PROMOTING INNOVATION IN CHINA

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Executive Summary

1. Innovation policies have gained increasing prominence in China's policy agenda, leading to a rapid increase in government expenditure on science and technology. The government will strengthen its support for R&D activities in strategic sectors as well as basic research.

2. The share of government expenditure on science and technology in fiscal expenditure rose from 3.7% in 2001 to 4.5% in 2019. Expenditure on science and technology is largely for R&D activities in research institutes and universities. In 2020, R&D expenditure as a share of GDP in China reached 2.4%.

3. Before the 1980s, R&D activities in China were mostly top-down and government research institutes were the major players in the system on innovation.

4. Market reforms in the 1980s and 1990s changed this totally. Since the mid-2000s, however, the state has again played a critical role in the innovation system.

5. China's *Made in China 2025* initiative in 2015 places a stronger emphasis on self-reliance, with the state playing a more active role in achieving ambitious objectives.

6. Besides increasing fiscal support and providing tax breaks for high-tech enterprises, the government is in charge of industrial guidance funds to support breakthrough innovations in emerging industries and industry upgrading.

7. However, issues in the innovative system in China remain. Many "chokepoint" technologies are still imported, a serious concern amidst growing China-US tension in security, trade, investment and technology after 2018. The input on basic research which is considered fundamental for long-term development is still inadequate.

8. The allocation of government scientific research fund/R&D subsidy is also not very effective, while the synergy between government, universities and enterprises in innovation needs to be improved.

9. The Chinese government has introduced policy initiatives to address these concerns. First is the call for a larger role by the state, a "new type" of whole-of-nation approach and the strengthening of support for R&D activities in "chokepoint" technologies.

10. Second is the whole-of-nation approach involving "new types" of research institutes to facilitate more effective coordination across different entities, including universities, research institutes and enterprises. Third is the reform of the research grant allocation system and fourth is the support for basic research.

11. Since the measures are not comprehensive, issues such as improving the efficacy of the self-reliance strategy, incentive structure of state-owned enterprises in conducting R&D activities, accountability of research funds and industry guidance funds, and synergy among research institutes, universities and enterprises relating to constraints arising from "chokepoint" technologies remain.

PROMOTING INNOVATION IN CHINA

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China's Achievements in Innovation

1.1 Innovation policies are gaining prominence in China's policy agenda. The 14th Five-Year Plan (FYP, 2021-2025) released in March 2021 stated that the country should "insist on the core position of innovation in China's continuous nation building, and regard scientific and technological self-reliance as the strategic support of national development".[1]

1.2 Since 2018, growing China-US tension in security, trade, investment and technology has demonstrated the challenges faced by China in its management of bilateral ties and exposed China's vulnerability due to its heavy reliance on foreign technology and imports of high-tech products.[2]

1.3 Innovation has been defined as "the applications of new ideas to the products, process of other aspects of activities of a firm that lead to increased value".[3]

1.4 The pace and direction of the pursuit of innovation are shaped by several factors. First, innovations are built on scientific knowledge generated in preceding innovations. In this context, the scientific knowledge generated from basic research is considered indispensable for innovation.[4]

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1 See section 2 of the Five-Year Plan from http://www.gov.cn/xinwen/2021-03/13/content_5592681.htm, accessed 18 August 2021.

2 See a discussion on this topic from Baark, E, Hofman, B and Qian, J (ed) (2021). *Innovation and China's Global Emergence*, NUS Press.

3 Greenhalgh, C and Rogers, M (2010). *Innovation, intellectual property, and economic growth.* Princeton University Press, p. 4.

4 See a general discussion on this, Mokyr, J (1990) *The Gifts of Athena.* Princeton University Press.

1.5 Second, the closer an economy is to the world technology frontier, the more it will rely on innovation for growth.[5] For example, the pharmaceutical industry in the United States is taking a lead at the world technology frontier and its R&D expenditure as a share of sales is significantly higher than that in other high-income countries.[6]

1.6 Third, innovative activities face huge uncertainties and in many cases, an innovator cannot appropriate full surpluses of the innovation. In these cases, researchers and firms might not have strong incentives to conduct innovative activities.

1.7 China now is one of the major powers for both the inputs and outputs of innovation. Its R&D expenditure is ranked second in the world, behind that of the United States.[7] In 2017, China's accounted for 20% of total world R&D expenditure.[8] As a share of China's GDP, R&D expenditure hit 2.4% in 2020, similar to the OECD average rate of 2.5% in 2019 . The annual growth rate of China's R&D expenditure reached about 18.5% on average between 1995 and 2020.

1.8 In comparison with the United States, Japan, Korea and Germany on expenditures of R&D activities in 2019, China's research personnel per 1,000 employees was still smaller than that of many high-income countries; in terms of the size of research personnel China's much larger than that of other countries.

TABLE 1 R&D INPUTS IN CHINA AND OTHER COUNTRIES IN 2019

	China	**USA**	**Japan**	**Korea**	**Germany**
R&D expenditure in total GDP (%)	2.23	3.07	3.24	4.64	3.18
Basic research expenditure in total GDP (%)	0.13	0.49*	0.40	0.68	n/a
R&D expenditure (current PPP US$, billion)	525.7	657.5	173.3	102.5	147.5
Research personnel (,000)	2,109	1,555*	682	431	449
Research personnel per 1,000 employees	5.65*	n/a	13.0	19.4	16.2
Government share in business enterprise R&D (%)	20.5	22.4*	14.7	20.7	27.9*
Business enterprises share of R&D expenditure (%)	76.3	63.1	78.9	80.0	66.0*

*Based on 2018 data. Source: OECD science and technology indicators.

[5] Aghion, P, Akcigit, U and Howitt, P (2015). The Schumpeterian growth paradigm. *Annual Reviews of Economics*, 7(1), 557-575.

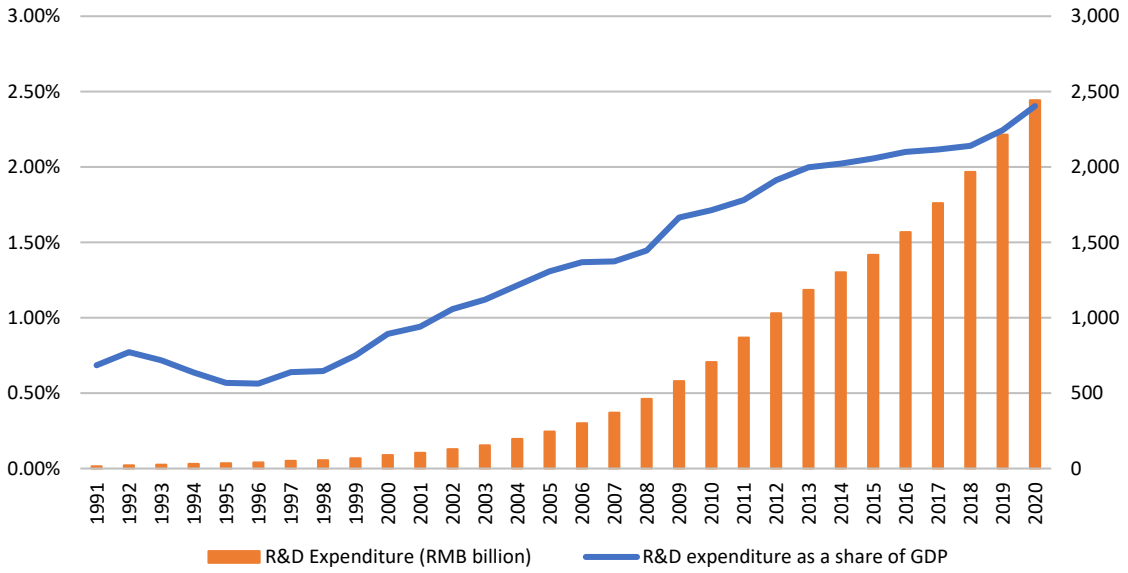
[6] Acemoglu, D, Robinson, J A and Verdier, T (2017). Asymmetric growth and institutions in an interdependent world. *Journal of Political Economy*, 125(5), 1245-1305.

[7] OECD science and technology indicators.

[8] https://knowledge4policy.ec.europa.eu/foresight/topic/expanding-influence-east-south/industry-science-innovation_en, accessed 9 September 2021.

1.9 China's R&D intensity (R&D expenditure as a share of GDP) has been increasing significantly in the recent two decades from 0.5% in the mid-1990s to 2.4% in 2020 (Figure 1)

FIGURE 1 R&D INTENSITY IN CHINA, 1991-2020



Note: R&D intensity is defined as R&D expenditure as a share of GDP.
Source: *China Statistical Yearbook on Science and Technology*, various years and CEIC.

1.10 China is also a leading country in the world for patent applications and research publications used commonly to measure the rate of innovation. China ranked second (after the United States) in the Nature Index 2021, which is calculated based on research publications in 82 prestigious journals.[9]

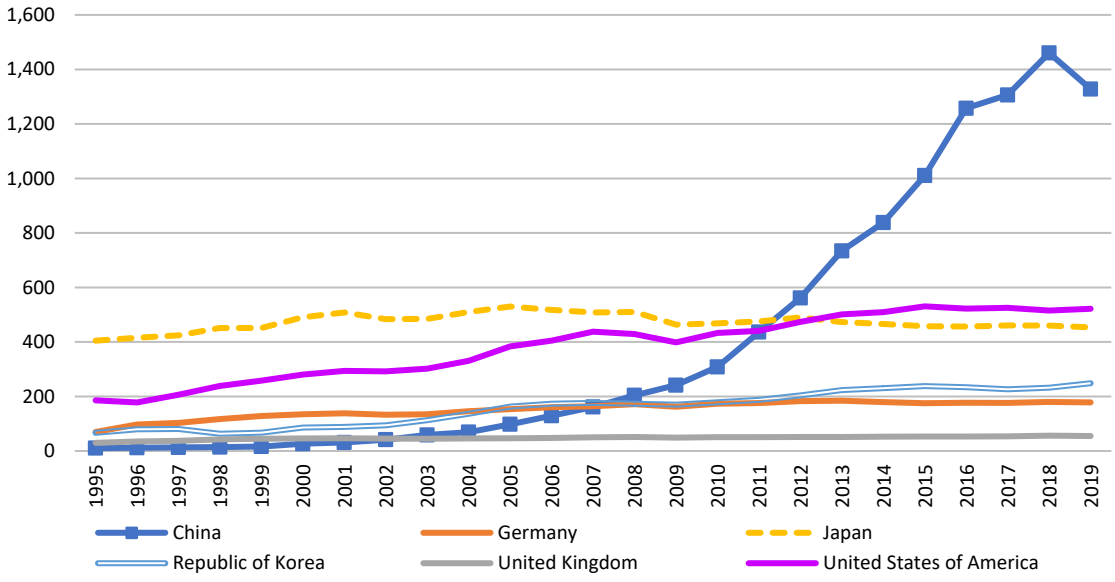
1.11 China's patent applications submitted to patent authorities in the United States and Europe have increased significantly. China now ranks number one in the world for total number of patent applications in China (Figure 2).

1.12 At the industry level, China is now a leading country in technology sectors such as nuclear energy, new energy vehicles and artificial intelligence, as well as in some advanced manufacturing sectors.[10]

[9] https://www.natureindex.com/annual-tables/2021, accessed 9 September 2021.

[10] https://knowledge4policy.ec.europa.eu/foresight/topic/expanding-influence-east-south/industry-science-innovation_en, accessed 9 September 2021.

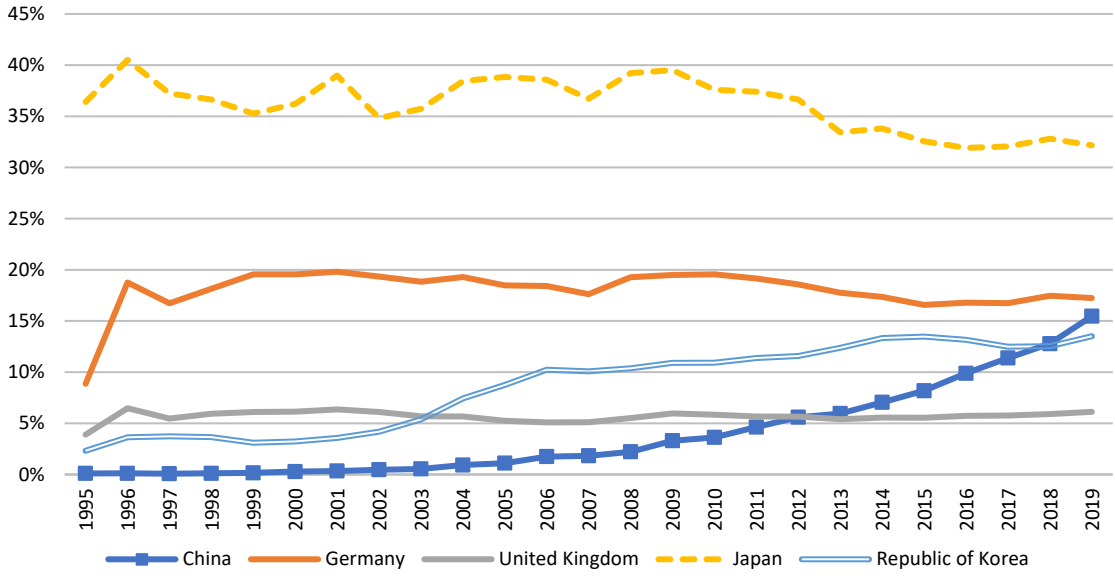
FIGURE 2 TOTAL NUMBER OF PATENT APPLICATIONS BY APPLICANT'S ORIGIN (,000)



Source: WIPO.

1.13 However, expenditure on basic research as a share of GDP is still falling behind that of other major countries. China only spent about 0.13% of its GDP on basic research while Korea spent 0.68% in 2019 (Table 1). While patent applications submitted to patent authorities in the United States and Europe have shown significant growth, the number of applications from China is still smaller than that of the United States, Japan and Germany (Figure 3).

FIGURE 3 PATENT APPLICATIONS FROM COUNTRIES AS A SHARE OF THOSE FROM THE UNITED STATES IN THE USPTO AND EUROPE PATENT OFFICE



Source: WIPO.

Developments of the Innovation System in China: From Pre-reform Era to the Mid-2010s

2.1 Before the 1980s, R&D activities in China were organised in a top-down manner.[11] The first tier of the system consisted of research institutions under the Chinese Academy of Science. The second tier comprised those under different industrial ministries and military-industry research labs. The third tier included research institutions at the local level.

2.2 This hierarchical system had the advantage of mobilising resources to focus on a mission.[12] In some major missions since 1949 (e.g. the development of atomic and hydrogen bombs and satellites), the system had proven to be effective in resource mobilisation and inter-agency coordination.

2.3 Since the 1980s, major changes to the innovative system have taken place. The market mechanism and material incentives had played a much more important role in research activities. Many spin-offs from research institutes and universities including Legend computer group and Founder group have also emerged in this period.

2.4 In this connection, foreign direct investment (FDI) became an important source of technology transfer. Many multinational companies have established R&D centres in China. FDI was reported to have a positive and significant spillover effect on patent applications and patent quality in China in the 2000s.[13]

2.5 Further, during the 1980s and 1990s, many government policies had been initiated to support the development of the high technology sector. Based on the definition of the National Bureau of Statistics, high technology industries, which have high

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[11] Zhang, M Y (2014). Innovation management in China. in *The Oxford Handbook of Innovation Management* (pp. 355-374). Oxford: Oxford University Press; and Simon, D F and Goldman, M (eds.) (1989). *Science and technology in post-Mao China* (No. 5). Harvard University Asia Centre. p. 74.

[12] Lu, Feng and He, Pengyu (2021), The New-type System of Nationwide Mobilization and Breakthroughs: Historical Experiences of Accomplishing Major Tasks by Special Agencies and the Lessons, *Management World*. 7, 1-18.

[13] Liu, Y and Wang, X (2021). The Impact of FDI on Domestic Firm Innovation. World Bank Policy Research Working Paper 9672.

intensity of R&D activities, include information technology, biotechnology, space technology, energy technology and new materials.[14]

2.6 The *Torch* programme was initiated in 1988 to establish high-tech development zones and science parks to support start-ups in high-tech industries.

2.7 Other policy support for innovation encompasses a two-year income tax exemption and other tax reduction for high-tech companies, and business tax exemption for technology transfer and technology-related services.[15]

2.8 The Chinese government has also introduced programmes to support universities and research institutes in their basic research. For example, National High-Tech R&D programme (i.e. "863" programmes) was initiated in 1986 to promote selected areas such as biotech, aerospace and new materials.

2.9 While the top-down innovative system had been overhauled by the market reform in the 1980s and 1990s, the state has made a comeback and played a critical role in the innovation system since the mid-2000s.[16] In early 2006, China rolled out a 15-year "Medium-to-Long-Term Plan (MLP) for the Development of Science and Technology (2006-2020)", with the guiding principle of "independent innovation, leap frog in key areas, sustain development, and lead the way for the future".[17] While there were inward-looking tendencies in the 2006 MLP, some viewed it as an attempt to balance indigenous efforts and engagement with the global community.[18]

2.10 About a decade thereafter, China issued two documents, namely the Made in China 2025 initiative issued in 2015 and the *Outline for National Innovation-driven Development Strategy* issued in 2016 to place a stronger emphasis on self-reliance

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14 http://www.stats.gov.cn/tjsj/tjbz/201310/P020131021347576415205.pdf, accessed 9 September 2021.

15 Kou Zonglai, (2008), *Tongwang Chuangxin Zhilu, Shanghai* People's Press, Chapter 5.

16 Zhou, Y and Liu, X (2016). Evolution of Chinese state policies on innovation. In *China as an Innovation Nation*, edited by Zhou, Y, Lazonick, W and Sun, Yifei, Oxford University Press, 33-67.

17 http://www.gov.cn/gongbao/content/2006/content_240244.htm, accessed 23 November 2020.

18 Cao, Cong, Richard P Suttmeier and Denis Fred Simon, "China's 15-year science and technology plan", *Physics Today*, December 2006.

and the state to play a more active role in achieving ambitious objectives. The 2016 *Outline* included policies both to promote innovation and build strong institutions supporting innovative activities.[19]

2.11 Overall, however, these initiatives seemed to aim primarily at achieving fast outcomes as growth has been decelerating and China needs to switch to a development path based on innovation-based productivity improvement.

The Role of Government in Financing and Managing Innovation

3.1 The government is tasked to play a major role in financing and supporting basic research as it is of little interest to the private sector. It is also to play a role in supporting frontier research in areas with high uncertainties.

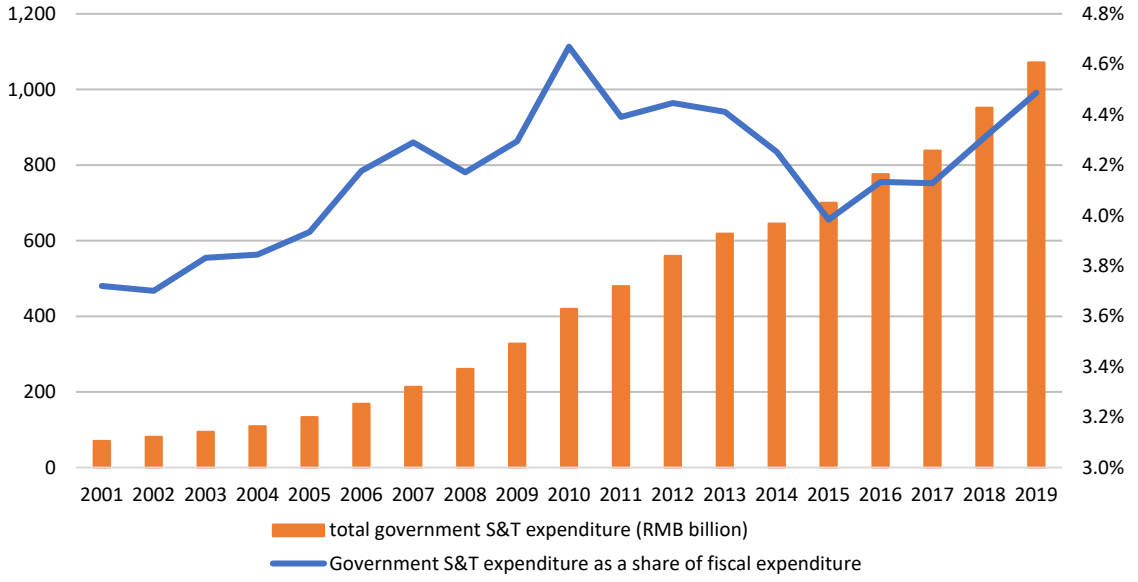
3.2 Government expenditure on science and technology has increased rapidly in recent years. It is unlike R&D expenditure funded by the government as some of the government expenditure on science and technology is not related to R&D expenditure (e.g. administration expenditure and expenditure of providing technology). In 2019, government expenditure on science and technology reached over RMB1 trillion while R&D expenditure funded by the government amounted to about RMB454 billion.

3.3 Between 2001 and 2019, government expenditure on science and technology rose from RMB70 billion to RMB1.07 trillion (Figure 4). Its share in fiscal expenditure increased from 3.7% in 2001 to 4.5% in 2019.

3.4 Government R&D expenditure as a share of total R&D expenditure in China was about 20% in 2019 (Figure 5). The share is similar to those in major OECD countries, such as the United States' 23% and the UK's 26% in 2018.

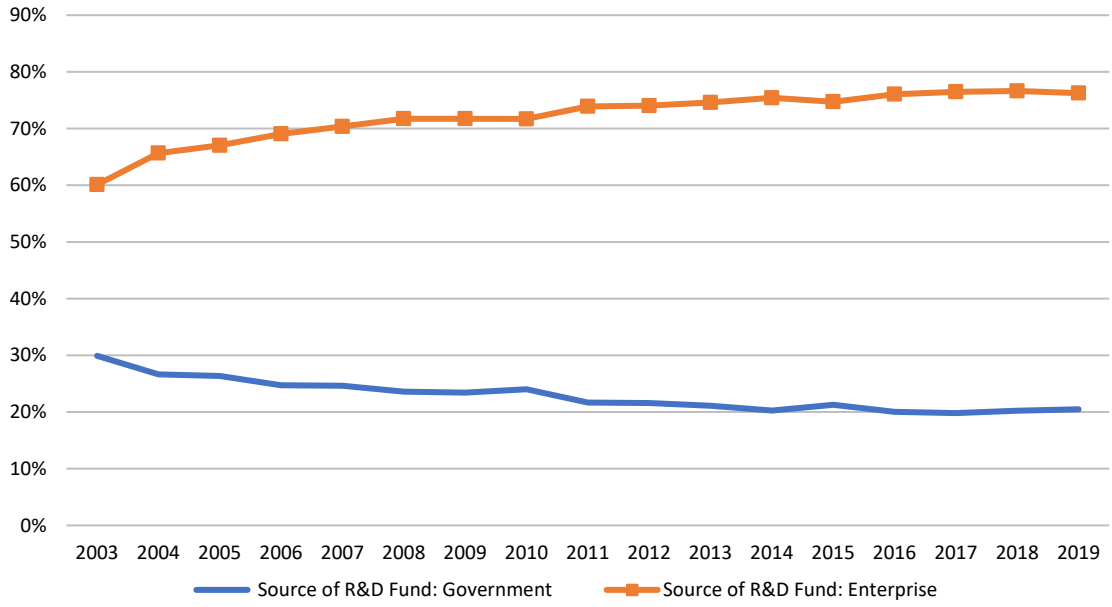
[19] http://www.gov.cn/zhengce/2016-05/19/content_5074812.htm, accessed 3 January 2021.

FIGURE 4 GOVERNMENT SCIENCE AND TECHNOLOGY EXPENDITURE AS A SHARE OF FISCAL EXPENDITURE



Source: *China Statistical Yearbook on Science and Technology*, various years and CEIC.

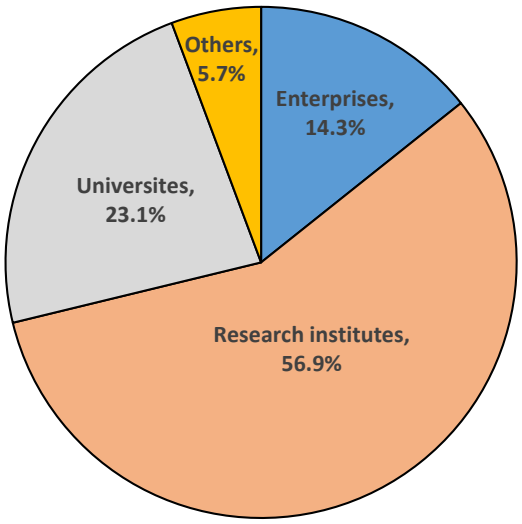
FIGURE 5 FUNDING SOURCES OF R&D EXPENDITURE



Source: CEIC.

3.5 Most government expenditure on R&D has been allocated for financing research institutes (56.9% in 2019) (Figure 6). Significant portions of R&D expenditure also went to finance R&D activities in universities and enterprises (23.1% and 14.3% respectively in 2019).

FIGURE 6 COMPOSITION OF GOVERNMENT R&D EXPENDITURE IN 2019



Source: *China Statistical Yearbook on Science and Technology 2020*.

3.6 The major bureaucracy and policymaker for science and technology in the innovation system is the Ministry of Science and Technology (MOST). MOST drafts science and technology development plans, and manages a variety of National S&T programmes[20] and many national-level research funds including National Nature Science Foundation of China.

3.7 To support breakthrough innovations in emerging industries and industry upgrading, the government has in place industrial guidance funds under its charge.[21] For example, the China National Integrated Circuit Industry Investment Fund[22] was initiated by the central government in 2014. By the end of 2019, the fund invested more than RMB138 billion on firms in the semiconductor supply chain.[23]

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[20] Hu, A G and Jefferson, G H (2008). Science and technology in China. *China's Great Economic Transformation*, 286-336.

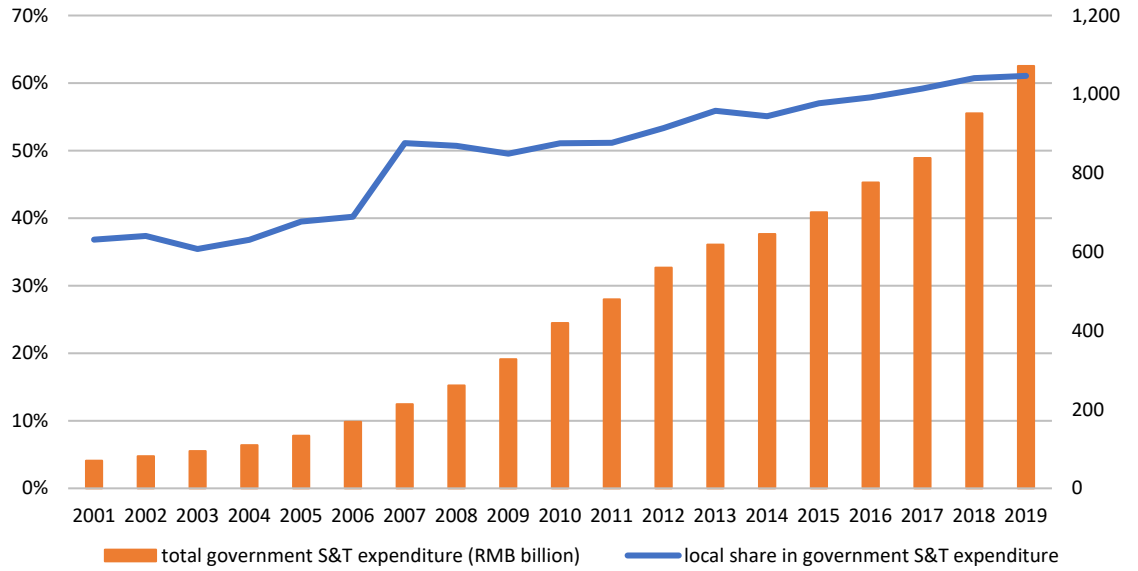
[21] Bank of China, 2019. https://pic.bankofchina.com/bocappd/rareport/201908/P020190806625380855490.pdf, accessed 3 August 2021.

[22] The fund is managed by a holding company with the China Development Bank as the largest shareholder; see https://new.qq.com/omn/20201224/20201224A07GTI00.html, accessed 31 August 2021.

[23] https://pdf.dfcfw.com/pdf/H3_AP201912311373119321_1.pdf?1577789587000.pdf, accessed 24 August 2021.

3.8 Local governments also played an important role in the innovation system. They accounted for about 61.1% of total government science and technology expenditure in 2019 (Figure 7).

FIGURE 7 LOCAL GOVERNMENT'S SHARE IN GOVERNMENT S&T EXPENDITURE



Source: CEIC.

3.9 Local governments are also in charge of about three-fourths of industrial guidance funds,[24] more than a half which have been invested in high-tech firms.

3.10 Government research institutes are another major player in the innovation system. At the central level, research institutes work on both basic research and applied research. At the ministry level, research institutes specialised in different industries. At the local level, these research institutes are more likely to work on applied research. Figure 8 shows that government funding in total R&D expenditure in research institutes has been over 80% in recent years.

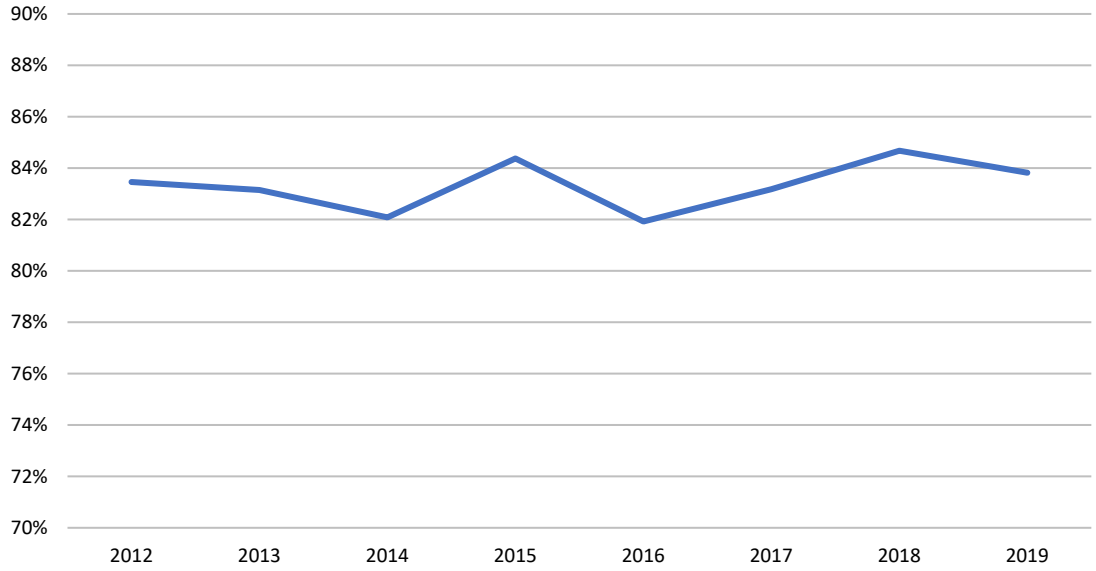
3.11 Universities also play an important role in innovation. The number of R&D personnel in universities increased from 387,000 in 2005 to 1.23 million in 2019.[25] R&D expenditure in universities is on an upward trend and the share of universities

[24] Naughton, B (2019) "The Financialisation of China's State-owned Enterprises", in Yongnian Zheng and Sarah Y Tong, eds., *China's Economic Modernization and Structural Changes: Essays in Honour of John Wong*. Singapore: World Scientific.

[25] *China Statistical Yearbook on Science and Technology 2020.*

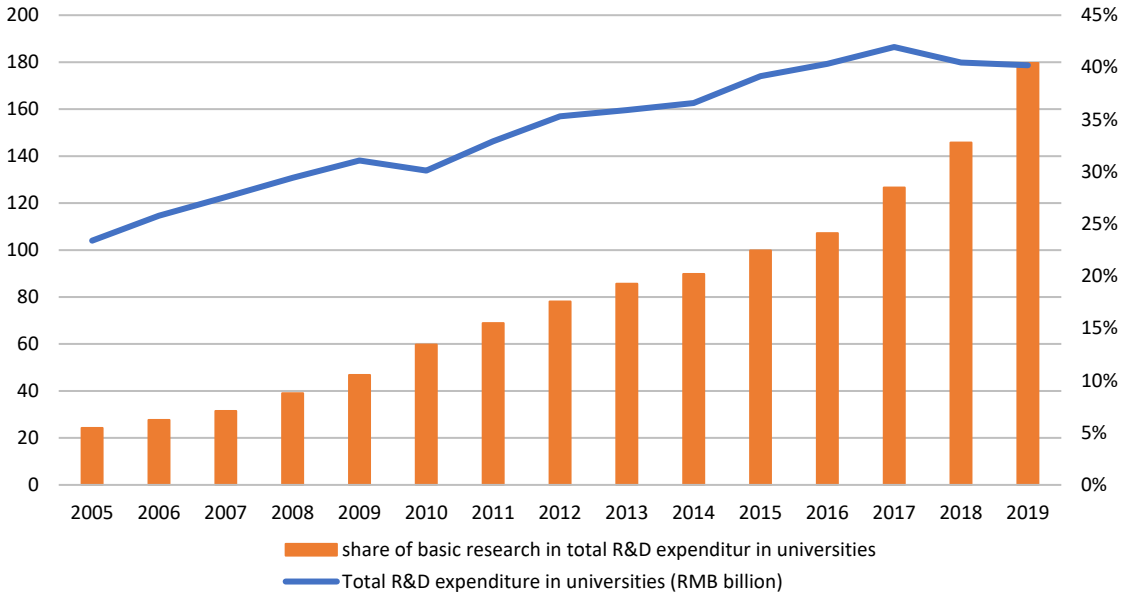
in total R&D expenditure increased from 23% in 2005 to 40% in 2019. Figure 9 highlights increase in R&D expenditure from RMB24 billion in 2005 to RMB180 billion in 2019.

FIGURE 8 GOVERNMENT FUNDING IN TOTAL R&D EXPENDITURE IN RESEARCH INSTITUTES



Source: *China Statistical Yearbook on Science and Technology*, various years.

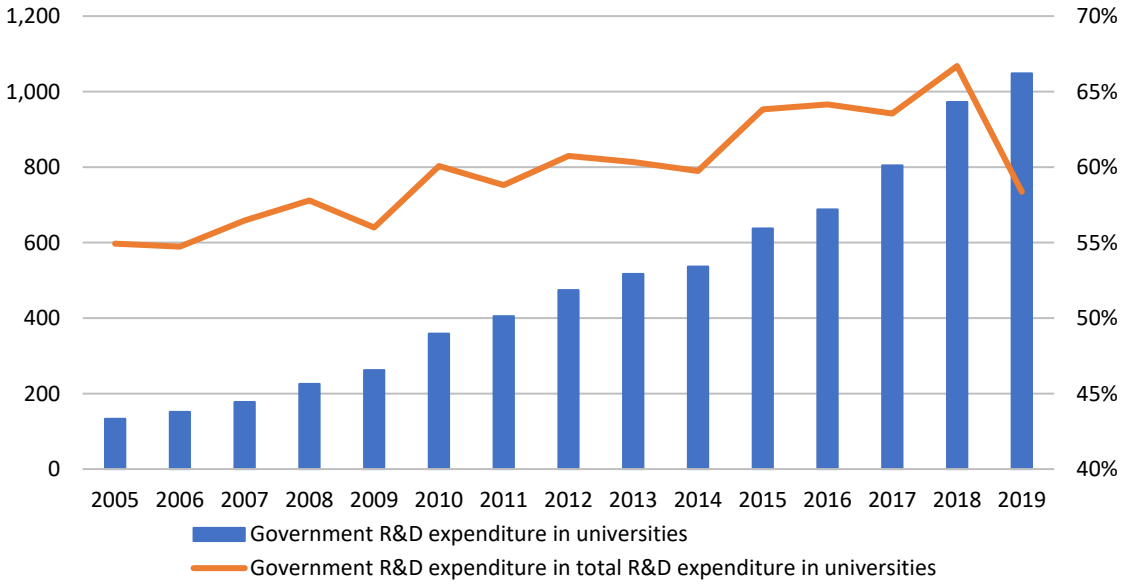
FIGURE 9 UNIVERSITY R&D ACTIVITIES IN CHINA: 2005-2019



Source: *China Statistical Yearbook on Science and Technology*, various years.

3.12 The government has financed about 60% of universities' total R&D expenditures in recent years (Figure 10). For example, the government financed RMB105 billion out of RMB180 billion R&D expenditure in universities in 2019.

FIGURE 10 GOVERNMENT AS THE MAJOR SOURCE OF UNIVERSITY R&D FUNDING



Source: CEIC.

3.13 Outlay from enterprises accounted for more than three-fourths of total R&D expenditure. In 2018, R&D expenditure as a share of sales in above-scale enterprises in high-tech industries was 2.27%, 0.93% higher than the share in all above-scale enterprises.[26]

3.14 In recent years, the government continued to use fiscal subsidies and tax breaks to support high-tech enterprises. For example, in February 2021, the Ministry of Finance and Ministry of Industry and Information Technology jointly released a document to allocate at least RMB10 billion in support of innovative activities related to "chokepoint" technologies in small and medium-sized enterprises between 2021 and 2025.[27]

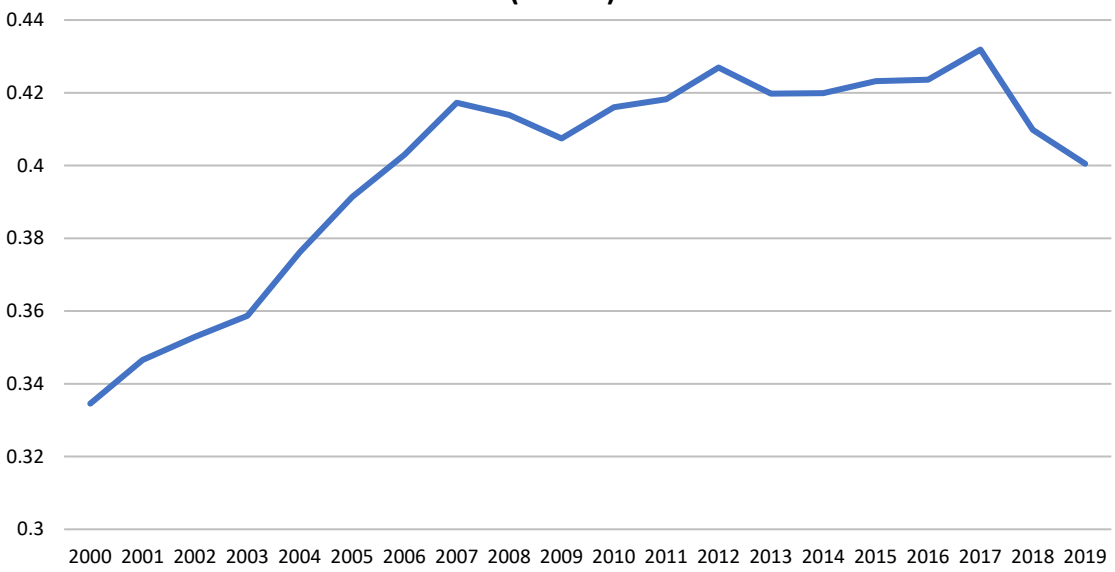
[26] Based on the numbers reported in the national economic census in 2018. http://www.stats.gov.cn/tjsj/zxfb/201911/t20191119_1710339.html, accessed 9 September 2021.

[27] http://www.gov.cn/xinwen/2021-02/06/content_5585367.htm, accessed 9 September 2021.

Major Issues of the Current Innovation System

4.1 Innovation is considered a major source of "high-quality growth" (i.e. high productivity growth) in China.[28] While significant progress has been made in the recent two decades, productivity growth has taken a beating in China. Figure 11 shows the decreasing trend of productivity growth in China in recent years.

FIGURE 11 CHINA'S TOTAL FACTOR PRODUCTIVITY LEVEL AT CURRENT PPPs (USA=1)



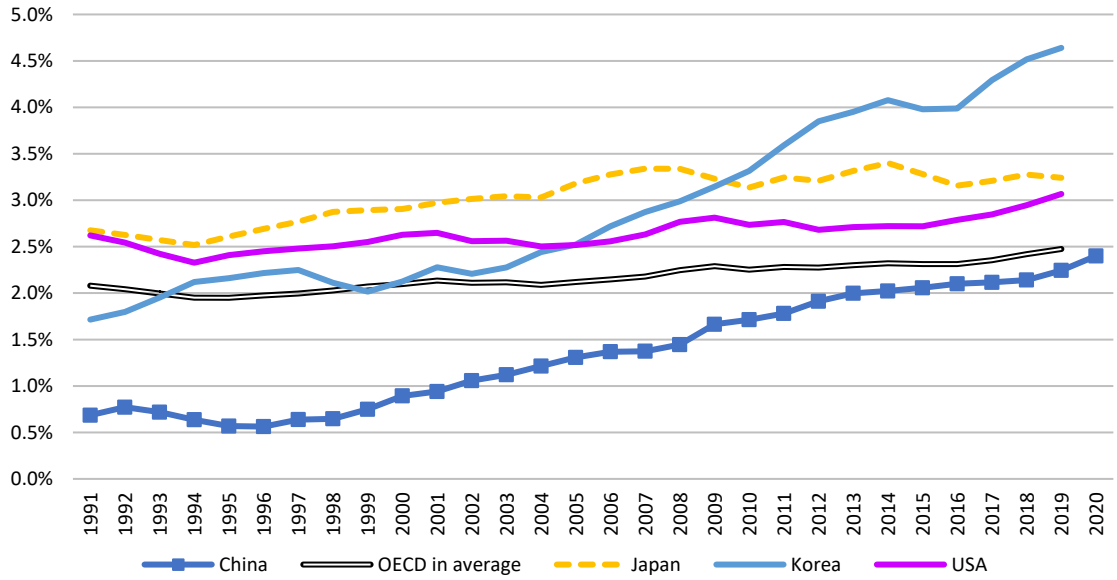
Source: Penn World Table 10.0.

4.2 China is also behind some high-income countries such as Korea, Japan and the United States in terms of research intensity. China's R&D intensity (R&D as a share of GDP) in 2020 reached 2.4%. The ratio is close to the average of OECD countries, but is still trailing behind countries such Korea and the United States (Figure 12).

4.3 There is still much room for improvement for China's innovation system. First, many "chokepoint" technologies are still imported from other countries. Compared to those in high-income countries, the value added from Chinese companies in the global supply chain is still low. Many Chinese firms are thus vulnerable in the US-China trade war.

[28] Wei, S J, Xie, Z and Zhang, X (2017). From "Made in China" to "Innovated in China": Necessity, prospect, and challenges. *Journal of Economic Perspectives,* 31(1), 49-70.

FIGURE 12 R&D INTENSITY IN CHINA AND OTHER COUNTRIES



Note: R&D intensity is defined as R&D expenditure as a share of GDP.
Source: OECD.

4.4 Second, the input on basic research is still insufficient. Expenditure on basic research is much smaller in China than in high-income countries, which could weaken its long-run innovation capacity. The share of GDP in basic research was about 0.49% in 2018 for the United States and over 0.64% in 2019 for Korea. Based on 2020's data, China's expenditure on basic science was about 0.15% of GDP, still far behind those of OECD countries.

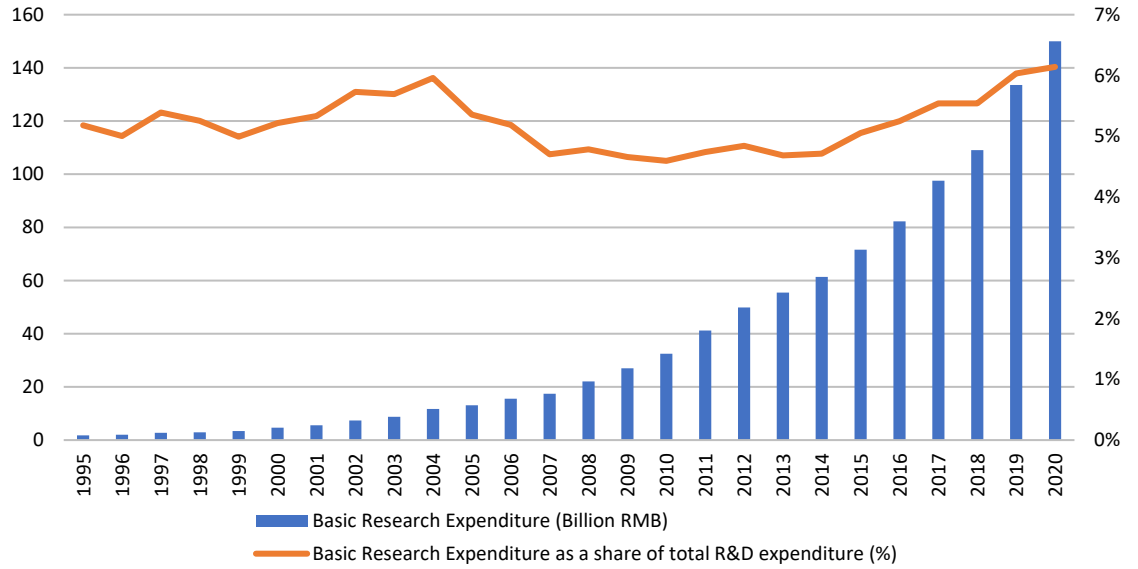
4.5 While expenditure on basic research has increased considerably in recent years, from RMB32 billion in 2010 to over RMB133 billion in 2019, its share in the total remains low, at about 6% in 2019 (Figure 13).

4.6 While the number of researchers in basic research in universities has taken a leap in recent decades, jumping from 165,000 in 2009 to about 392,000 in 2019, the share of basic research personnel in total researchers had decreased from 10% in 1998 to 8% in 2019 (Figure 14).

4.7 The role of enterprises in basic research is also very limited. While the enterprises' R&D expenditure accounted for over 76.4% of total R&D expenditure, their share in basic research was a mere 3.8% in 2019 (i.e. RMB5.08 billion out of RMB133.56

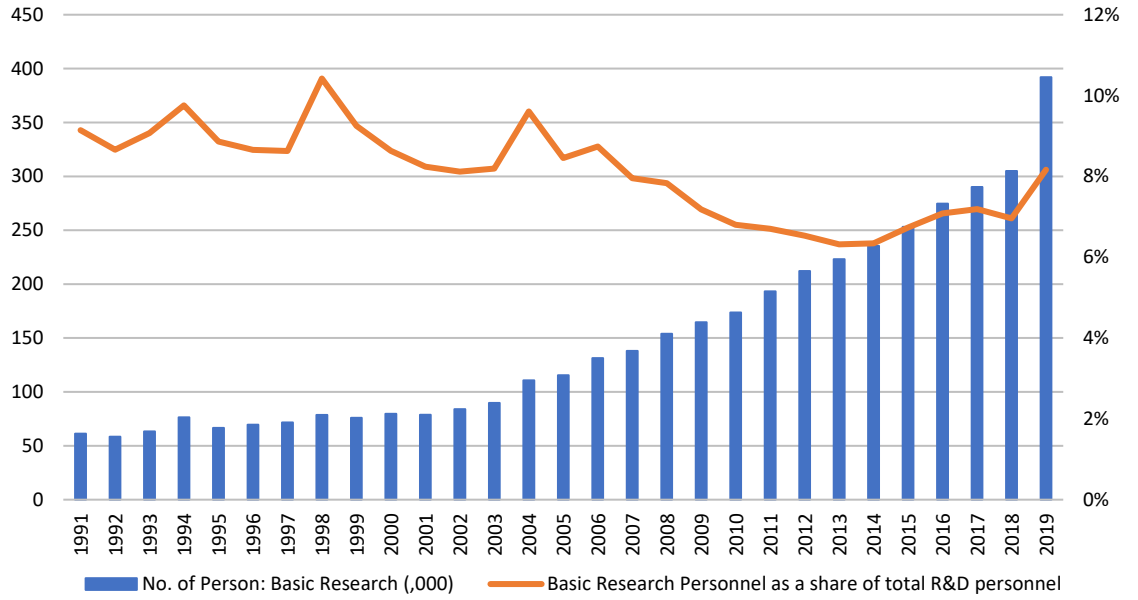
billion).[29] In 2019, basic research expenditure in enterprises amounted to only about 0.3% of total enterprise R&D expenditure.

FIGURE 13 BASIC RESEARCH EXPENDITURE AND ITS SHARE IN TOTAL R&D EXPENDITURE



Source: CEIC.

FIGURE 14 NUMBER OF PERSONNEL IN BASIC RESEARCH



Source: CEIC.

[29] http://www.xinhuanet.com/tech/2020-08/31/c_1126432186.htm, accessed 9 September 2021.

4.8 Third, the allocation of government scientific research fund/R&D subsidy is not very effective. A recent research on a major scheme of research subsidy for firms shows that allocation was based on political connections and the grant did nothing to boost the actual innovative outcome of the firm.[30]

4.9 Fourth, the synergy between government, universities and enterprises in innovation leaves much to be desired. Many university patents have not been commercialised. While the number of patent applications in Chinese universities reached 340,000, only 9,300 patents were transferred to the market in 2019.[31]

Recent Reforms in Innovative Policies

5.1 In recent years, a series of policy initiatives in China have been introduced to address the aforementioned concerns. First, the government will strengthen its support for R&D activities related to "chokepoint" technologies. It calls for the state to take a larger role in the "new type" of whole-of-nation approach to "fight the tough battles in key core technology areas so as to improve the overall efficiency of the innovation chain".

5.2 In the 14th FYP, annual growth of R&D expenditure was 7% or higher between 2021 and 2025. Some sectors were highlighted in the FYP as frontier fields including artificial intelligence, quantum information, integrated circuits, life and health science, neuroscience, genetics, deep earth and sea exploration, and aerospace technology.

5.3 In a way, the "new type" of whole-of-nation approach is government-led and mission-oriented, similar to the traditional top-down innovation system. However, in the "new type" of whole-of-nation approach, market-based incentives are used to leverage non-state resources in the preferred areas.

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30 Wang, Y, Li, J and Furman, J L (2017). Firm performance and state innovation funding: Evidence from China's Innofund program. *Research Policy,* 46(6), 1142-1161.

31 *China Statistical Yearbook on Science and Technology 2020.*

5.4 For example, in a recent government initiative, tax rebate is used to encourage investments in the integrated circuit and software industry from the private sector.[32] Government funds which are operated in a similar structure as venture capital are also mobilised to promote investment in strategic and frontier sectors via the market mechanism.

5.5 Second, to facilitate more effective coordination across different entities, including universities, research institutes and enterprises, under the whole-of-nation mechanism is to have "new types" of research institutes.[33] Unlike traditional government research institutions, many of these "new types" of research institutes are spinoffs from universities and registered as private non-enterprise units.

5.6 To support these new types of research institutes, in some cities, enterprises are provided with "innovation vouchers" (*Chuanxinquan*) by local government to purchase services from "new types" of research institutes (e.g. in Shanghai).[34] In other cases, these research institutes can enjoy tax breaks for enterprise income tax and individual income tax.

5.7 Third, the research grant allocation system is also undergoing reform as research grants are very useful for improving the productivity of researchers affiliated with less prestigious institutes.[35]

5.8 According to the 14th FYP, China will allow open competition in the selection of the best talents to lead key research projects.[36] Implementing the intellectual property protection system and increasing the penalty for the violation of intellectual property rights are again given top emphasis.

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32 http://www.gov.cn/zhengce/content/2020-08/04/content_5532370.htm, accessed 9 September 2021.

33 http://www.gov.cn/gongbao/content/2020/content_5469722.htm, accessed 9 September 2021.

34 http://stcsm.sh.gov.cn/zwgk/kjzc/zcwj/kwzcxwj/20210129/846d5dc95bc649819a6c0ec9c5e3cdde.html, accessed 9 September 2021.

35 Hu, A G (2020). Public funding and the ascent of Chinese science: Evidence from the National Natural Science Foundation of China. *Research Policy*, 49(5), 103983.

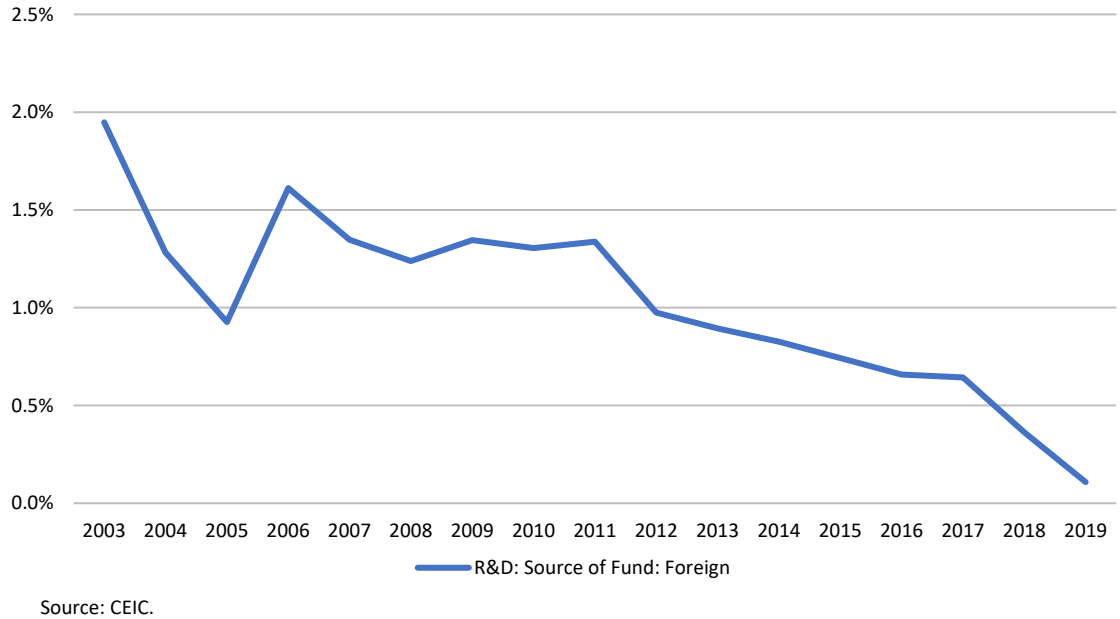
36 http://www.xinhuanet.com/2021-03/13/c_1127205564_3.htm, accessed 9 September 2021

5.9 Fourth, basic research is also highlighted as a major area for support. According to the Minister of Science and Technology Wang Zhigang, central government spending on R&D increased by 70% during the 13th FYP (2016-2020) while the spending on basic science increased by 100%.[37] In the 14th FYP, the expenditure on basic research in total R&D expenditure is targeted to reach 8% by 2025, up from 6% in 2019.

Remaining Issues in Innovation Policies

6.1 Remaining issues to be addressed in the area of innovation policy include first, the question of the efficacy of the self-reliance strategy. For decades, the foreign sector has made significant contributions to R&D activities in China via foreign direct investment and the technology market.[38] However, under the self-reliance strategy, the share of foreign funding of R&D activities has been decreasing in recent years (Figure 15). The self-reliance strategy where China aims to push forward development in a wide range of technologies could be very costly and take time to materialise.

FIGURE 15 DECREASING SHARE OF FOREIGN SOURCES IN R&D



Source: CEIC.

37 https://www.chinanews.com/gn/2021/03-08/9427592.shtml, accessed 9 September 2021

38 Hu, A G and Jefferson, G H (2008). Science and technology in China.

6.2 Second is the incentive structure of state-owned enterprises (SOEs), which have been assigned the lead role in conducting R&D activities in "chokepoint" technologies and frontier research areas.[39] As SOEs are subject to soft budget constraints, they are likely to persist with innovation projects that do not work.[40]

6.3 Indeed, recent research shows that while SOEs are more likely to conduct R&D activities, these activities in SOEs are much less efficient than those in the private sector.[41]

6.4 Third is the accountability of research funds and industry guidance funds. For example, local governments are tempted to rush into supporting very expensive, but questionable projects. Their attempts to identify and pick winners in potential areas of technology breakthroughs have frequently been costly. The recent abandonment of Wuhan Hongxin Semiconductor Manufacturing is one such case.

6.5 Fourth is the synergy among research institutes, universities and enterprises in innovative activities. For example, the 14th FYP for the development of Zhangjiang high-tech park in Shanghai has designated the ecosystem between research institutes, universities and enterprises to be enterprise-oriented.[42] However, as Zhangjiang high-tech park is not only a high-tech hub hosting many major semiconductor, biomedical and software firms among others, but also a "comprehensive national science centre" focusing on basic research, it may not attract the investment of enterprises which do not have a strong incentive to work on basic research projects. The challenge is in connecting the basic research part of the innovation system to an enterprise-oriented ecosystem.

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39 http://finance.people.com.cn/n1/2021/0821/c1004-32202320.html, accessed 9 September 2021.

40 König, M, Song, Z M, Storesletten, K and Zilibotti, F (2020). From imitation to innovation: Where is all that Chinese R&D going? (No. w27404). National Bureau of Economic Research; and Guo, D, Huang, H, Jiang, K and Xu, C (2021). Disruptive innovation and R&D ownership structures. *Public Choice,* 187(1), 143-163.

41 Wei, S J, Xie, Z and Zhang, X (2017). From "Made in China" to "Innovated in China". 49-70; and Cheng, H, Fan, H, Hoshi, T and Hu, D (2019). Do innovation subsidies make Chinese firms more innovative? evidence from the China employer employee survey (No. w25432). National Bureau of Economic Research.

42 https://www.shanghai.gov.cn/nw12344/20210716/ebe18fe83b724f14b9120d218ec33ed0.html, accessed 31 August 2021.