 8.3%,

[11] Source: "*Communiqué on National Expenditures on Science and Technology in 2020–2024*".

making China the second-largest R&D investor across the globe[12]. However, a quick look at the statistics in 2022 reveals that China's R&D expenditure was 49.57% of that in the US; and in 2024, R&D expenditure accouted for 2.68% of the nation's GDP, higher than the rate in the EU (2.1%), but remained lower than that in the U.S. (3.4%) and Japan (3.4%)[13].

The imbalance between investments into applied research and fundamental research expenditure emerges as another challenge. Figure 4 shows the percentage of corporate R&D investments in China's overall R&D expenditure; Figure 5 illustrates the distribution of R&D expenditure across different types of research activities in China in 2020–2023; and Table 3 shows the comparison between China and some more developed countries in R&D expenditure in 2019–2023.

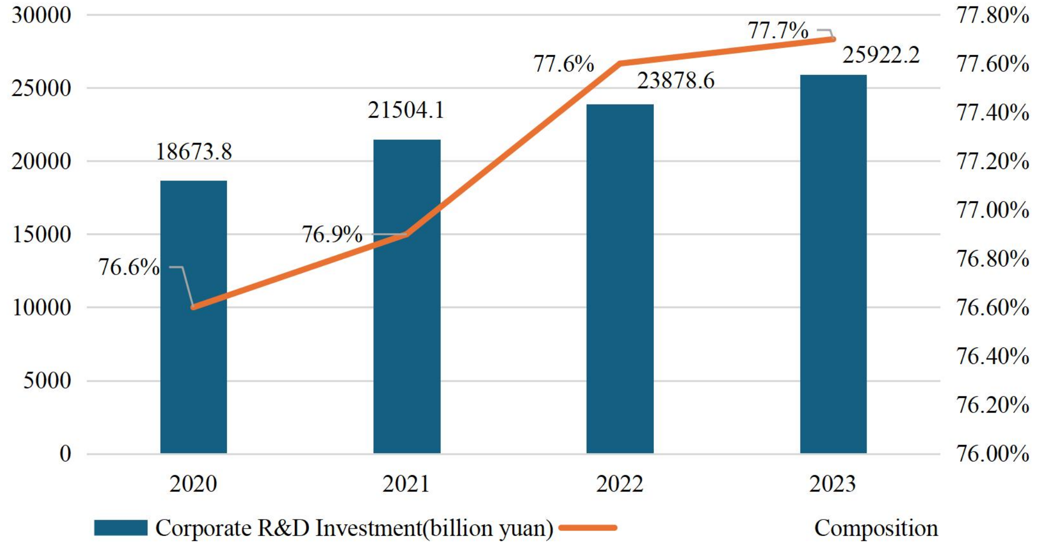

Figure 4. R&D Investments by Enterprises in China in 2020-2023[14]

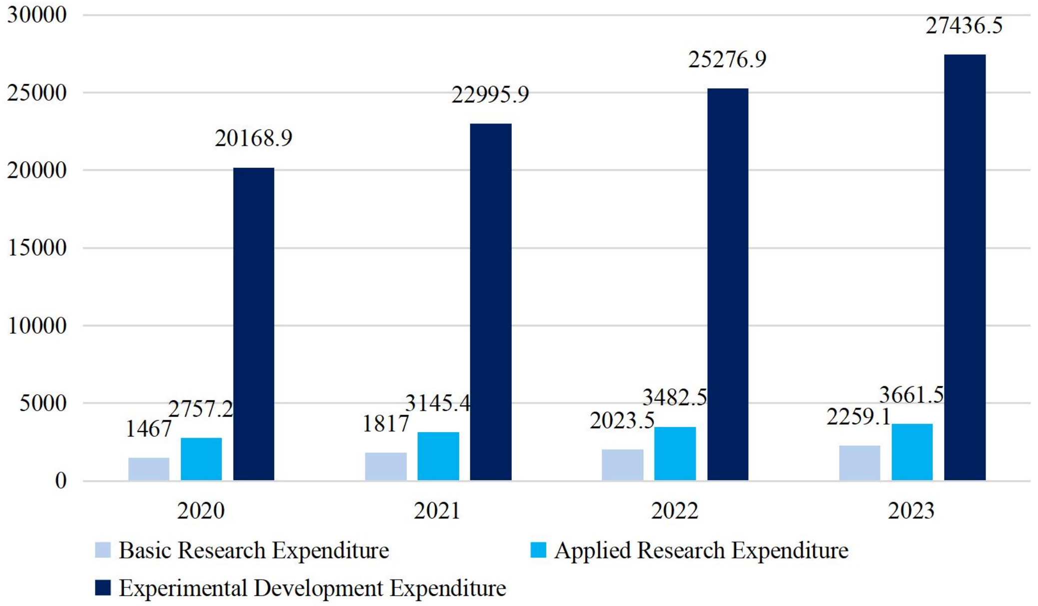

Figure 5. Distribution of R&D Expenditures in China in 2020-2023[15]

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[12] Source: Statistics from China's National Bureau of Statistics.
[13] Source: Statistics from China's National Bureau of Statistics, NSF, and OECD.
[14] Source: "*Communiqué on National Expenditures on Science and Technology in 2020–2024*".
[15] Source: "*Communiqué on National Expenditures on Science and Technology in 2020–2024*".

Table 3. R&D Expenditure and Input Intensity in different Countries in 2019-2023

Year	China (R&D expenditure/investment intensity)	US (R&D expenditure/investment intensity)	EU (R&D expenditure/investment intensity)	Japan (R&D expenditure/investment intensity)
2019	328.434 billion USD/ 2.23%	726 billion USD/ 3.0%	470.358 billion USD/ 2.7%	190 billion USD/ 3.2%
2020	353.426 billion USD/ 2.40%	780 billion USD/ 3.0%	507.4 billion USD/ 2.8%	195 billion USD/ 3.2%
2021	433.346 billion USD/ 2.44%	820 billion USD/ 3.1%	526.504 billion USD/ 2.9%	198 billion USD/ 3.2%
2022	457.554 billion USD/ 2.54%	885.6 billion USD/ 3.4%	486.225 billion USD/ 3.0%	200 billion USD/ 3.3%
2023	473.363 billion USD/ 2.65%	900 billion USD/ 3.4%	504.022 billion USD/ 3.1%	205 billion USD/ 3.4%

Data source: National Bureau of Statistics, Ministry of Science and Technology, "*Communiqué on National Expenditures on Science and Technology in 2023 by the National Bureau of Statistics*" released by the Ministry of Finance [16].

In China, enterprises remain the largest R&D investors, who account for 75% of the nation's total R&D expenditure, a ratio close to that in the U.S. (79.0%) and Japan (79.4%), but higher than the ratios in European nations like Germany (67.4%) and France (65.8%). Nonetheless, most of these corporate investments go to applied research, while fundamental research takes up merely 6.91% of the total R&D expenditure. Though fundamental research expenditure in China has grown by 10%, it is far below that in the more developed nations[17].

The aggregation of R&D resources has exacerbated regional inequality in China. The distribution of R&D resources exhibits pronounced spatial polarization. Table 4 shows the R&D expenditure of provinces and regions across China in 2023.

As Table 4 shows, in 2023, eastern China took up 65.4% of the total R&D expenditure nationwide, with Guangdong, Jiangsu, and Beijing collectively claiming a percentage of 39.8%. Pronounced aggregation effects were observed in the Pearl River Delta (Shenzhen's R&D inputs took up 46.6% of the R&D expenditure of Guangdong) and the Yangtze River Delta (Shanghai's R&D inputs accounted for 6.2% of the national R&D expenditure). However, 12 cities in eastern, western, and northern Guangdong, though also in eastern China, accounted for less than 5% of the provincial R&D investment. Notably, central and eastern regions witnessed a surge in the R&D expenditure by 9.2%–10%, outstripping the figure of 7.8% in eastern China. The R&D intensity (measured by the ratio of R&D expenditure to regional GDP) along the Yangtze River Economic Belt and the Yellow River rose to above 9.0%, indicating improved synergy across regions in R&D expenditure[18] [5].

[16] Source: https://www.stats.gov.cn/sj/zxfb/202410/t20241002_1956810.html (National Bureau of Statistics); *"Research and Development: U.S. Trends and International Comparisons"* https://casisd.cas.cn/zkcg/ydkb/kjzcyzxkb/2024/zczxkb202407/202410/t20241029_7409909.html; https://zh-cn.eureporter.co/business/research/2023/12/07/eu-expenditure-on-rd-reaches-e352-billion-in-2022 (Eurostat).
[17] Source: Statistics from China's National Bureau of Statistics, NSF, and OECD.
[18] Source: Statistical communiques released by National Bureau of Statistics and regional statistics bureaus in China.

Table 4. R&D Expenditure and Input Intensity across China in 2023

Province/Region	R&D Expenditure (100 million yuan)	Ratio to GDP (%)
Nationwide	33357.1	2.65
Beijing	2947.1	6.73
Tianjin	599.2	3.58
Hebei	912.1	2.08
Shanxi	298.2	1.16
Inner Mongolia	228.1	0.93
Liaoning	676.4	2.24
Jilin	210.2	1.55
Heilongjiang	229.3	1.44
Shanghai	2049.6	4.34
Jiangsu	4212.3	3.29
Zhejiang	2640.2	3.20
Anhui	1264.7	2.69
Fujian	1171.7	2.16
Jiangxi	604.1	1.88
Shandong	2386.0	2.59
Henan	1211.7	2.05
Hubei	1408.2	2.52
Hunan	1283.9	2.57
Guangdong	4802.6	3.54
Guangxi	228.1	0.84
Hainan	89.8	1.19
Chongqing	746.7	2.48
Sichuan	1357.8	2.26
Guizhou	211.4	1.01
Yunnan	346.7	1.15
Xizang	7.2	0.30
Shaanxi	846.0	2.50
Gansu	156.2	1.32
Qinghai	30.3	0.80
Ningxia	85.5	1.61
Xinjiang	115.5	0.60

Data source: Communiqué on National Expenditures on Science and Technology in 2023 by the National Bureau of Statistics[19]

2.2.3. Unleashed Human Capital: Compensation System Optimization amidst Structural Tensions

The compensation rise for researchers in China fails to catch up with the growth in R&D expenditure. Over the half decade from 2019 to 2023, the mean salary of the SRS industry rose from 133,459 yuan to 164,686 yuan, a 23.4% growth. However, this pales against the 48.2% surge in R&D expenditure within the same timeframe. The salary rise is barely half the rise in the R&D spending, signaling the uncoupling between human capital inputs and R&D outputs. Meanwhile, stark regional disparity was observed: the salary in Beijing and Shanghai doubled that in eastern China (Henan and Shanxi, for instance), as shown in Tables 5 and 6, and Figure 6.

Table 5. Mean Salary of China's SRS Industry in 2019–2023

Year	Mean Salary (yuan/year)
2019	133,459
2020	139,851
2021	151,776
2022	163,486
2023	164,686

[19] Source: https://www.stats.gov.cn/sj/zxfb/202410/t20241002_1956810.html.

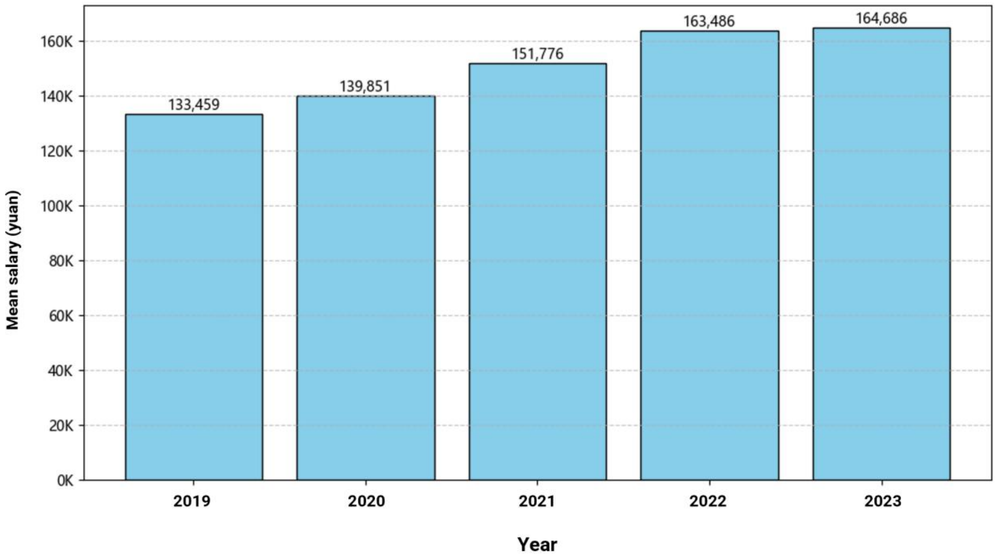

Figure 6. Mean Salary Trends in China's SRS Industry in 2019-2023

Table 6. Mean Salary of the SRS Industry and the Educational Industry across China in 2023[20]

Province/Region	SRS Industry		Education Industry	
	Year-End Population	Mean Salary (yuan)	Year-End Population	Mean Salary
Nationwide	**3,974,977**	**164,686**	**18,617,148**	**126,861**
Beijing	535,891	234,604	479,594	234,872
Tianjin	93,129	222,701	201,911	152,979
Hebei	130,325	118,557	824,677	101,227
Shanxi	78,450	100,784	522,957	94,788
Inner Mongolia	54,914	113,165	357,593	111,896
Liaoning	81,855	136,110	503,996	108,289
Jilin	57,022	122,242	337,067	101,806
Heilongjiang	49,116	114,749	365,583	109,104
Shanghai	235,861	253,805	357,873	240,821
Jiangsu	247,022	163,654	1,113,293	161,267
Zhejiang	224,809	186,738	855,853	170,394
Anhui	101,762	132,788	654,737	122,501
Fujian	74,232	150,658	571,232	135,345
Jiangxi	67,338	121,359	620,999	107,275
Shandong	231,365	127,960	1,265,321	126,069
Henan	164,448	98,416	1,168,052	83,934
Hubei	153,643	163,355	710,158	119,924
Hunan	120,060	125,339	782,202	101,333
Guangdong	404,470	181,066	1,501,113	155,247
Guangxi	88,232	114,862	824,064	94,351
Hainan	25,441	135,699	161,989	115,944
Chongqing	69,425	160,587	411,129	142,801
Sichuan	26,5935	147,044	1,175,184	120,105
Guizhou	45,254	121,764	553,235	103,182
Yunan	80,560	131,054	596,793	123,458
Xizang	11,537	147,275	54,265	196,425
Shaanxi	131,110	143,797	585,347	104,876
Gansu	59,864	122,175	378,982	112,019
Qinghai	18,616	135,441	84,251	137,438
Ningxia	12,851	122,574	103,823	117,901
Xinjiang	60,443	136,444	493,875	121,445

[20] Source: China's National Bureau of Statistics.

The decline in the rise of researcher salaries of foreign firms has intensified the global talent battle. As revealed in the *"Labor Market & Salary Report*" issued by the German Chamber of Commerce, German firms in China projected a 3.81% salary rise in 2025, hitting a four-year low; the salary rise for China-based US firms was estimated to hover between 1.5% and 3.5%, so did their Japanese and European counterparts in China. This attenuated rate of salary growth in foreign-funded firms has turbocharged the competition between Chinese and foreign-funded companies for skilled talents. Meanwhile, as the five mega-city clusters in China—eastern China, southern China, the Jing-Jin-Ji metropolitan region, the Yangtze River Delta, Pearl River Delta, and the Chengdu-Chongqing cluster—have siphoned over 60% of research talents from across the nation, the regional aggregation of talents grows increasingly prominent.

2.3. Social Factors

2.3.1 Structural Shifts in the Researcher Cohort: Scale Expansion Along with Cohort Optimization

China has witnessed a surge in both the quantity and quality of research talents. In the decade from 2012 to 2022, China's S&T workforce registered explosive growth: the group population grew by 71.8% to 124.66 million[21], where the full-time equivalent (FTE) of R&D personnel soared from 3.25 million to 7.24 million person-years, topping the world's list for ten years in a row[22]. The quality of research talents also improved substantially: from 2014 to 2022, Chinese researchers who made it to the world's Highly Cited Researchers list rocketed from 111 to 1,169, ranking second globally[23].

China's higher education institutions (HEIs) have laid the foundation for the advancement of the nation's SRS sector. Table 7 and Figure 7 show the trends in the number of full-time teachers in China's HEIs in 2019–2023.

Table 7. Changes in the Number of Full-Time Teachers in China's HEIs in 2019–2023[24]

Teaching Faculty Distribution	Population				
	2019	2020	2021	2022	2023
Regular Undergraduate Institutions	123	126	126.97	131.58	134.55
Undergraduate-level Vocational Colleges	2.5	3.08	2.56	2.78	3.08
Higher Vocational Colleges	51.44	55.64	57.02	61.95	68.46
Adult Higher Education Institutions	3.61	3.25	1.97	1.47	1.41
Total	180.55	187.97	188.52	197.78	207.49
Percentage of Teachers with Master's Degree or above	75.10%	75.80%	77.50%	78.54%	79.14%

As Table 7 and Figure 7 show, in 2023, the cohort of key clients of China's SRS industry reached a population of over two million, including 2.0747 million full-time teachers in higher educational institutions (1.3455 million in regular undergraduate institutions and 684,600 in higher vocational colleges) and 51,800 full-time researchers. Notably, in 2022, 34.6% of these key clients were young researchers aged between 30 and 39, who were the main drivers for the increasing demand for advanced research instrumentation and cutting-edge data analytics solutions.

Faculty members in China's HEIs showed a strong trend of spatial aggregation. Table 8 displays the distribution and breakdown of faculty members in HEIs across China in 2023.

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[21] Sources: "*China S&T Talent Development Report (2020)*", "*China S&T Talent Development Report (2022)*".
[22] Source: "Historic Achievements and Changes in Economic and Social Development" released by National Bureau of Statistics, https://www.gov.cn/lianbo/bumen/202312/content_6920471.htm, https://www.gov.cn/lianbo/bumen/202409/content_6975155.htm.
[23] Source: "*China S&T Talent Development Report (2022)*": https://www.gov.cn/lianbo/bumen/202312/content_6920471.htm
[24] Source: "China's Educational Achievements in 2023" released by Ministry of Education on October 24th, 2024: http://www.moe.gov.cn/jyb_sjzl/sjzl_fztjgb/202410/t20241024_1159002.html.

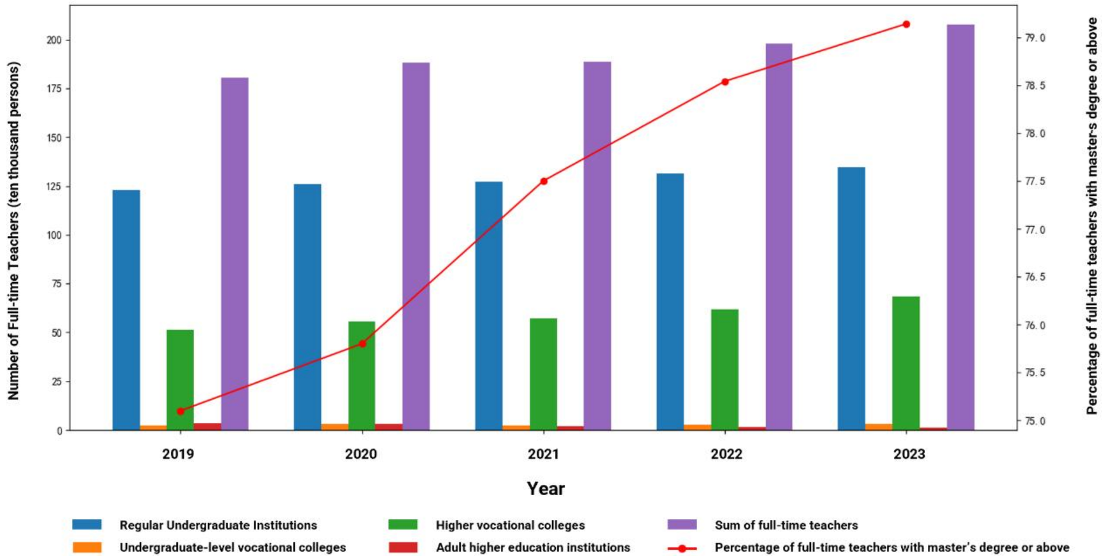


Figure 7. Trends of Full-time Teachers in China's HEIs in 2019–2023

Table 8. Faculty Composition in Higher Educational Institutions across China in 2023[25]

Region	Full-time Teacher	Administrative staff	Teaching Assistants	Logistics Staff	Full-time Researchers	Staff in affiliated institutions	Off-campus teachers	Industry tutors	Foreign teachers
Total	2,099,350	406,894	244,031	110,961	51,802	33,393	446,861	460,558	19,175
Beijing	79,237	30,711	20,795	10,567	12,200	10,295	13,347	15,448	1,896
Tianjin	35,103	8,821	4,728	1,121	681	230	8,097	8,502	444
Hebei	99,818	16,256	8,799	5,679	410	689	18,240	15,618	440
Shanxi	45,219	8,553	6,866	2,673	2,050	225	6,242	8,619	49
Inner Mongolia	29,986	7,178	4,026	1,496	193	152	4,797	5,436	91
Liaoning	67,673	17,412	10,471	4,002	687	459	14,407	16,282	712
Jilin	39,012	10,842	6,050	2,784	387	150	12,402	12,103	333
Heilongjiang	52,666	12,680	6,302	4,212	1,483	726	18,107	9,138	458
Shanghai	52,461	16,817	12,241	2,519	3,464	1,234	14,853	14,931	2,014
Jiangsu	132,228	27,658	14,853	5,168	3,126	2,006	40,711	40,639	2,423
Zhejiang	82,966	19,077	10,210	1,923	3,378	2,041	16,215	21,984	1,960
Anhui	81,971	10,841	5,814	3,116	1,304	562	17,253	15,748	208
Fujian	60,698	13,956	6,593	2,350	854	358	15,934	16,945	711
Jiangxi	79,967	8,961	9,869	3,107	385	161	17,022	13,104	429
Shandong	147,267	21,727	14,983	4,020	2,347	787	22,242	43,602	919
Henan	157,649	19,981	9,233	8,321	908	842	28,864	20,513	817
Hubei	100,407	21,720	14,547	6,274	3,114	1,339	21,858	23,613	479
Hunan	92,137	14,394	8,823	4,314	833	1,066	23,047	25,566	356
Guangdong	144,783	28,001	16,826	7,234	7,627	2,575	29,642	32,451	1,704
Guangxi	66,271	11,770	5,806	3,813	209	305	17,385	18,754	248
Hainan	14,584	3,060	2,061	1,486	269	117	2,310	2,118	186
Chongqing	61,329	9,610	4,155	2,045	645	604	13,379	11,474	364

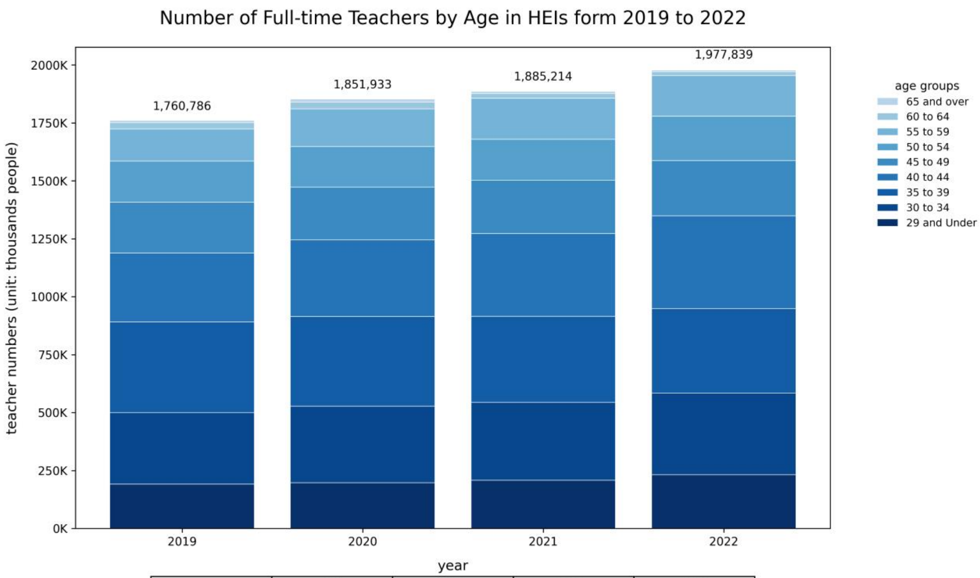
[25] Source: "*China's Educational Achievements in 2023*" released by Ministry of Education on October 24th, 2024: http://www.moe.gov.cn/jyb_sjzl/sjzl_fztjgb/202410/t20241024_1159002.html.

Table 8. Faculty Composition in Higher Educational Institutions across China in 2023[26] (continued)

Region	Full-time Teacher	Administrative staff	Teaching Assistants	Logistics Staff	Full-time Researchers	Staff in affiliated institutions	Off-campus teachers	Industry tutors	Foreign teachers
Sichuan	112,734	19,150	11,484	6,730	2,807	3,122	20,449	27,100	590
Guizhou	46,504	7,412	4,378	1,922	171	143	8,940	6,638	129
Yunnan	48,238	8,474	5,060	3,310	215	134	11,041	14,703	371
Xizang	2,948	634	235	153	20	94	130	97	0
Shaanxi	82,910	17,402	10,329	4,035	1,302	1,139	13,921	9,981	664
Gansu	36,190	5,140	2,852	1,592	399	1,493	7,103	3,160	111
Qinghai	5,222	1,405	824	817	266	6	354	520	11
Ningxia	9,752	2,110	1,016	350	41	206	2,029	531	31
Xinjiang	31,420	5,141	3,802	3,828	27	133	6,540	5,240	27

As Tables 8 shows, in 2023, the population of full-time teachers in Beijing, Shanghai, and Jiangsu reached 130,000, accounting for 18.3% of the nation's total; Shenzhen, Hangzhou, and other better-developed cities in eastern China, by dint of their high-caliber scientific research platforms, have already morphed into talent magnets; in central and western China, talents concentrated in regional hubs like Wuhan (with 31,000 full-time researchers) and Chengdu (23,000). In contrast, northeastern China has a shallower talent pool: the full-time teachers in Changchun, for instance, were merely 5,200 in 2023.

The research team in China is growing younger. As revealed in "*China Science and Technology Human Resources Development Research Report*" released by the China Association for Science and Technology, China's S&T human capital is dominated by researchers aged between 30 and 39 (36.3%), an age bracket characterized by strong plasticity, unfettered vigor, and infinite possibilities. These young scientists have also played a crucial part in mission-critical research programs, with scientists aged below 45 taking up 80% of all the human capital inputs into state-level R&D initiatives[27]. Table 9 and Figure 8 visualize the age breakdown of research talents and full-time teachers in HEIs in China from 2019 to 2022.



year	2019	2020	2021	2022
total number	1,760,786	1,851,933	1,885,214	1,977,839

Figure 8. Sum and Age Breakdown of Full-Time Teachers in Higher Educational Institutions in China in 2019–2022

[26] Source: "*China's Educational Achievements in 2023*" released by Ministry of Education on October 24th, 2024: http://www.moe.gov.cn/jyb_sjzl/sjzl_fztjgb/202410/t20241024_1159002.html.
[27] Source: https://www.gov.cn/lianbo/bumen/202312/content_6920471.htm.

Table 9. Changes in the Number of Research Talents of Different Age Groups in China in 2019–2022[28]

Year	≤ 29 years old	30–34 years old	35–39 years old	40–44 years old	45–49 years old	50–54 years old	55–59 years old	60–64 years old	≥ 65 years old
2019	190500	309687	391312	297124	219003	177535	137862	27676	10087
2020	196892	331072	386801	329898	227734	176165	161847	28993	12531
2021	207351	337435	370316	357417	229540	176886	177183	19783	9303
2022	231139	352938	365286	399290	239065	190688	175472	17058	6903

2.3.2. Rapid Upgrading of Talent Training System: Seeking Balance between Scale Expansion and Structural Optimization

China boasts the world's largest reservoir of emerging research talents. This is powered by the expanding scale of HEIs. Table 10 shows the changes in the number of students in HEIs, and Table 11 displays the number of universities and "double first-class" universities across China in 2023.

Table 10. Changes in Admissions and Enrollments in HEIs in China from 2019 to 2023[29]

Type		Number of students /million				
		2019	2020	2021	2022	2023
Regular undergraduate and vocational diploma programs (admissions)	Regular undergraduate programs	4.3129	4.4316	4.4460	4.6794	4.7816
	Vocational undergraduate programs	Pilot period	0.0385	0.0414	0.0763	0.0899
	Higher vocational diploma programs	4.8361	5.2434	5.5258	5.3898	5.5507
	Total	9.1490	9.7135	10.0132	10.1455	10.4222
Adult higher education programs		3.0221	3.6376	3.7853	4.4002	4.4549
postgraduate programs (admissions)	PhD programs	0.1052	0.1160	0.1258	0.1390	0.1533
	Master's programs	0.8113	0.9905	1.0507	1.1035	1.1484
	Totatl	0.9165	1.1066	1.1765	1.2425	**1.3017**
Postgraduate programs (enrollment)	PhD programs	0.4242	0.4665	0.5095	0.5561	0.6125
	Master's programs	2.4395	2.6730	2.8229	3.0975	3.2705
	Total	2.8637	3.1396	3.3324	3.6536	3.8829
Total		15.9513	17.5973	18.3074	19.4418	20.0617

[28] Source: "*China's Educational Achievements in 2023*" released by Ministry of Education on October 24th, 2024: http://www.moe.gov.cn/jyb_sjzl/sjzl_fztjgb/202410/t20241024_1159002.html.

[29] Source: "*China's Educational Achievements in 2023*" released by Ministry of Education on October 24th, 2024: http://www.moe.gov.cn/jyb_sjzl/sjzl_fztjgb/202410/t20241024_1159002.html.

Table 11. Number of HEIs and "Double First-Class" Institutions in Main Cities across China in 2023[30]

City	HEIs	Double First-Class Institutions
Beijing	92	34
Shanghai	64	15
Guangzhou	82	7
Shenzhen	11	1
Nanjing	53	13
Wuhan	83	8
Chengdu	59	8
Xi'an	63	8
Hangzhou	38	3
Tianjin	54	7

As Table 10 shows, undergraduate admissions grew by 420,000 to 1,301,700 from 2019 to 2023, where PhD admissions reached 153,300 with a 9.8% annual growth. These allowed China to top the world's list in the reserve of high-caliber scientists. In 2024, the enrollments and graduates of HEIs in China reached 4.095 million and 1.084 million, respectively. This massive population of emerging scientists is estimated to perform tens of millions of experiments, fueling the need for laboratory apparatuses, data analytics services, and academic communication events. Cities like Beijing, Shanghai, Guangzhou, and Shenzhen—home to world-leading HEIs and research institutions like Tsinghua University, Beijing University, Fudan University, Shanghai Jiao Tong University, Sun Yat-sen University, South China University of Technology, and Shenzhen University—provide a strong foothold and ceaseless innovation power for the SRS sector.

Educational system restructuring boosts the upgrading of the scientific research services. Reforms in postgraduate programs are reshaping the disciplinary portfolio in HEIs, with emerging engineering tracks (artificial intelligence, integrated circuits, etc.) and life sciences (such as biomedicine and gene editing) prioritized in the establishment of new programs. This has inevitably resulted in a dynamic redistribution of postgraduate admission shares across disciplines. Notably, admissions to master's programs in engineering, agriculture, and medicine take up 60% of the total[31], and PhD admissions in these fields account for half of the total. Meanwhile, key laboratories and research task forces established jointly by universities and local governments for domain-specific breakthroughs are also driving up the demand for scientific research services, generating needs for customized high-end research apparatuses, rare reagents, cross-disciplinary technical solutions, etc. Moreover, the growing admissions to postgraduate programs, including applied programs (approaching 60% of the total), will turbocharge the establishment and improvement of comprehensive service platforms oriented to meet the needs of specific industries through university-industry partnerships.

High-caliber talents are facing growing competition in the job market. In 2024, only 44.4% of master's and doctoral graduates received offers, marking a 12.3% drop from 2023. The competition was more cut-throat among graduates from non-elite universities, where the employment rate in 2024 was 33.2%, a sharp decline of 17% from the previous year[32]. Though the expansion of postgraduate admissions, against the backdrop of continued growth of enrollments at HEIs (47.63 million enrollments in 2023, with an annual growth of over 2%[33]), has alleviated the employment pressure, it adds to the competition for research-oriented positions.

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[30] Source: "*List of higher education institutions in China (as of June 20th, 2024)*" released by Ministry of Education (MOE) on the official website of MOE; "*List of Institutions and Disciplines for the Second Round of the Double First-Class Initiative (DFC)*" released on https://www.gov.cn/; "*Statistics of the second round of double first-class initiative*" released on https://www.eol.cn/; "*Distribution of double first-class institutions cross provinces in China*" released on https://www.eol.cn/.
[31] Source: https://news.eol.cn/meeting/202403/t20240301_2560925.shtml.
[32] Source: "*2024 Graduate Employability Report*" released by zhaopin.com.
[33] Source: "China's Educational Achievements in 2023" released by Ministry of Education.

2.3.3. Shifts in Talent Flow Landscape: Growing Global Competition amidst Regional Rebalancing

Talent flows in China now exhibit a tiered migratory formation. As indicated in the Global Talent Competitiveness Index (GTCI) report[34], Beijing (5th globally), Shanghai (12th globally), and Shenzhen (4th domestically), by dint of their economic strength and favorable environments for innovation, have risen to China's main magnets of high-calibre talents. Scientific researchers are increasingly clustering in three areas—Bohai Rim, Yangtze River Delta, and Pearl River Delta—making the eastern region the central hub of the nation's talent flow network. On the contrary, central and western areas witness a net talent outflow and challenges in talent retention. One solution to this regional imbalance is to develop specialized scientific research services, such as establishing technology transfer platforms with regional characteristics.

Global talent circulation has entered a new phase of strategic equilibrium. Driven by the policy innovations such as its entry-exit administration reforms ("high-efficiency customs clearance" for the Hetao Shenzhen-Hong Kong S&T Innovation Cooperation Zone) and targeted talent attractiveness programs (such as the CAS President's International Fellowship Initiative), China has transitioned from "the world's largest talent exporter" to "a talent-return hub": In 2021–2024, 3878 world-class scientists returned China for entrepreneurial ventures[35]. As indicated in the 2022 "Ideal City" Global High-Level Scientists Analysis Report, Beijing and Shanghai have witnessed a surge in the concentration of top-tier researchers by 215.7% and 281.5%[36], respectively, in 2022, exhibiting nascent but accelerating dynamics of talent circulation with global innovation epicenters like Silicon Valley and Boston.

As Table 12 shows, the salary gap is fueling a reset in the talent valuation system. Foreign-funded scientific research service providers are facing a stagnation in employment growth, witnessing a mere 16.9% growth in 2018 to 2023, while employment in their domestic counterparts surged by 52.6% within the same time frame[37]. Despite this divergence, foreign-funded firms continue to maintain a higher salary benchmark for R&D positions: their median monthly salary reaches 23,800 yuan, higher than their Chinese peers' median of 18,600 yuan[38]. In addition, the proportion of scientists with overseas experience returning to China witnessed a steady growth from 12% in 2018 to 19% in 2023. These experts, back in China from abroad, gravitate towards three domains—biopharma (32%), new materials (25%), and information technology (21%).

Table 12. Number of Corporate Units and Employees in Scientific Research and Technical Services by Registration Status, and Growth Rate (%)

Classification	2018		2023		Growth Rate 2018–2023 (%)	
	Corporate Legal Entities (10,000 units)	Employees (10,000 persons)	Corporate Legal Entities (10,000 units)	Employees (10,000 persons)	Corporate Legal Entities	Employees
Domestic-funded Enterprises	118.2	992.2	200	1514.4	69.20%	52.60%
Enterprises with Investment from Hong Kong, Macao, and Taiwan	0.7	15.5	1.1	21.6	57.10%	39.40%
Foreign-invested Enterprises	0.7	21.3	0.9	24.9	28.60%	16.90%
Other Statistical Categories	4.9	33.7	4.6	13.1	-6.10%	-61.10%
Total	119.5	1029	206.7	1574	73.00%	53.00%

[34] Source: "*Global City Talent Retention Index 2024*" released by Beiing Institute of Talent Development Strategy.
[35] Source: https://news.qq.com/rain/a/20250225A08FGR00.
[36] Source: "*2022 'Ideal City' Global High-level Scientist Analysis Report"*: http://edu.china.com.cn/2022-08/28/content_78392718.htm.
[37] Source: "*Communiqué on the Fourth National Economic Census"* and "*Communiqué on the Fifth National Economic Census*" released by National Bureau of Statistics.
[38] Source: "*Report on Scientific Researcher Salary in Chinese Enterprises in 2023*".

2.4. Technological Factors

2.4.1. Smart Tools Disrupting Conventional Models of Scientific Research Services

The rise of artificial intelligence (AI) and big data has contributed to the optimized allocation of scientific resources. AI-powered systems like LitLit are fine examples in this regard: this reference recommendation system enables cross-lingual literature mapping based on its semantic parsing algorithm and allows researchers to capture a panoramic view of their research domain by constructing a knowledge graph-based network of specific research fields [6]. Likewise, 5G-enabled edge computing connects the key technological infrastructure across the globe, providing remote access to supercomputing centers and colossal instruments like particle accelerators. In the meantime, AI tools have realized real-time reprioritization of research equipment: CAS's High Performance Computer Research Center has enhanced the utilization efficiency of research facilities by over 30% [7].

R&D administration is turning increasingly automated. Smart literature management tools like Web of Science AI, equipped with natural language processing (NLP) modules, perform automated sorting of research background information; deep learning-based systems provide risk profiling for research project applications. These systems, with access to the lab instrument reservation and expense reimbursement modules through APIs, realize paperless management and control. Blockchain notarization ensures data integrity across the workflow, and smart contracts in IEEE's blockchain repository can automate intellectual asset sharing and resolve cross-institutional ownership verification [8,9].

2.4.2. Open Collaboration Platforms Reshaping the Scientific Research Ecosystem

SaaS-powered research networks are fundamentally disrupting the conventional workflow of scientific research. Zoom for Research, with its real-time transcription, AI minute-taking, virtual whiteboarding, and a kaleidoscope of other functions, automatically produces knowledge graph-like conference summaries and facilitates large-scale virtual conferences. Teams For Science, Microsoft's corporate SaaS solution, offers on-premises deployment options to keep confidential data within the corporate firewalls and ensure encrypted transmission and storage of confidential data while granting employees varied levels of access permissions. Open-source communities and forums have evolved beyond code repositories like GitHub and Hugging Face: AI-powered assistants like Copilot provide convenience in code sharing, documentation, and reuse of snippets in daily work; moreover, the work completed by these software assistants now feeds into the contribution assessment network of arXiv [10,11].

Hybrid meeting technologies are reshaping the models of academic exchange. Huawei's MetaStudio, through a fusion of holographic projection and digital twin, makes remote control of lab devices and observation of molecular dynamics simulations possible, and enables synchronized projection of AR data annotations remotely in physical event venues. Smart conference scheduling systems like WhenIWork optimize event scheduling by aligning speaker availability windows with the interests of participants and maximizing engagement through sentiment analysis, automatically generating customized learning routes to participants [12,13].

2.4.3. Deep Integration of Artificial Intelligence Scientific Research Value Chain

AI has run beyond the functions of literature generation to experiment design, reshaping the research paradigm. Top journals like *Nature* implement double-blind AI review, using the GPT-4 model to detect and label machine-generated content, establishing tamper-proof, traceable certificate blockchains of academic integrity. Automated experiment systems have also made much headway: MTI's "Boris" can design compound synthesis routes and execute pipetting, which cuts human procedural errors by 15%, with its inherent digital twin AI system forecasting the risks of the experiment. AiScholar has rolled out a complete set of smart solutions based on NLP and a multi-hop reasoning engine; with its technological framework integrating cloud computing and edge computing, AiScholar realizes smart literature meta-analysis, experiment design optimization, and academic collaboration, providing its users with solutions for research topic selection, technical roadmap planning, research paper writing, and submission [14–17].

Emerging paradigms of scientific research have gained robust technological underpinnings. The chemist robot "Luke" rolled out by the University of Science and Technology of China, by integrating high-throughput computing and AI simulation training, has cut the discovery-synthesis-application cycle of new materials by 60%, and this technical framework has also seen adoption in domains like drug development and climate simulation. The convergence of AI with quantum computing has unlocked infinite possibilities for breakthroughs: quantum computing simulation environments provided by cloud platforms like AWSBraket allow scientists to accelerate AI model training through hybrid classical-quantum algorithms. Fine examples in this regard include Google DeepMind and AlphaFold Quantum.

2.4.4. Technological Governance and Ethical Concerns

The world is speeding up in establishing an ethical governance framework for AI. The EU's "*AI Act*" imposes risk-based regulations on the provision and use of AI research tools, where third-party verification is required for high-risk AI tools. China's "*AI Ethical Governance Standardization Guidelines*" and "*Ethical Norms for New Generation Artificial Intelligence*" prohibit academic misconduct, including AI-enabled ghostwriting of assignments and research papers. Technological transparency is also improving: IBM's open-source TensorBoard visualizes the neural network decision-making logic with graphics, hence enhancing the interpretability of models.

Meanwhile, the system for research data security and sovereignty has been maturing. The "*Data Security Law*", issued by the Chinese administration to strengthen research data security and protect data sovereignty, relies on its state cryptographic algorithms (ShangMi algorithms) to encrypt cross-border flows of confidential data. Domestic independent R&D of core technologies is also in full swing: DaMeng database is displacing Oracle in world-class programs like the European Organization for Nuclear Research. This year, homegrown research databases have taken up 28% of the domestic market, growing into sovereign shields for core research data [18–20].

3. CONCLUSIONS

3.1. Summary and Implications

The PEST model is employed in this study to examine the development of China's scientific research service (SRS) industry. The political environment has injected new momentum into China's SRS sector; moreover, with economic booms and improved living quality, the consumption demand grows, which, together with favorable policies, provides a fertile ground for growth of the SRS industry. Nonetheless, concerns remain: dominance of foreign capital in the high-end market, structural imbalance in research expenditure, uncoordinated development, and misallocation of talents, to name a few.

In the political dimension, strategic steering has intensified as China optimizes the allocation of innovation resources by issuing nation-level S&T policies, revolutionizing the evaluation system, and establishing S&T innovation pilot zones. From the economic perspective, the industry is expanding amid structural conflicts, and foreign-funded firms keep a stranglehold on the high-end market of scientific research services. Analyses through the social prism reveal that the talent pipelines have been strengthening and talent training systems are improving; however, problems like imbalanced cross-sector talent flows and the employment dilemma of research talents remain to be resolved. Technologically speaking, disrupting technologies—from smart tools to open-source platforms—are revolutionizing and empowering the SRS sector; innovative governance models are needed to allow technological empowerment and oversight to advance in lockstep.

Given the PEST-based multi-dimensional analyses, it is concluded that China's SRS sector demonstrates four characteristics:

3.1.1. A New Development Pattern Driven by Policies and Digitalization

With the continuous release of favorable policies, China's SRS sector is now seeing a constantly improved policy support system hinging on research funding, tax waivers, and platform construction. The surging investment in scientific R&D has turbocharged the market needs. Meanwhile, the wave of digital transformation has fundamentally disrupted this industry: online research platforms and academic networking have untethered research from spatial and temporal boundaries, channeling overseas R&D resources to domestic innovation hubs and weaving global knowledge flows into the fabric of domestic innovation. In addition, big data enables research trend forecasts and dynamic allocation of research resources; digital conversion channels have organically fused industry, university, and research into a continuous loop, catalyzing scientific research services from mere consultancy to integrated, end-to-end solutions.

3.1.2. Accelerated Market Concentration

A fierce wave of reshuffling of the SRS sector is underway: players equipped with technological heft and brand clout are claiming dominance in the market. These titans invest relentlessly in R&D activities to defend their competitive edge and build resource-sharing networks to enable seamless collaborations between industries, universities, and research institutions. In this way, they forge a close loop from the upstream production to the downstream applications, leveraging their brand clout to create an insurmountable competitive moat, upgrading the services and optimizing resource allocation in the industry, thereby sharpening the expertise of the industry overall.

3.1.3. Technological Fusion Empowering Industry Revolution

The fusion of big data, AI, and cloud computing provides powerful engines for scientific discovery and technological innovation. Smart analytical tools have made it possible to distill massive data into new findings and breakthroughs; AI has, by automating project management and literature retrieval, increased research efficiency. More notable is that the technological fusion has shattered the walls between institutions, enabling elastic supply and collaborative sharing of computing resources across institutions. Emerging technologies like blockchain have provided a tamper-resistant and reliable environment for scientific research. The fusion of traditional and advanced technologies is advancing the SRS industry to a smarter future with standardized frameworks.

3.1.4. Globalization Deepening Resource Integration

Increased cross-border collaborations in scientific research have created new opportunities for China's scientific research service providers to upgrade their service packages by absorbing knowledge and experience from their overseas counterparts. China's strategic involvement in global megaprojects has broadened its partnership networks and facilitated its absorption of global standards. Moreover, China has now been providing technical solutions for global concerns like global warming and public health crises, which not only promotes the cross-border flow of global innovation resources but also cements the nation's steering position in global technological governance.

3.2. Countermeasures and Recommendations

3.2.1. Forging a Global Tech Dynamic Response System

China needs to construct a monitoring architecture for scientific research services covering global S&T policies and economic trends, with a focus on the critical technology governance measures issued by tech-strong regions like the US and the EU. It is also necessary to improve the prediction of the development and volatilities of the global SRS industry, engage in the construction of global collaboration platforms, and extend the multi-layered cooperation channels to gain a stronger voice in global S&T governance. In addition, a S&T governance system needs to be constructed to realize tech-security alerts and quick response to the short supply of core technologies, thereby achieving safe and stable running of the industry supply chain.

3.2.2. Fortifying Fundamental Research and Technological Independence

More financial funding needs to be put into fundamental research. Policy support, like tax waivers and provision of subsidies for corporate R&D activities, needs to be strengthened to kindle the enthusiasm for innovation across all sectors. Multi-pronged roadmaps need to be charted to develop substitutions for integrated circuits, high-end instrumentation, and other critical technologies. A risk compensation framework needs to be established for buyers of China's first-generation pioneering tech equipment to accelerate the adoption of the equipment and the upgrading of domestic equipment. Meanwhile, industry-university-end user collaborative innovation platforms can be set up to extend the adoption of domestic scientific research equipment, reducing China's dependence on foreign providers of key technologies.

3.2.3. Deepening the Fusion of Digital Technologies

The new-generation technologies like AI and blockchain can be further incorporated into scientific research services. Research data hubs need to be built to enhance the power of massive data storage and massive computing. A system of smart tools for literature mining, lab simulation, and IP-to-solution conversion can be established to cover the whole workflow of scientific research and fuel breakthroughs in cross-modal data analytics and digital twin experimentation. To incorporate digital technologies into scientific research services, China can create demonstrative intelligent research platforms for areas like biopharma and new materials, which will enable the shift of scientific research services from a passively-responsive model to an active, predictive model.

3.2.4. Upgrading the All-Round Talent Training System

An industry-university-research collaborative talent training system can be established by embedding disciplines of intelligent science and technologies into the university classroom. The school curricula can be reformed by introducing practical modules like scientific research project management and data sciences. A performance-based assessment system needs to be introduced to optimize a royalty-sharing framework for research commercialization. The government should encourage corporate giants to build innovation bootcamps where research-tool developers and technology transfer agents can be certified to cultivate multi-tiered innovation-driven talents with technological foresight.

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