The Yellow Book on Science and Technology Vol. 13

CHINA SCIENCE AND TECHNOLOGY INDICATORS 2016

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OF THE PEOPLE'S REPUBLIC OF CHINA

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This book is the 13th volume of the biennially-released *China Science and Technology Indicators*, i.e. the Yellow Book on Science and Technology, published by the Ministry of Science and Technology of China.

The report has, on the basis of China's national S&T statistics and relevant economic and social statistics, presented a systematic analysis and evaluation of China's S&T human resources, R&D expenditures, S&T output, S&T activities carried out by major entities (enterprises, higher education institutions and government research institutes), high-technology industries, the overall scale and structural distribution of regional S&T development. The report has reflected the main characteristics of China's S&T activities.

With the help of richly and solidly collected S&T development data and information, the report has made itself a reliable evidence and data source not only suitable for studying China's S&T status quo, strength, achievements and development tendency but also desirable for the macro management and decision-making process. It could also serve as a fine reference book for S&T professionals and school teachers and students.

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PREFACE

Science and Technology (hereafter referred to as “S&T”) indicators represent quantitative means through which people can observe or measure S&T activities. S&T indicators can accurately reflect the status of S&T development and their roles and impact on social and economic development. S&T indicators act as basic evidences in decision-making process and important instruments in evaluating the effects of S&T policies. Almost all nations and international organizations have been paying more and more attention to S&T indicators and using them as the basic tools of scientific decision-making and policy analysis.

Since the 1990s, the Ministry of Science and Technology of China has, together with other governmental departments under the State Council as well as relevant institutions, compiled and published report series as a government publication on China’s S&T indicators in the form of S&T Yellow Book. *China Science and Technology Indicators 2016*, or the No.13 Yellow Book on Science and Technology, is the 13th volume of the series.

This issue has made full use of the scientific statistics and relevant economic and social statistics until the end of 2015, mainly reflecting the basic S&T development status since the release of the *Outline of the National Program for Medium- and Long-Term Scientific and Technological Development (2006–2020)* and the *12th Five-Year Scientific and Technological Development Plan (2011–2015)*. It unveils major characteristics of China’s S&T activities in the course of supporting the economic and social transformation and reflects historical process of strengthening China’s capacity of indigenous innovation and developing an innovative country.

As one of the serial reports, this volume is consistent with the structures and indicators system applied in the previous volumes. The report presents a systematic analysis and evaluation of China’s S&T human resources, R&D expenditures, S&T output, S&T activities carried out by major entities (enterprises, higher education institutions and government research institutes), high-technology industries, the overall scale and structural distribution of regional S&T development in the recent decade. At the same time, this volume also features some updates. First, it underscores the analysis of the trend of S&T indicators and the comparison with historical data. Through the analysis and comparison, it reviews China’s S&T development history and the process of developing an innovative country in recent years, and tries to analyze the trend and rule of S&T development from a longer-term perspective. Second, this report continues to emphasize on international comparability. Some representative and comparative S&T indicators have been used in the report to compare China with some important developed countries and emerging economies so as to reflect the national characteristics of China's S&T and China's position in the world. Because of the limitation in statistics collection and application, the report, unless noted, does not contain the data on Hong Kong SAR, Macao SAR and Taiwan regions. The Editorial Board of *China Science and Technology Indicators 2016* acknowledges its gratitude for the guidance and assistance provided by authorities, experts and scholars of government agencies and institutions including Ministry of Science and Technology, China Association for Science and Technology, Chinese Academy of Sciences, National Natural Science Foundation of China, State Administration of Foreign Exchange, Ministry of Education, National Bureau of Statistics, State Intellectual Property Office, National Development and Reform Commission, Ministry of Finance, General Administration of Customs, State Administration of Science, Technology and Industry for National Defence. The Board also appreciates comments or suggestions, if any, from readers.

Editorial Board of
China Science and Technology Indicators 2016

CONTENTS

Summary

The year 2015 marked the closing year of the 12th Five-Year Plan (2011–2015) and saw China's economic, social and S&T development enter a new era. The 12th Five-Year Plan period was an important transitional period for the implementation of the *Outline of National Program for Medium- and Long-Term Scientific and Technological Development (2006–2020)* and building China into an innovative country. During the period, China scored significant achievements in science, technology and innovation (STI). With the steady improvement in innovation capacity, China rose to the 18th globally in the national innovation index, meeting the intended goal. The national S&T investment and output increased substantially. In 2015, China's R&D expenditure rose to 1.42 trillion yuan, with the R&D/GDP ratio reaching the all-time high of 2.06%; the R&D personnel per 10 thousand persons employed reaching 48.5 person-years; SCI paper citations ranking the 4th in the world; the invention patents per 10 thousand persons reaching 6.3, with the actual increase being 2.9 times the targeted increase; and the patent applications per 100 R&D personnel reaching 24.3, with the actual increase being 7.1 times the targeted increase. As STI played an increasing role in supporting economic development and industrial transformation, the MFP contribution to economic growth reached 55.3%. The STI environment improved as well, with the completed transactions in the national technology market reaching 983.6 billion yuan. China enjoyed a favorable situation of robust development across the board in terms of S&T input and output, STI performance of different sectors, and the industrial development.

1 S&T investment remains upward with world-leading R&D expenditure

Human resources in science and technology (HRST) are major drivers and strategic resources for China's innovation-driven development strategy. During the 12th Five-Year Plan period, China's HRST stock saw a steady growth thanks to continued higher education and S&T talent development. In 2015, China's HRST stock reached 79.15 million, up 5.4% year on year, including 34.2 million with a bachelor's degree or higher, up 7.9% year on year. China's HRST stock in 2015 was 3.2 times that in 2000, representing an average annual growth of 8.0%, or 8.5% for those with a bachelor's degree or higher. The scientific literacy of the Chinese population continued to rise, with HRST per 10 thousand persons increasing from 197 in 2000 to 576 in 2015, representing an average annual growth of 7.4%.

In 2015, China's R&D personnel totaled 5.5 million, up 2.4% from 5.4 million in 2014, keeping the upward trend. They included 357 thousand doctorates, 805 thousand masters, and 1.6 million bachelors, representing 6.5%, 14.7% and 29.3%, respectively. Measured on a full-time equivalent (FTE) basis, China had 3.8 million person-years of R&D employment in 2015, up from 2.8 million in 2000, representing an average annual growth of 9.8%.

Among the three sectors of performance of R&D activity, enterprises remained the principal actors of R&D in China. In 2015, enterprise R&D personnel accounted for 77.4% of China's total R&D personnel, versus 10.2% for research institutes and 9.4% for higher education institutions. The R&D personnel of research institutes as a percentage of the national R&D personnel and that of higher education institutions posted an increase of 0.1 percentage point and 0.4 percentage point, respectively, reversing their downward trend for many years. In 2015, of all the R&D personnel in China, 253 thousand person-years, or 6.7% of the total, were engaged in basic research, versus 430 thousand person-years in applied research, or 11.5%, and 3.1 million person-years in experimental development, or 81.8%.

HRST development mainly relies on higher education. Science graduates of higher education institutions are a primary source of HRST in China. In 2015, China graduated 11.7 million students with either bachelor's or associate degrees, including 5.8 million with bachelor's degrees and 6.0 million with associate degrees. In the same year, China graduated 552 thousand students with either master's or PhD degrees, including 54 thousand with PhD degrees and 498 thousand with master's degrees. Higher education supplied China with more than 10 million high-caliber workers every year. During the 12th Five-Year Plan period, the number of PhD candidates, master's degree candidates, bachelor's degree candidates and associate degree candidates enrolled posted an average annual growth of 3.2%, 3.6%, 2.2% and 1.8%, respectively.

Graduates of bachelor's programs in natural science and engineering are a main source of future scientists and engineers. In 2015, there were 2.4 million students graduated from the bachelor's programs in science and engineering at Chinese higher education institutions, up 6.3% year on year, slightly higher than the growth of all bachelor's program graduates. Graduates of master's and PhD programs in science and engineering reached 327 thousand, up 3.9% year on year, accounting for 59.2% of all master's and PhD program graduates in the year, including 54 thousand PhDs, or 9.8%, and 498 thousand masters, or 90.2%.

Returned overseas graduates are also an important source of HRST in China. Against the background of China's rapid economic growth and the continuous increase in residents' income, the number of Chinese students going abroad to study has been growing at a high speed since 2005. In 2015, a total of 524 thousand Chinese students went abroad to study, representing an increase of 405 thousand from 2005, or an average annual growth of 16%. In 2015, Chinese students returning home after studying abroad reached 409 thousand, up 43.6% year on year, being 11.7 times the number in 2005, representing an average annual growth of 27.9%.

As the Chinese economy shifts gear from the previous high speed to a medium-to-high speed growth, the rapid rise in R&D expenditure has given a strong boost to innovation activity in China. In 2015, China's R&D expenditure reached 1.42 trillion yuan, up 9.3% year on year at constant price. Between 2001 and 2015, China's R&D expenditure expanded by 16% per year on average terms, which was 1.6 times China's average GDP growth during the same period at 9.7% per year. In 2015, China's R&D intensity reached a new high of 2.06%. According to the latest statistics, there are six countries and regions—Israel, Korea, Japan, Sweden, Austria and Taiwan of China—whose R&D intensity has exceeded 3%, and some developed countries such as the United States, Germany and France have all posted more than 2%. In 2015, China's R&D intensity exceeded that of some developed countries including the United Kingdom, Italy and Canada and the average level of the 28-member EU bloc but remained below the average of OECD countries at 2.4% and significantly behind that of developed countries like the United States, Japan and Germany.

In 2015, the global R&D expenditure reached approximately USD 1.45 trillion, with the top ten countries being the United States, China, Japan, Germany, Korea, France, the United Kingdom, Australia, Brazil and Canada. Among them, the top three countries—the United States, China and Japan—all posted more than USD 100 billion and their combined expenditure accounted for 60.1% of the global total. In 2015, the United States' R&D expenditure stood at USD 502.9 billion, accounting for 34.6% of the global total, ranking first. China's R&D expenditure was USD 227.5 billion (converted according to the average exchange rate in 2015, the same below) and accounted for 15.6% of the global total. Japan ranked the third globally with USD 144 billion. Among the top ten spenders on R&D between 2013 and 2015, China recorded the highest growth with an average growth of 8.9%; Korea, the United Kingdom, the United States, Germany and Italy saw their R&D expenditure continue to expand at the average rate of 4.0%, 3.9%, 3.4%, 2.6% and 1.4%, respectively; and France and Japan experienced a slowdown in their R&D expenditure growth, which was under 1.0% for both countries.

By type of R&D activity, China spent 71.6 billion yuan on basic research (5.1%), 152.9 billion yuan on applied research (10.8%) and 1.19 trillion yuan on experimental development (84.2%) in 2015. Compared to some countries, China's expenditure on scientific research (including basic research and applied research) as a percentage of its total R&D expenditure was rather low, at 15.8% in 2015, versus over 30% for the majority of developed countries and emerging industrialized countries.

By sector of performance of R&D activity, Chinese enterprises, research institutes and higher education institutions contributed 1.09 trillion yuan, 213.7 billion yuan and 99.9 billion yuan, accounting for 76.8%, 15.1% and 7.0%, respectively, of China's total R&D expenditure. Internationally, enterprise R&D expenditure as a percentage of China's R&D expenditure was higher than that of most OECD countries; research institute R&D expenditure as a percentage was comparatively high; and higher education institution R&D expenditure as a percentage was comparatively low.

By type of costs of R&D, China's R&D expenditure in 2015 included 28.1% of labor costs, 58.7% of other routine expenses, 11.3% of instrument and equipment purchases, and 1.8% of other assets expenses. Labor costs of R&D saw a gradual increase, rising from 63 thousand yuan per person-year in 2009 to 106 thousand yuan per person-year in 2015.

By source of funding, China's R&D expenditure in 2015 included 301.3 billion yuan, or 21.3%, from government, 1.06 trillion yuan, or 74.7%, from enterprises, 10.5 billion yuan, or 0.7%, from foreign entities, and 46.3 billion yuan, or 3.3%, from other sources. Of the 301.3 billion yuan of government funding, 59.8% went to research institutes, 21.1% to higher education institutions, 15.4% to enterprises, and 3.6% to other entities. Of the 1.06 trillion yuan of enterprise funding, 1.02 trillion yuan, or 96.3%, was used internally as R&D funds, with only less than 4.0% going to higher education institutions, research institutes and other entities.

2 S&T output reaches a new height with the improvement in both quantity and quality

With the steady improvement in international competitiveness of China's scientific research in recent years, the number of China's SCI papers has been steadily increasing. In 2015, China published a total of 297 thousand papers, representing an increase of 229 thousand papers from 2005 and an average annual growth of 15.8%. This put China in the second place globally in the number of SCI papers published for the 7th consecutive year, next only to the United States, with the other three countries in the top five being the United Kingdom, Germany and Japan. China's SCI papers as a percentage of the total SCI papers published worldwide rose to 16.3% in 2015 from 5.3% in 2005.

China's SCI papers were highly concentrated in basic disciplines and industrial technology, with papers in the first category accounting for 47.3% with 126 thousand and papers in the second category accounting for 27.2% with 72 thousand in 2015. With the exception of few years, the period between 2005 and 2015 saw an overall growth of SCI papers in all subject areas. Among the fields of science and technology, medical and health sciences recorded the highest average annual growth of papers published at 27.1% during the period, with papers published in the field in 2015 as a percentage of the total papers jumping up by 14.0 percentage points from 2005, versus 12.4% of average annual growth and a decrease of 14.5 percentage points for basic disciplines, and 15.3% of average annual growth for industrial technology.

Between 2006 and 2016 (as of September 2016), Chinese researchers published a total of 1.7

million SCI papers, representing an increase of 10.2% from the data collected in 2015. In 2016 (up to September), China continued in the second place globally in SCI papers published; and the papers received 14.9 million citations, up 15.7%, retaining the fourth spot worldwide as in the previous year. China registered 8.55 citations per paper, up 5.0% from the previous year, though still being significantly behind the world average of 11.5, but the gap was steadily narrowing. Among the 21 countries with annual publication of more than 200 thousand papers, China ranked the 15th in citation count per paper.

In terms of citation count, China has published some of the widely influential SCI papers in the world. Between 2006 and 2016, China entered the top ten globally in 18 fields and the top three in 10 fields in terms of citation count. Among them, materials science received 1.7 million citations (24.5% of the global total), chemistry 3.9 million (19.3%), mathematics 279 thousand (17.7%), engineering technology 1.2 million (17.1%), physics 1.8 million (15.2%), computer science 249 thousand (12.9%), agricultural science 301 thousand (10.0%), and pharmacology and toxicology 381 thousand (8.7%), all ranking in the second place and retaining their place in the previous year with the exception of physics which improved by one place.

According to SCI statistics, China's SCI papers in 2015 included 75 thousand internationally co-authored papers, representing an increase of 9872, or 15.2%, from 2014, and accounting for 25.4% of China's total SCI papers. They included 52 thousand papers with Chinese researchers as the first author, accounting for 69.1% of China's total internationally co-authored papers, which involved collaborators coming from 148 countries (regions) around the world. The top six countries were the United States, Australia, the United Kingdom, Canada, Japan and Germany.

In 2015, China filed 2.8 million patent applications, up 18.5% year on year. They included 1.1 million invention patent applications, up 18.7% year on year, accounting for 39.4%. In 2015, a total of 1.7 million patents were granted in China, up 31.9% year on year. They included 359 thousand invention patents, up 54.1% year on year.

Domestic invention patent applications as a percentage of the total invention patent applications increased by 1.6 percentage points from the previous year to 87.9%. In the same period, foreign invention patent applications in China reached 134 thousand, an increase of 5.2% over the previous year. With the exception of 2013, the number of domestic invention patents granted has maintained a trend of high-speed growth and, after overtaking foreign invention patents granted in 2009, continued to expand their share. In 2015, domestic invention patents granted posted a significant growth from the previous year, with invention patents granted as a share of all patents granted continuing to rise and reaching 73.3%, representing an increase of 3.6 percentage points from the previous year.

As of the end of 2015, China had a total of 1.5 million invention patents in force. They included

922 thousand domestic invention patents, or 62.6%, representing an increase of 30.1% from the previous year. However, domestic invention patents as a share of all domestic patents in force remained low at 19.2%. In comparison, foreign invention patents reached a total of 551 thousand pieces in force as a share of all foreign patents in force was as high as 80.4%.

Among the domestic invention patents in force in 2015, 585 thousand (63.5%) were held by enterprises, 174 thousand (18.9%) by colleges and universities, 82 thousand (8.9%) by individuals, 70 thousand (7.6%) by research institutes and 10 thousand (1.1%) by government agencies and organizations.

Compared internationally, China continued to lead the world in invention patent applications and domestic patent applications in 2015. China's invention patent applications were close to those of the United States, Japan and Korea combined, and its domestic invention patent applications were far higher than those of the United States, Japan, Korea and Germany combined. China also overtook the United States and Japan to rank the first globally in both total invention patents granted and resident invention patents granted. China continued to be in the third place globally in total invention patents in force and resident invention patents in force. China's patent applications filed under PCT maintained a two-digit growth in 2015 by increasing 16.8% year on year to 30 thousand. China's PCT patent applications continued to rank the third in the world. In terms of triadic patents, China's triadic patents increased 16.6% year on year to 2889, or 5.3% of all triadic patents, with its global rank going up two places from the previous year to the fourth.

In 2015, China's technology market signed a total of 307 thousand technical contracts with a turnover of 983.6 billion yuan, up 3.4% and 14.7% respectively over the previous year. The average transaction value per contract reached 3.2 million yuan, an increase of 10.9% over the previous year. In terms of turnover, technical service contracts ranked the first among the four categories of contracts with 505.9 billion yuan, accounting for 51.4% of the market. Technology development contracts came the second with 153 thousand contracts, up 3.0% year on year, and a turnover of 304.7 billion yuan, up 3.3%, accounting for 31.0% of the market.

In 2015, China's technology balance of payments was in good shape overall, with payments reaching USD 46.2 billion, down 0.8% year on year, and receipts reaching USD 42.5 billion, up 8.6% year on year, representing a balance of payments of USD 3.7 billion, slightly down over the previous year. China's technology payments included USD 21.0 billion for technical services, accounting for 45.5%, and USD 11.6 billion for transfer of techniques, accounting for 25.1%, in addition to payments for industrial rights transactions (19.1%) and industrial and technological R&D (10.3%).

3 Collaboration among enterprises, higher education institutions and research institutes achieved progress and innovation output made breakthroughs

With the acceleration of China's effort to build a national innovation system, the scale of R&D activity of Chinese enterprises has significantly expanded. In 2015, China had 2.9 million enterprise R&D personnel in FTE, 6.1 times that in 2000, rising as a percentage of the national total of R&D personnel (in FTE) to 77.4% from 52.1% in 2000. In 2015, China's enterprise R&D expenditure reached 1.09 trillion yuan, 20.3 times that in 2000, rising as a percentage of the national R&D expenditure to 76.8% from 60.0% in 2000. This trend has highlighted the increasing role played by enterprises in innovation.

Industrial enterprises above designated size are the mainstay of enterprise R&D innovation in China and a major driving force of China's technology and innovation development. In 2015, China had 74 thousand industrial enterprises above designated size that had R&D activity, 4.3 times that in 2000. Enterprises with R&D activity as a percentage of industrial enterprises above designated size reached 19.2% in 2015, representing an increase of 8.6 percentage points over 2000. Among the industrial enterprises above designated size, 53 thousand had R&D organizations, accounting for 13.8%, up 8.8 percentage points over 2004. R&D organizations established by industrial enterprises above designated size reached 63 thousand, 4.1 times that in 2000.

In 2015, industrial enterprises above designated size had 2.6 million person-years of R&D personnel in FTE, 6 times that in 2000, including 2.0 million person-years in large and medium-sized enterprises, 6 times that in 2000. Between 2000 and 2015, large and medium-sized enterprises contributed more than 70% of all R&D personnel of industrial enterprises above designated sizes, serving as a leading force of enterprise innovation. R&D expenditure of industrial enterprises above designated size in China had shown a trend of steady increase. In 2015, industrial enterprises above designated size recorded 1001.4 billion yuan in internal R&D expenditure, 20.4 times that in 2000. The amount included 779.2 billion yuan from large and medium-sized industrial enterprises, 22.1 times that in 2000.

Patent applications from industrial enterprises above designated size in China rose sharply from 26 thousand in 2000 to 639 thousand in 2015, representing an increase of 23.4 times; at the same time, the number of invention patent applications also showed a trend of rapid growth. Industrial enterprises above designated size filed not more than 10 thousand invention patents in 2000, which, however, quickly leaped to 246 thousand in 2015, representing an increase of 29.8 times. The structure of patent applications of industrial enterprises showed an improvement as well, with invention patent applications as a percentage of all patent applications rising from 30.4% in 2000 to 38.5% in 2015. In terms of new product development, the number of projects of new product development of industrial enterprises in China rose quickly from 92 thousand in 2000 to 326 thousand in 2015, representing an increase of 2.6 times.

According to *China Enterprise Innovation Survey and Statistics 2014*, China had 266 thousand enterprises with innovation activity in 2014, accounting for 41.3% of all Chinese enterprises, including 256 thousand that achieved innovation, accounting for 39.7%. 58 thousand, which is 9.1% of all enterprises, achieved innovation in product, process, organization and marketing, including 121 thousand which achieved innovation in product (18.7%) and 129 thousand in process (20.0%), with those which achieved both product innovation and process innovation accounting for 14.4%; and 218 thousand which achieved either organizational innovation or marketing innovation (33.8%), with those which achieved organizational innovation accounting for 27.9%, those which achieved marketing innovation accounting for 25.8%, and those which achieved both organizational innovation and marketing innovation accounting for 19.9%.

Higher education institutions are an important component of the national innovation system and serve as main actors of R&D and innovation activity and major bases of innovation talent development. In 2015, China had 2560 higher education institutions, representing an increase of 693 or 37.1% over 2006.

In recent years, China's higher education R&D personnel and expenditure have been steadily increasing, though the trend has been downward as a percentage of the national R&D expenditure. In 2015, China's higher education R&D personnel reached 355 thousand in FTE, representing an increase of 113 thousand or an average annual growth of 4.3% from 2006 but a drop to 9.4% from 16.1% in 2006 as a percentage of the national R&D personnel. In 2015, China's higher education R&D expenditure reached 99.9 billion yuan, representing an average annual growth of 15.2% between 2005 and 2015 but a drop to 7.1% from 9.9% in 2005 as a percentage of the national R&D expenditure.

Government funding was the primary source of higher education R&D expenditure, followed by enterprise funding. The higher education R&D expenditure in 2015 included 63.7 billion yuan of government funding (63.8%), 30.15 billion yuan of enterprise funding (30.2%) and 6.0 billion yuan of other domestic sources of funding and foreign funding (6.0%).

The higher education R&D expenditure in 2015 included 51.6 billion yuan of applied research expenditure, up 53.2% from 2010; 39.1 billion yuan of basic research expenditure, up 117.4%; and 9.1 billion yuan of experimental development expenditure, up 13.6%. Between 2005 and 2015, basic research expenditure as a percentage of the total higher education R&D expenditure rose significantly from 23.4% to 39.2%; applied research expenditure remained stable within the 50%~55% range; and experimental development expenditure gradually decreased from 25.0% to 9.1%.

The output of China's R&D activity, including scientific papers and patents, has been steadily increasing. In 2015, China's higher education institutions produced 220 thousand SCI papers, representing an increase of 171 thousand or nearly four times from 2005. The dominant position of higher education institutions in scientific research has remained basically intact by producing more than 80% of SCI papers in the country for a long period of time. The number of patent applications of higher education institutions increased significantly from 20 thousand in 2005 to 235 thousand in 2015, representing an average annual growth of 28.0%. Among them, invention patent applications increased from 15 thousand to 133 thousand, representing an average annual growth of 24.7%. The number of patents granted to higher education institutions increased from 7399 in 2005 to 136 thousand in 2015, representing an average annual growth of 33.8%. However, a downward trend was registered for both invention patent applications and invention patents granted as a percentage of all patent applications of and all patents granted to higher education institutions, which decreased from 73.5% and 60.2% in 2005 to 56.8% and 42.0% in 2015, respectively. Patent applications and patents granted to higher education institutions as a percentage of the national total maintained a slow gradual increase, rising to 8.9% and 8.5%, respectively, in 2015.

The number of contracts signed by higher education institutions as sellers in the technology market saw a steady growth, rising to 57 thousand in 2015, 1.9 times that in 2008, and the number as a percentage of the national total number of technology contracts rose to 18.6% from 13.3% in 2008; and the total value of the technology contracts signed by higher education institutions in 2015 reached 31.4 billion yuan, 2.7 times that in 2008, accounting for 3.2% of the value of all contracts in the national technology market. In 2015, higher education institutions transferred and licensed a total of 2257 patents, representing an increase of 2.2 times from 2007, and getting a total income of 669 million yuan, an increase of 1.7 times from 2007.

Government research institutes are an important component of the national innovation system and also the main actors of basic, strategic and public research activity in China. In 2015, China had 3650 public research institutes, including 715 centrally administered research institutes and 2935 locally administered research institutes.

In 2015, R&D expenditure by public research institutes reached 213.65 billion yuan, of which 88.5% was by centrally administered research institutes. Government funding has always been the primary source of R&D expenditure of research institutes. Government funding increased from 42.5 billion yuan in 2005 to 180.3 billion yuan in 2015. Government funding as a percentage of the total R&D expenditure of research institutes has always stayed above 80% in spite of some fluctuations.

Of the R&D expenditure, 3.1% was from enterprise funding, 0.2% from foreign funding and 12.3% from other sources of funding. Compared to developed countries, labor cost as a percentage of the total R&D expenditure of research institutes in China has been rather low at around 20%, which was 19.9% for 2015; and capital expenditure as a percentage has been fairly high at above 20.0%, which was 20.9% for 2015. In terms of the allocation of R&D expenditure by type of R&D activity, the 2015 R&D expenditure was 57.2% taken up by experimental development, 13.8% by basic research and 28.9% by applied research. In terms of the allocation by discipline, the expenditure was 71.0% taken up by engineering and technology sciences, followed by natural science with 15.6%, agricultural science with 7.0%, medical science with 4.4%, and humanities and social sciences with 2.0%.

R&D projects are an important way of R&D activity taking place. In 2015, among the 62 first-level disciplines, the top ten in terms of R&D project-based funding were aeronautics/aviation/aerospace science and technology; electronics, communications and control; nuclear science and technology; basic disciplines in engineering and technology sciences; earth science; agricultural science; physics; biology; materials science; and computer science and technology. In terms of R&D collaboration, 82.3% of research institutes' R&D projects were conducted independently; 8.0% in collaboration with other domestic research institutes; 2.9% with domestic enterprises; and 3.4% with domestic higher education institutions.

In 2015, China's R&D personnel at research institutes reached 384 thousand person-years, down as a percentage of the national total number of R&D personnel to 10.2% from 15.8% in 2005. In terms of the education structure, China's R&D personnel at research institutes in 2015 included 73 thousand with a PhD degree, or 16.8%, and 146 thousand with a master's degree, or 33.5%. Between 2009 and 2015, there had been a steady trend of growth of highly educated researchers represented by PhD and master's degree holders.

In terms of affiliation, centrally administered research institutes had a total of 336 thousand R&D personnel in 2015. They included 62 thousand PhD holders, or 18.4%, and 115 thousand master's degree holders, or 34.1%. Locally administered research institutes had a total of 100 thousand R&D personnel, including 12 thousand PhD holders, or 11.6%, and 32 thousand master's degree holders, or 31.7%.

In terms of the output of R&D activity, Chinese research institutes published 57 thousand domestic scientific papers in 2015, basically on par with that in 2010, representing 11.5% of all domestic scientific papers, up 0.8 percentage point from 2010, and 29.7 thousand SCI papers, basically on par with that in the previous year. Chinese research institutes filed 64 thousand patent applications in 2015, representing an average annual growth of 20.8% from 2005. They included 45 thousand invention patent applications, or 69.1%, representing an average annual growth of 20.8%. The number of patents granted to research institutes also saw a high growth, reaching 34 thousand in 2015, representing an average annual growth of 23.2% from 2005. They included 19 thousand invention patents, or 57.2%, representing an average annual growth of 23.0%.

Research institutes transferred and licensed a total of 3567 patents for an income of 724 million yuan, including 959 transferred by centrally administered research institutes for an income of 661 million yuan. In 2015, research institutes created a total of 3813 national and industry standards, including 2685 by centrally administered research institutes (70.4%) and 1128 by locally administered research institutes (29.6%).

4 Strength of industrial innovation continued to improve and high-technology industry achieved remarkable success

China's high-technology industry has been steadily rising in the world. According to the *Science and Engineering Indicators 2016* of the US National Science Foundation, the value added of China's high-technology industry as a percentage of the global total stood at only 9.8% in 2005, surpassed Japan in 2007, and reached 27.3% in 2014, ranking the second in the world, next only to the United States. According to the *World Development Indicators 2016* of the World Bank, China's high-technology exports as a percentage of the world rose to 25.9% in 2014, ranking the first in the world.

China's R&D investment in the high-technology industry has been steadily going up. In 2015, the R&D expenditure of large and medium-sized enterprises reached 222.0 billion yuan, accounting for 29.7% of the R&D expenditure of all large and medium-sized manufacturing enterprises, up 2.2 percentage points over the previous year. At the same time, the R&D intensity of the high-technology industry reached 1.98%. Among the industries, aircraft and spacecraft and equipment manufacturing registered the highest R&D intensity of 5.46%, and electronic computer and office equipment manufacturing had a rather low R&D intensity of only 0.88%. Overall, the R&D intensity of China's high-technology industry was fairly low and wide-varying among individual industries.

With the increase of R&D investment, China's high-technology industry achieved a significant increase of invention patents in force. The number of invention patents in force owned by China's large and medium-sized high-technology enterprises increased from 6658 in 2005 to 199.7 thousand in 2015, representing an increase of nearly 30 times.

The expenditure on technology import of large and medium-sized enterprises in China's high-technology industry hit the historical high of 13.1 billion yuan in 2007 and then gradually decreased to 5.3 billion yuan in 2013, which slightly rebounded to 7.2 billion yuan in 2015. The number of enterprises that purchase technology domestically to advance their technological transformation has been steadily increasing, with their expenditure on domestic technology transfers increasing from 954 million yuan in 2005 to 6.3 billion yuan in 2015. In 2015, China's high-technology industry spent 1.3 billion yuan on technology introduction and absorption.

Between 2005 and 2013, China's high-technology imports and exports showed an overall upward trajectory, though the trend began reversing in recent two years. In 2015, China's high-technology imports and exports reached USD 1.20 trillion, including USD 655.3 billion in exports, down 0.8% year on year, and USD 549.3 billion in imports, down 0.4% year on year. Internationally, due to the sluggish investment demand in developed western countries as well as developing countries, China's high-technology imports and exports will face a further downward pressure.

In terms of the distribution of technological fields, China's high-technology exports in 2015 by and large continued to be focused on computer and communication technology and electronic technology as before. Among the technological fields of China's high-technology exports, computer and communication technology remained in the dominant position by exporting USD 441.9 billion worth of goods, accounting for 67.4%, followed by electronic technology in the second place with USD 125.5 billion, or 19.2%.

In 2015, a total of 31 provincial-level high-technology zones were approved by the State Council as national high-technology zones, bringing the total number of national high-technology zones to 146. In 2015, there were more than 965 thousand registered industrial and commercial enterprises hosted by national high-technology zones. According to the statistics of 82 712 enterprises of them, there were 1170 listed companies and 2110 listed on the New Third Board; 31 160 high-technology enterprises; 10 enterprises with an annual revenue of more than 100 billion yuan, an increase of 3 over the previous year; 362 enterprises with more than 10 billion yuan, an increase of 13 over the previous year; 3532 enterprises with more than one billion yuan, accounting for 4.3%; and 20 633 enterprises with more than 100 million yuan, accounting for 24.9%.

Among the enterprises hosted in national high-technology zones, there were 36 827 in high-technology manufacturing and high-technology services, accounting for 44.5%; they included 12 364 in high-technology manufacturing, or 14.9%, and 24 463 in high-technology services, or 29.6%. The number of high-technology services enterprises was twice of the high-technology manufacturing enterprises.

In 2015, the national high-technology zones achieved 25.4 trillion yuan in total revenue, 18.6 trillion yuan in total industrial output value, 1.6 trillion yuan in net profit, 1.4 trillion yuan in tax payments, USD 473.3 billion in foreign exchange from export, and 8.1 trillion yuan in total products, accounting for 11.9% of the gross domestic products.

In 2015, enterprises in national high-technology zones filed 353 thousand patent applications, including 187 thousand invention patents which accounted for 17.0% of the national invention patent applications, and were granted 215 thousand patents, including 71 thousand invention patents which accounted for 19.8% of the national invention patents granted in the year. In 2015, enterprises in the national high-technology zones had 926 thousand patents in force, including 279 thousand invention patents, representing 162.3 patents per 10 thousand employees, 8.5 times the national average (19.0).

The output value of new products developed by enterprises in the 146 national high-technology zones reached 5.9 trillion yuan, up 3.3% year on year, and their sales reached 5.9 trillion yuan, up 3.0% year on year, accounting for 30.8% of their total product sales revenue. Enterprises in national high-technology zones were active in technology transfer, closing contracts with a total value of 263.6 billion yuan, or 26.8% of the technology contract value in the national technology market (983.5 billion yuan). In 2015, enterprises in the national high-technology zones registered 35 thousand new trademarks and obtained 50 808 software copyrights, 1088 integrated circuits and 218 new plant varieties, bringing the ownership per 10 thousand persons in the national high-technology zones to 168.9 registered trademarks, 145.3 software copyrights, 3.7 integrated circuits and 0.9 new plant variety.

The recent years have seen high-technology enterprises pursue innovation-driven development with steadily increasing innovation capacity and competitiveness. As of the end of 2015, there were a total of 76 141 high-technology enterprises being included for statistical analysis, up 21.7% over the previous year. High-technology enterprises were mainly distributed in Beijing, Guangdong, Jiangsu, Shanghai, Zhejiang and Shandong, which were home to 63.3% of all high-technology enterprises nationwide.

In 2015, high-technology enterprises had a workforce of 20.5 million people, including 10.5 million with an associate degree or higher, accounting for 51.2%, up 0.5 percentage point over the previous year. They included 80 thousand PhDs, 883 thousand master's degree holders and 90 thousand overseas returnees.

High-technology enterprises filed a total of 576 thousand patent applications, including 275 thousand invention patent applications, or 25.0% of all invention patents filed nationwide, were granted 374 thousand patents, including 115 thousand invention patents, or 32.0% of the national total of invention patents granted, and had 1.7 million patents in force, including 445 thousand invention patents in force, representing 217.6 invention patents per 10 thousand employees, 11.5 times the national average. In 2015, high-technology enterprises achieved 8.2 trillion yuan in new product sales revenue, accounting for 44.0% of their total product sales revenue.

In 2015, China had 1775 venture capital institutions, representing an increase of 224 or 14.4%.

According to disclosed data, venture capital institutions in China invested in a total of 3423 projects in 2015, up 39.2% year on year, and the total investment amounted to 46.6 billion yuan, representing an increase of 24.4% year on year and 13.6 million yuan per project. As of the end of 2015, China's venture capital institutions had cumulatively invested in 17 thousand projects, representing an increase of 3258 or 23.1% from 2014, and their cumulative investment amounted to 336.1 billion yuan, up 14.6% from 2014.

In 2015, there was a comparative increase of venture capital investment in high-technology enterprise projects, though at a lower investment intensity, with investment trending to smaller early-stage enterprises. The year registered a total of 820 venture capital investments in high-technology enterprise projects, up 19.0% year on year; the total investment amounted to 11.7 billion yuan, slightly down from a year earlier, with the average investment amount per project standing at 14.3 million yuan.

Chapter 1 Human Resources in Science and Technology

Human resources in science and technology (HRST) refer to the human resources that are actually or potentially engaged in the systematic production, dissemination and application of scientific and technological knowledge, which include labor forces that are either actually engaged in or qualified for carrying out S&T activities. HRST are the leading force and strategic resources for China's building of an innovative country and implementation of the innovation-driven development strategy. This chapter aims to address the current status and future development of HRST in China from three perspectives, i.e. overview of HRST, R&D personnel and cultivation of HRST, and demonstrate China's international standing in HRST and its gap with leading nations through comparison with international standards.

Section 1 Overview of Human Resources in Science and Technology

China's HRST stock refers to the combined volume of the stock of graduates holding a junior college or above diploma (or degree) in S&T and the stock of labor forces without a S&T diploma (or degree) in a higher education institution but actually engaged in S&T activities. HRST stock is a reflection of the current stock of S&T human resources and potential input of S&T personnel in China.

China's higher education development and the great importance attached to S&T talent training have ensured a stable growth of the country's HRST stock. In 2015, China's HRST stock reached 79.15 million, up 5.4% year on year, including 34.2 million with a bachelor's degree or higher, up 7.9% year on year. China's HRST stock in 2015 was 3.2 times that in 2000, representing an average annual growth of 8.0%, or 8.5% for those with a bachelor's degree or higher (Figure 1-1). In terms of the number of HRST per 10 000 persons, the Chinese population has seen a steady improvement in scientific literacy overall. The indicator rose from 197 in 2000 to 576 in 2015, representing an average annual growth of 7.4%.

China's HRST stock with a bachelor's degree or higher is comparable to the United States' scientists and engineers (university graduates with science and engineering degrees). According to the *Science and Engineering Indicators 2016*, the United States had 21.1 million scientists and engineers in 2013, or 667 per 10 000 persons. China's HRST stock with a bachelor's degree or higher has always outnumbered the United States' since 2009, but China has stayed behind the United States in terms of the number per 10 000 persons (249 in 2015).

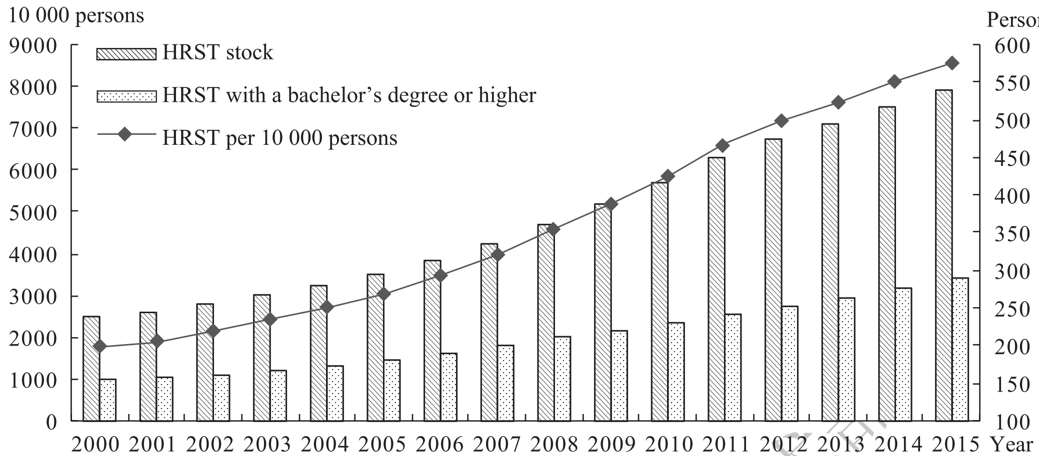

Figure 1-1 China's HRST stock (2000–2015)

See Annexed Table 1-1

China Science and Technology Indicators 2016

Section 2 R&D Personnel

Research and development (R&D) refers to the systematic and creative work carried out in the S&T field for the purpose of increasing the total volume of knowledge and creating new applications with the knowledge.

R&D personnel refer to those directly engaged in R&D activities as well as management, administration and logistical personnel that directly serve R&D activities. The quantity and quality of R&D personnel is one of the key indicators of a country's innovation capability. Using the total volume and distribution of R&D personnel as the main indicators, this section aims to present a picture of China's input of R&D personnel and an international comparison of R&D personnel.

1 Total R&D personnel

The number of China's R&D personnel has maintained a high growth. In 2015, China had 5.5 million R&D personnel, up 2.4% from 5.4 million in 2014, including 357 thousand doctorates (6.5%), 805 thousand masters (14.7%) and 1.6 million bachelors (29.3%).

Measured on a full-time equivalent (FTE) basis, China had 3.8 million person-years of R&D employment, up from 2.8 million in 2000, representing an average annual growth of 9.8%

(Figure 1-2).

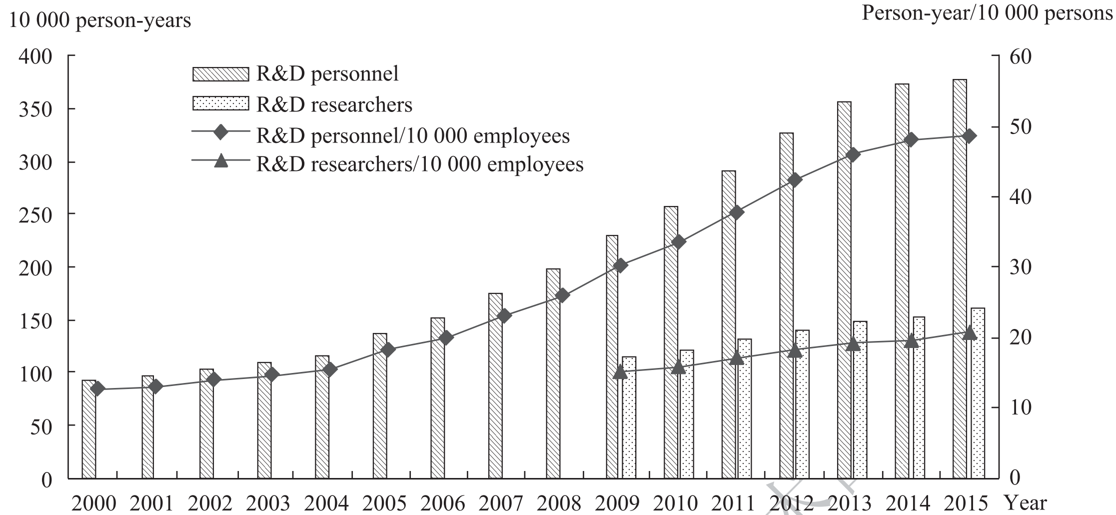

Figure 1-2 Total volume and input intensity of R&D personnel (2000–2015)

China Science and Technology Indicators 2016

Researchers refer to professionals that are engaged in the conception or creation of new knowledge, new product, new technique, new method and new system as well as senior management personnel of R&D subjects. In the actual S&T statistics, they refer to R&D personnel with an intermediate or above professional title or a PhD diploma (degree). The proportion of researchers reflects the competence of the R&D team and the quality of R&D activities. In 2015, China had a total of 1.6 million researchers, up 6.2% from 2014, with researchers as a percentage of all R&D personnel standing at 43.1%.

The number of R&D personnel (or researchers) per 10 000 employees is an important indicator of a country's intensity of R&D human resources and reflects its overall level of HRST. The 12th Five-Year Plan period saw a steady increase of R&D personnel per 10 000 employees, rising to 48.5 person-years per 10 000 employees in 2015 from 33.6 person-years per 10 000 employees in 2010, representing an increase of 44.3% or an average annual growth of 7.7%.

In 2015, China had 20.9 person-years of researchers per 10 000 employees, representing an increase of 5.0 person-years per 10 000 employees or 31.4% from 2010 and an average annual growth of 5.6%, and down 2.1 percentage points from the number of R&D personnel per 10 000 employees for the same period.

2 R&D personnel by sector of performance

In China, R&D is carried out by three sectors of performance—enterprises, government research institutes and higher education institutions. Among the three sectors of performance of R&D activity, enterprises remained the principal actors of R&D in China. In 2015, enterprise R&D personnel as a percentage of all R&D personnel was slightly down from a year earlier to 77.4%, versus 10.2% for government research institute R&D personnel, 9.4% for higher education institutions R&D personnel and 2.9% for R&D personnel of other public institutions (Table 1-1). The number of R&D personnel from research institutes and higher education institutions has been increasing year by year. In 2015, as a percentage of the national R&D personnel, the number posted an increase of 0.1 percentage point and 0.4 percentage point respectively from the previous year, reversing their downward trend for many years.

Table 1-1 R&D personnel by sector of performance (2005–2015)

Year	Total		Government research institutes		Higher education institutions		Enterprises		Others	
	10 000 person-years	%	10 000 person-years	%	10 000 person-years	%	10 000 person-years	%	10 000 person-years	%
2005	136.5	100	21.5	15.8	22.7	16.6	88.3	64.7	3.9	2.9
2006	150.2	100	23.2	15.4	24.3	16.2	98.8	65.8	4.0	2.7
2007	173.6	100	25.6	14.7	25.4	14.6	118.7	68.4	4.0	2.3
2008	196.5	100	26.0	13.2	26.7	13.6	139.6	71.0	4.3	2.2
2009	229.1	100	27.7	12.1	27.5	12.0	164.8	71.9	9.1	4.0
2010	255.4	100	29.3	11.5	29.0	11.4	187.4	73.4	9.7	3.8
2011	288.3	100	31.6	11.0	29.9	10.4	216.9	75.2	9.9	3.4
2012	324.7	100	34.4	10.6	31.4	9.7	248.6	76.6	10.3	3.2
2013	353.3	100	36.4	10.3	32.5	9.2	274.1	77.6	10.4	2.9
2014	371.1	100	37.4	10.1	33.5	9.0	289.6	78.0	10.6	2.8
2015	375.9	100	38.4	10.2	35.5	9.4	291.1	77.4	11.0	2.9

* Others refer to government-affiliated public institutions that are engaged in S&T activities yet cannot be defined as research institutes.

See Annexed Table 1-1

China Science and Technology Indicators 2016

3 R&D personnel by type of activity

R&D activities can be divided into three types according to the nature of such activities, namely, basic research, applied research and experimental development. In 2015, of all the R&D personnel in China, 253 thousand person-years, or 6.7% of the total, were engaged in basic research, versus 430 thousand person-years in applied research, or 11.5%, and 3.1 million person-years in experimental development, or 81.8% (Figure 1-3).

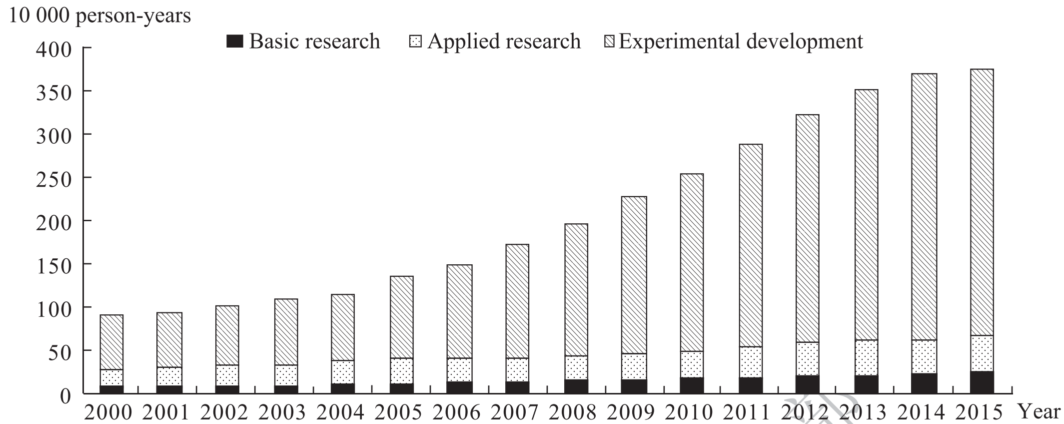

Figure 1-3 R&D personnel by type of activity (2000–2015)

China Science and Technology Indicators 2016

China's scientific research personnel (i.e. the sum of basic research personnel and applied research personnel) rose from 412 thousand in 2005 to 684 thousand in 2015, representing an average annual growth of 5.2%; experimental development personnel increased by 2.1 million person-years, representing an average annual growth of 12.4%. Basic research personnel and applied research personnel in terms of their percentage in the total R&D personnel had maintained an overall downward trend for years, but the trend reversed in 2015 with the percentage rising from 6.3% in 2014 to 6.7% in 2015 for basic research personnel and from 11.0% to 11.5% for applied research personnel. Experimental development personnel in percentage terms, however, experienced the first decrease in many years by falling 0.9 percentage point from a year earlier.

4 International comparison of R&D personnel

The international comparison of the total volume of R&D personnel and the intensity of personnel input (the number of R&D personnel per 10 000 employees) shows China's gap with world leaders in the input of R&D personnel as well as its international standing in R&D capability.

4.1 Total volume and input intensity of R&D personnel

In 2015, the total volume of R&D personnel in China reached 3.8 million person-years, and the number of researchers totaled 1.6 million person-years, both of which ranked the first in the world (Table 1-2).

Measured by the indicator of input intensity, despite the rapid growth in recent years, China is still lagging behind in the world. In 2015, the R&D personnel in FTE per 10 000 employees stood at 48.5 person-years in China, lower than all the developed countries and Russia. In terms of researchers in FTE per 10 000 employees, China also ranked lower than most of the countries with over 100 000 person-years of R&D personnel. The number of researchers per 10 000 employees in countries like Korea, Japan, France, the UK and the US remained at least four times as large as that of China (Table 1-2).

Table 1-2 Countries with over 100 000 person-years of R&D personnel

Country	Year	R&D personnel (10 000 person-years)	R&D personnel per 10 000 employees (Person-year/10 000 persons)	R&D researchers (10 000 person-years)	R&D researchers per 10 000 employees (Person-year/10 000 persons)
China	2015	375.9	48.5	161.9	20.9
Australia	2010	14.8	132.2	10.0	89.8
Brazil	2010	26.7	21.7	13.9	11.3
Canada	2013	22.7	125.6	15.9	88.2
France	2014	41.7	152.3	26.7	97.6
Germany	2015	61.4	142.5	35.8	83.0
Italy	2015	24.8	101.4	12.1	49.3
Japan	2015	87.5	133.6	66.2	101.1
Korea	2015	44.2	170.4	35.6	137.4
Netherlands	2015	12.8	146.0	7.7	87.6
Poland	2015	10.9	68.4	8.3	51.7
Russia	2015	83.4	115.3	44.9	62.1
Spain	2015	20.1	108.4	12.2	66.1
Turkey	2014	11.5	44.5	9.0	34.6
UK	2015	41.7	133.1	28.9	92.5
US	2014			135.2	91.0

See Annexed Table 1-2

China Science and Technology Indicators 2016

Between 2005 and 2015, China’s R&D personnel had an average annual growth of 10.7%, significantly higher than other countries. Countries that posted an average annual growth of R&D personnel of more than 5% in the same period — with the exception of Korea — were mostly countries with a relatively small scale of R&D activity such as Ireland, Portugal and Slovakia. Between 2005 and 2015, Korea's R&D personnel had an average annual growth of 7.5%, versus 6.5% for both Portugal and Slovakia and 5.8% for Ireland. Most of the developed countries with a larger scale of R&D activity experienced a slow or even negative growth in the number of R&D personnel during the same period. Between 2005 and 2015, for example, Germany's total R&D personnel had an average annual growth of 2.6%, Italy 3.5%, and the United Kingdom 2.5%. From 2015, Japan's total R&D personnel dropped by 2.4%, Russia by 9.4% and Finland by 12.4%, with their average annual growth of R&D personnel of −0.2%, −1.0% and −1.3%, respectively.

In recent years, the growth of China's total R&D personnel experienced a significant slowdown, registering a growth of only 6.4% between 2013 and 2015, which was even lower than that of many other countries. Between 2013 and 2015, the growth was 22% for Ireland, 19.7% for Greece, 16.5% for Poland, 14.7% for Belgium, 12.4% for Luxembourg, 10.8% for Norway, 10.4% for the United Kingdom, and 10.1% for Korea.

4.2 International comparison of R&D personnel by sector of performance

The distribution of R&D personnel by the sector of performance reflects the characteristics and differences of countries in their innovation systems. According to these characteristics and differences, countries can be roughly divided into three categories.

The first category includes countries with a fairly strong R&D capability in enterprises. China and Korea led the world in their enterprise R&D personnel as a percentage of their national R&D personnel with 77.4% (2015) and 73.2% (2015), respectively. Most OECD countries, such as Austria, Sweden, Japan, Canada, Germany, France and Finland, had enterprise R&D personnel as a percentage of the national total at above 50.0% (Table 1-3).

Table 1-3 International comparison of the distribution of R&D personnel by sector of performance

Unit: %

Country	Year	Enterprises	Higher education institutions	Government research institutes	Others
China	2015	77.4	9.4	13.1	0.0
Korea	2015	73.2	16.5	8.6	1.7
Austria	2015	70.1	25.4	3.8	0.6
Sweden	2015	69.5	25.3	5.0	0.2
Japan	2015	67.7	23.8	6.9	1.6
Slovenia	2015	64.8	18.0	17.1	0.1
Netherlands	2015	62.4	26.1	11.5	0.0
Ireland	2015	62.1	34.6	3.2	0.0

Continued

Country	Year	Enterprises	Higher education institutions	Government research institutes	Others
Germany	2015	61.8	21.9	16.3	0.0
Denmark	2015	60.8	35.7	3.0	0.5
France	2014	59.5	26.8	11.9	1.8
Finland	2015	59.1	30.8	9.0	1.1
Canada	2013	58.4	33.0	8.0	0.6
Hungary	2015	57.1	20.9	22.0	0.0
Luxembourg	2015	55.9	20.5	23.6	0.0
Belgium	2015	55.7	35.3	8.5	0.4
Czech	2015	54.7	25.4	19.5	0.4
Iceland	2015	54.5	36.1	9.3	0.0
Turkey	2014	53.7	35.7	10.6	0.0
Italy	2015	51.8	30.2	15.4	2.6
Norway	2015	51.6	32.2	16.2	0.0
Russia	2015	51.1	14.6	34.1	0.2
Singapore	2014	50.9	40.9	8.2	0.0
Spain	2015	43.5	36.5	19.8	0.2
Portugal	2015	37.4	57.3	4.0	1.3
Greece	2015	16.1	56.4	26.6	0.8
Slovakia	2015	25.0	50.1	24.6	0.2
Australia	2010	38.2	46.9	12.4	2.5
South Africa	2013	31.3	46.8	19.5	2.3
New Zealand	2013	40.2	46.6	13.3	0.0
Poland	2015	38.5	41.2	20.2	0.1
Mexico	2013	32.5	35.7	28.7	3.1
Argentina	2014	13.0	36.3	49.1	1.7
Romania	2015	32.3	28.8	38.6	0.4

See Annexed Table 1-3

China Science and Technology Indicators 2016

Category 2 countries are those with relatively strong R&D capability in higher education institutions. Countries falling within this category included Portugal, Greece, Slovakia, Australia, South Africa, New Zealand, Poland and Singapore. Of these countries, Slovakia, Greece and Portugal all had more than 50% of their R&D personnel coming from higher education institutions. For most of the other countries, the proportion of R&D personnel from higher education institutions also exceeded 40%.

Category 3 countries are those with relatively strong R&D capability in government research institutes. Argentina and Romania both belonged to this category. The R&D personnel from research institutes accounted for as much as 49% of the total in Argentina.

Section 3 Cultivation of Human Resources in Science and Technology

The cultivation of HRST depends mainly on higher education. Graduates of higher education institutions in the S&T field are the primary source of HRST in China. This section analyzes China's progress in the development of higher education and the cultivation of HRST in recent years, with a focus on the education of undergraduate and postgraduate students and overseas Chinese students in the S&T field.

1 Higher education development trend

China's higher education began a large-scale expansion at the beginning of the 20th century, which gradually slowed down with stable development from 2004 and then has gradually recovered since 2013 in the enrollment of PhD, master's, bachelor's and associate degree students. The 12th Five-Year Plan period saw an average enrollment growth of 3.2% for PhD students, 3.6% for master's students, 2.2% for bachelor's students and 1.8% for associate degree students. The average annual enrollment growth of associate degree students has reached 4.6% since 2013, recovering the level during the period between 2005 and 2010 (4.6%); that of master's students and bachelor's students has reached 2.7% and 1.0%, respectively, still significantly below their level during the 2005–2010 period (8.9% and 6.9%, respectively); and that of PhD students fell 0.3 percentage point (2.8%) from their level during the 2005–2010 period (Figure 1-4).

During the 12th Five-Year Plan period, China's bachelor's and associate degree graduates saw an average annual growth of 4.6% and master's and PhD graduates 7.5%, both significantly down from that for the 11th Five-Year Plan period (8.2% and 15.1%). In 2015, China had a total of 11.7 million bachelor's and associate degree graduates (from programs at regular higher education institutions, adult colleges, online education and self-taught higher education), including 5.75 million bachelor's graduates, 6.0 million associate degree graduates; 552 thousand postgraduates, including 54 thousand doctorates and 498 thousand masters. Higher education provides China with more than 10 million high-caliber workers annually.

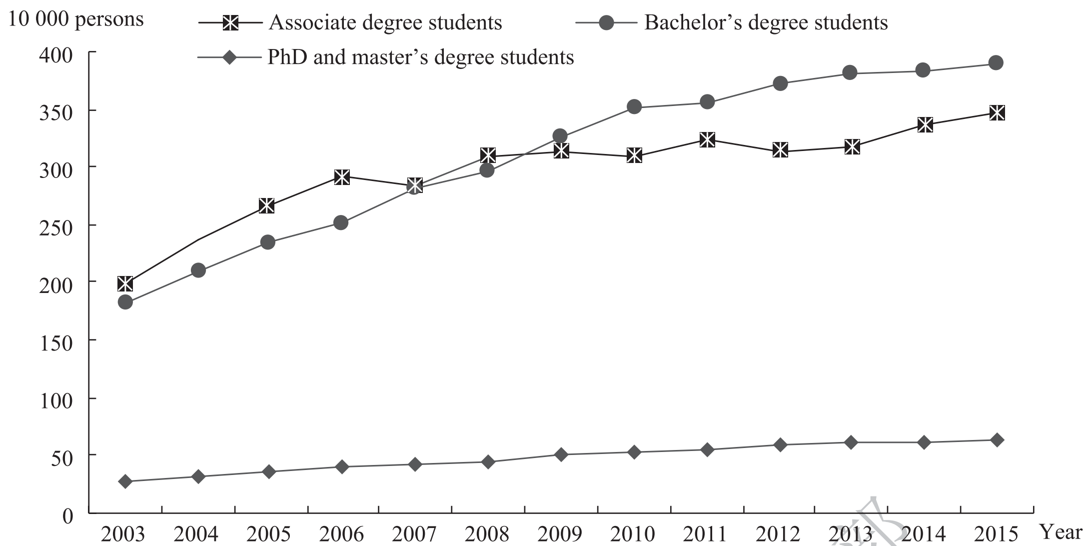

Figure 1-4 Trend of higher education enrollment (2003–2015)

China Science and Technology Indicators 2016

2 Undergraduates in the field of natural science and engineering technologies

Undergraduates in the field of natural science and engineering technologies are the main source of scientists and engineers. Traditionally, cultivating students in the field of natural science and engineering technologies has been a focus of China's higher education. The proportion of undergraduates in the field of natural science and engineering technologies normally exceeds 50%. In 2000, the figure was 59.6%, which was higher than that of western developed countries. Since 2000, as the market demand for university graduates becomes increasingly diversified, the proportion of undergraduates in the field of natural science and engineering technologies has gradually dropped, reaching 50.2% in 2004, which was more or less the same as graduates majoring in humanities and social sciences. In 2007, it hit a record low of 43.6%. After that, the proportion of students enrolled in the field of natural science and engineering technologies returned to the growth trajectory and reached 48.6% in 2015 (Figure 1-5).

Graduates in natural science and engineering technologies are an important source of R&D personnel for China's economic development. In 2015, China's bachelor's graduates in natural science and engineering technologies reached 2.4 million, up 6.3% over the previous year, slightly higher than the increase of all bachelor's graduates, which was 6.1%.

China's bachelor's graduates in natural science and engineering technologies began quickly increasing after 1998 when higher education enrollment began expansion, and the gap in growth speed has widened among different disciplines (Figure 1-6). Engineering graduates, which have always represented the largest group of graduates, rose to 1.6 million in 2015; medical graduates saw the fastest growth by rising 10.3% from the previous year (429 thousand) to 473 thousand in 2015; science graduates remained stable at the level of 2013 with 283 thousand; and graduates in agricultural science reached the historical high of 82 thousand.

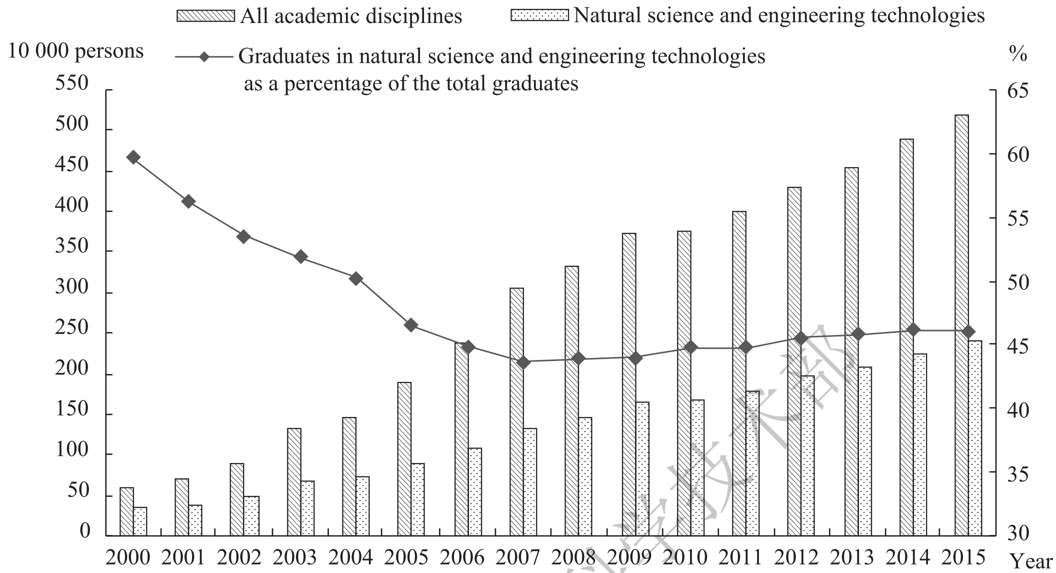

Figure 1-5 Number and share of China's bachelor's graduates in natural science and engineering technologies (2000–2015)

China Science and Technology Indicators 2016

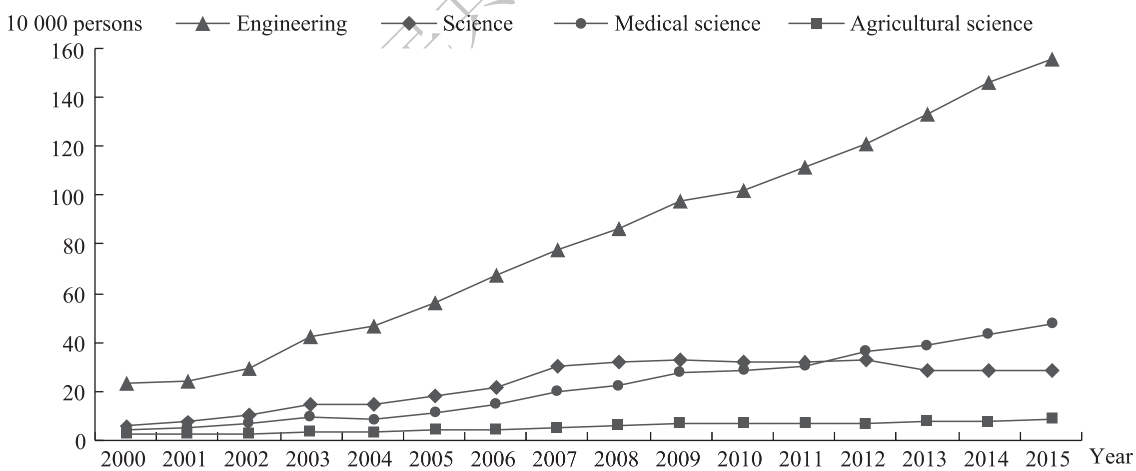

Figure 1-6 Number of Chinese undergraduates in natural science and engineering technologies by discipline (2000–2015)

China Science and Technology Indicators 2016

Between 2005 and 2010, China's bachelor's graduates in engineering increased by an average of 12.8% annually, medical graduates 21.4%, science graduates 11.9% and agricultural graduates 12.1%. Between 2011 and 2015, the average annual growth slowed down to 8.8% for bachelor's graduates in engineering, 12.2% for medical graduates, −2.9% for science graduates, and 6.1% for agricultural graduates. In 2015, China's graduates in natural science and engineering technologies with a bachelor's degree remained dominated by engineering graduates, who accounted for 65.1%, followed by science graduates with 11.8%, medical graduates with 19.7%, and agricultural graduates with 3.4%.

3 Postgraduates in the field of natural science and engineering technologies

Postgraduates in China are mainly produced by higher education institutions and research institutes, with the former accounting for more than 90% of the total. In 2015, the number of postgraduates in the field of natural science and engineering technologies reached 327 thousand, up by 3.9% year on year, accounting for 59.2% of all the postgraduates of the year. Among all the postgraduates in the field of natural science and engineering technologies, 49 thousand or 15.0% of the total majored in science; 195 thousand or 59.7% of the total majored in engineering, while those majoring in agricultural science and medical science totaled 20 thousand and 63 thousand respectively, accounting for 6.2% and 19.2% of the total. The number of PhDs and masters were 54 thousand and 498 thousand respectively, accounting for 9.8% and 90.2% of the total.

In 2015, China enrolled 390 thousand postgraduate students in natural science and engineering technologies, accounting for 60.5% of the total. Compared to 2010, postgraduate students in science saw the slowest growth at 8.9%, versus 47.8% for engineering, 61.7% for agricultural science, and 88.0% for medical science. The postgraduate students enrolled in natural science and engineering technologies were 58.2% represented by engineering, 16.3% by science and 6.2% by agricultural science, down 0.1, 0.3 and 0.1 percentage point, respectively, from a year earlier; with medical science registering an increase of 0.4 percentage point to reach 19.3% (Table 1-4). The significant increase in the number of agricultural and medical students enrolled during the 12th Five-Year Plan period indicated increasing importance and support given to disciplines relating to people's livelihood.

Table 1-4 Enrollment of postgraduates in natural science and engineering technologies by discipline (2005–2015)

Unit: 10 000 persons

Year	Total enrollment of postgraduate students	Natural science and engineering technologies	Science	Engineering	Agricultural science	Medical science
2005	36.48	22.87	4.52	13.13	1.39	3.83
2006	39.79	24.96	4.77	14.48	1.48	4.22
2007	41.86	25.76	5.14	14.63	1.57	4.42
2008	44.64	27.17	5.55	15.55	1.33	4.74
2009	51.10	27.75	5.93	15.87	1.48	4.47
2010	53.82	26.70	5.84	15.37	1.49	4.01
2011	56.02	33.37	5.77	19.51	2.01	6.08
2012	58.97	35.33	5.81	20.92	2.11	6.49
2013	61.14	36.75	6.02	21.73	2.34	6.65
2014	62.13	37.34	6.20	21.75	2.34	7.05
2015	64.51	39.02	6.36	22.72	2.41	7.53

See Annexed Table 1-4

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4 Overseas students

Returned overseas graduates are also an important source of HRST in China. Against the background of China's rapid economic growth and the continuous increase in residents' income, Chinese students going abroad to study have been growing at a high speed since 2005. In 2015, a total of 524 thousand Chinese students went abroad to study, representing an increase of 405 thousand from 2005, or an average annual growth of 16%.

China's strong economy and steadily improving innovation and entrepreneurial environment have attracted an increasing number of overseas graduates to return home to start business or pursue their careers. In 2015, Chinese students returning home after studying abroad reached 409 thousand, up 43.6% year on year, being 11.7 times the number in 2005, representing an average annual growth of 27.9%. In 2013, 85.4% of students going abroad to study returned home after their studies. However, such percentage is dropping in recent years to 78.1% in 2015 (Figure 1-7).

Chinese overseas students have mainly chosen western developed countries as their overseas study destinations. Chinese students studying at universities in countries such as the United States, the United Kingdom and Japan have increased quickly in recent years and become the largest foreign student group in many western developed countries.

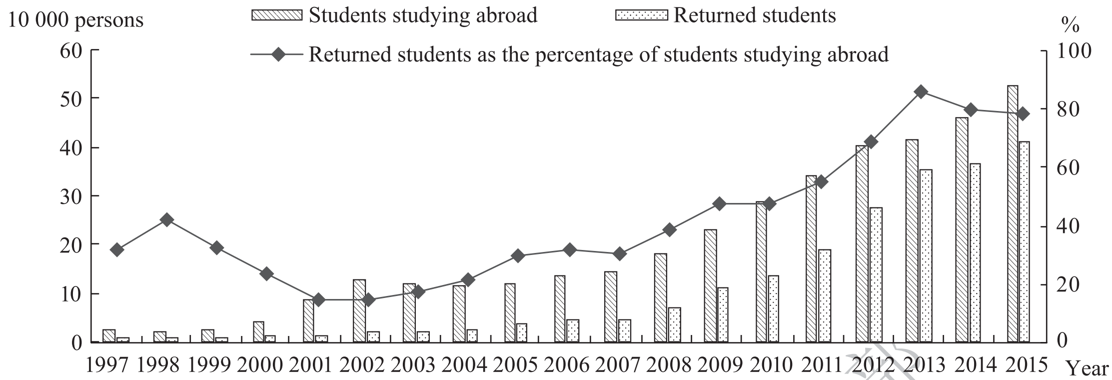

Figure 1-7 Chinese students studying abroad and returned students (1997–2015)

See Annexed Table 1-5

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There has been a substantial increase in the number of Chinese students pursuing associate degree and bachelor's programs in the United States. By November 2014, Chinese students studying at universities in the United States (including undergraduate and graduate students) reached 235 thousand, up 10.0% year on year. Since 2009, China has always been the No. 1 source of foreign students at universities in the United States. Chinese students as a percentage of all foreign students studying at US universities reached 31.4%, on par with a year earlier (31.6%). Chinese students pursuing associate degree and bachelor's programs in the United States reached 123 thousand, up 14.2% year on year; those pursuing associate degree and bachelor's programs in the United States as a percentage of all Chinese students in the country has been steadily increasing, reaching 52.1% in 2014, exceeding the number of Chinese students pursuing PhD and master's programs in the United States. In 2014, Chinese students pursuing master's and PhD programs in the United States reached 113 thousand, representing an increase of 5.8% over the previous year. By discipline, Chinese postgraduate students in the United States are mainly concentrated in the science and engineering field, accounting for 60.9% of the total in 2014. In fields other than science and engineering, Chinese undergraduate students outnumbered Chinese postgraduate students in the United States, accounting for 62.0% of the total. Chinese students represented the largest foreign student group in the United States for both undergraduate education and postgraduate education in 2014 (Table 1-5).

Figure 1-5　Top three countries by number of students in the US (2014)

Unit: Person

Country	All subjects			Science and engineering			Non-science and engineering		
	Undergraduate students	Postgraduate students	Total	Undergraduate students	Postgraduate students	Total	Undergraduate students	Postgraduate students	Total
China	122510	112730	235240	46540	68610	115150	75790	44130	119920
India	13520	88400	101920	7330	72690	80020	6190	15710	21900
Korea	37590	18770	56360	11380	6900	18280	26210	11870	38080

Source: National Science Board, *Science and Engineering Indicators 2014*.

China Science and Technology Indicators 2016

Japan was the second largest destination of Chinese students studying abroad. In 2014, Chinese students studying in Japan reached 68 174, representing a decrease of 8021 from 2012, and accounting for 57.3% of all foreign students studying at Japanese universities, down 5.2 percentage points from 2012. They included 44 257 in bachelor's programs and 23 917 in postgraduate programs. Chinese students in science and engineering accounted for 60.5% of all Chinese students studying at Japanese universities, versus 53.9% of Chinese students in postgraduate programs in science and engineering, which was slightly down from 2012. The number of Chinese students studying in Japan showed an overall downward trend, except in 2012 when it registered a slight increase, between 2010 and 2014, with the number of bachelor's students falling by 5581 and the number of postgraduate students remaining stable (Table 1-6).

Table 1-6　Number of Chinese students studying at Japanese universities (2010, 2012, 2014)

Unit: Person

Year	Type	All subjects	Science and engineering	Non-science and engineering
2010	Undergraduate students	49838	31862	17976
	Postgraduate students	23617	13061	10556
	Total	73455	44923	28532
2012	Undergraduate students	50976	33189	17787
	Postgraduate students	25219	13987	11232
	Total	76195	47176	29019
2014	Undergraduate students	44257	28337	15920
	Postgraduate students	23917	12901	11016
	Total	68174	41238	26936

Source: National Science Board, *Science and Engineering Indicators 2014.*

China Science and Technology Indicators 2016

The recent years have seen Chinese students studying science and engineering at the United Kingdom universities steadily increase. Chinese students pursuing associate degree and bachelor's programs in science and engineering in the United Kingdom increased from 7700 in 2007 to 12 180 in 2014, representing an average annual growth of 6.8%; those pursuing master's and PhD programs increased from 9850 in 2007 to 15 340 in 2014, representing an average annual growth of 6.5%. Chinese students pursuing master's and PhD programs in the United Kingdom slightly outnumbered those pursuing associate degree and bachelor's programs (Table 1-7).

Table 1-7 Number of Chinese students studying science and engineering at the UK universities (2007, 2009, 2011, 2012, 2014)

Unit: Person

Year	Total	Undergraduate students	Postgraduate students
2007	17550	7700	9850
2009	16930	7990	8940
2011	21620	10260	11360
2012	24545	11090	13455
2014	27520	12180	15340

Source: National Science Board, *Science and Engineering Indicators 2014*.

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Chapter 2 Research and Development Expenditure

Research and development expenditure, or R&D expenditure, refers to all the expenses actually spent on R&D activities. Based on domestic and international R&D statistics and economic statistics, this chapter includes an analysis of the total volume, the input intensity, the structural pattern and the trend of R&D expenditures in China, the evaluation of the international status of China's R&D activities and its gap with developed countries.

Section 1 Overview of R&D Expenditure

R&D expenditure refers to the total expenses spent on the R&D activities carried out inside a country, including the expenditures of R&D activities supported by foreign funds, but it does not include the expenditures of R&D activities supported by domestic funds in foreign countries. R&D expenditure is an important indicator for measuring the scale of R&D activities and evaluating the technological strength and the innovation capability of a country.

1 Total R&D expenditure

As the Chinese economy shifts gear from the previous high speed to a medium-to-high speed growth, the rapid rise in R&D expenditure has given a strong boost to innovation activity in China. In 2015, China's R&D expenditure reached 1.42 trillion yuan, representing an increase of 9.3% from the previous year at constant price (the same below) (Figure 2-1).

Between 2001 and 2015, China's R&D expenditure posed an average annual growth of 16%, versus the average annual GDP growth of approximately 9.7%. In other words, R&D expenditure growth was 1.6 times the GDP growth during the period.

2 R&D intensity

R&D intensity, defined as R&D expenditure as a percentage of GDP, is an important indicator of a country's R&D input as well as its economic growth pattern. In 2015, China's R&D intensity maintained more than 2% and reached an all-time high of 2.06% (Figure 2-2).

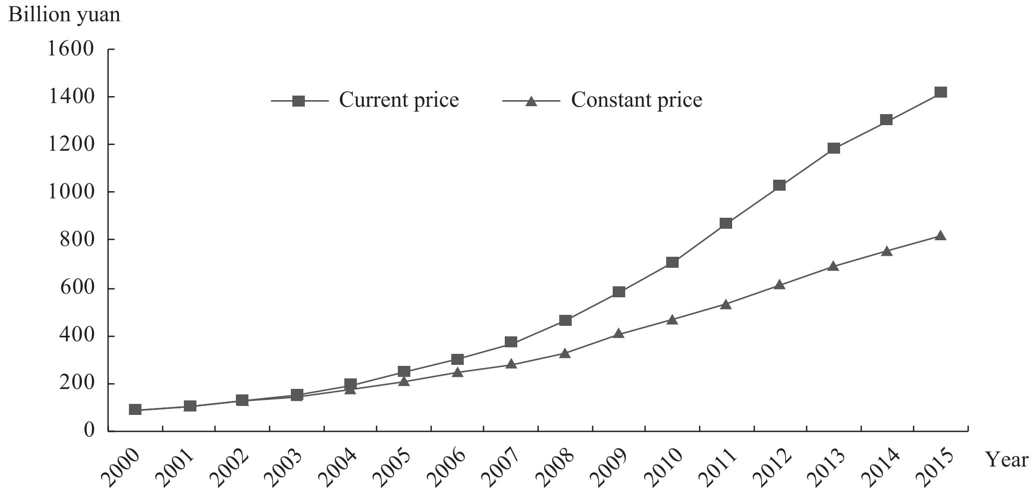

Figure 2-1 Trend of R&D expenditure in China (2000–2015)

Note: Constant price calculated based on GDP deflator.

See Annexed Table 2-1

China Science and Technology Indicators 2016

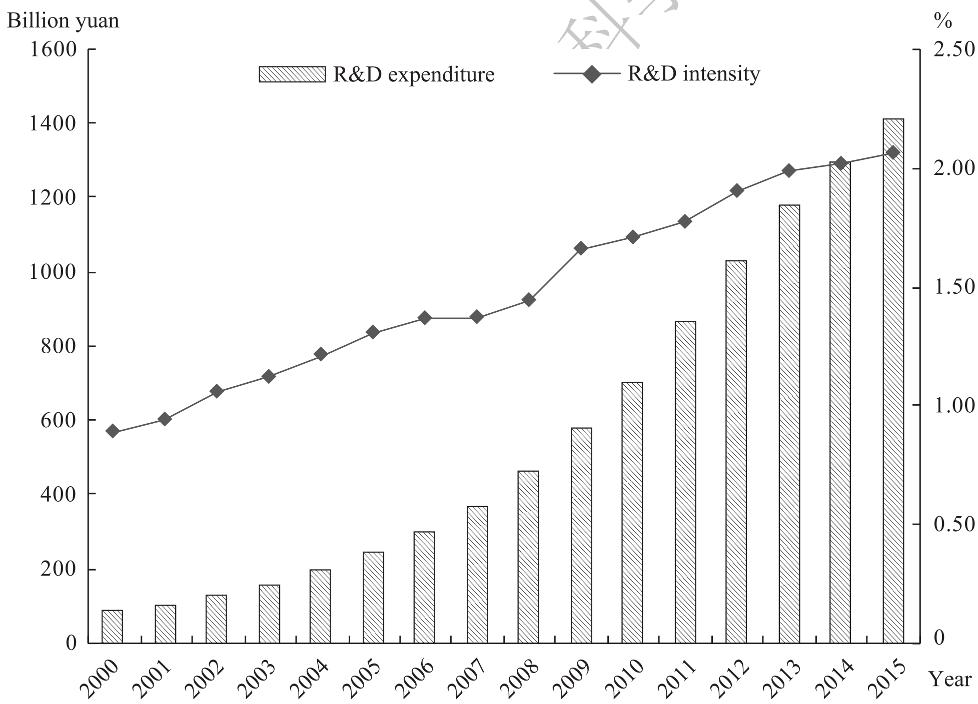

Figure 2-2 China's R&D expenditure and R&D Intensity (2000–2015)

See Annexed Table 2-1

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3 International comparison of R&D expenditure

According to OECD statistics of 38 countries and statistics of Brazil and India, the global R&D expenditure in 2015 reached approximately USD 1.4 trillion, with the top ten countries being the United States, China, Japan, Germany, Korea, France, the United Kingdom, Australia, Brazil and Canada. Among them, the top three countries — the United States, China and Japan — all posted more than USD 100 billion and their combined R&D expenditure accounted for 60.1% of the global total.

In 2015, the United States' R&D expenditure was USD 502.9 billion, accounting for 34.6% of the global total, ranking the first. China's R&D expenditure was USD 227.5 billion (converted according to the average exchange rate in 2015, the same below) and accounted for 15.6% of the global total. Japan ranked the third globally with USD 144 billion (Figure 2-3).

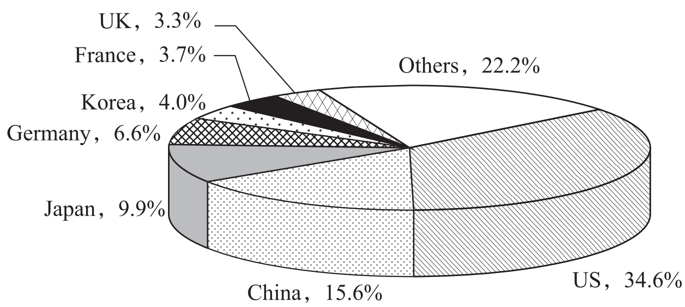

Figure 2-3 R&D expenditure of 40 countries (2015)

Source: OECD, *Main Science and Technology Indicators 2016*; Ministry of Science, Technology, Innovation and Communication, Brazil; Department of Science and Technology, India.

See Annexed Table 2-5

China Science and Technology Indicators 2016

Among the top ten spenders on R&D between 2013 and 2015, China recorded the highest growth with an average growth of 8.9%; Korea, the United Kingdom, the United States, Germany and Italy saw their R&D expenditure continue to expand at the average rate of 4.0%, 3.9%, 3.4%, 2.6% and 1.4%, respectively; and France and Japan experienced a slowdown in their R&D expenditure growth, which was under 1.0% for both countries.

For developed countries and emerging industrialized countries known for their innovation capability in the world, the input intensity of R&D expenditure is normally over 2.00%. According to the latest statistics, Israel, Korea, Japan, Sweden and Austria all have their input intensity of R&D expenditure over 3.00%, while in countries like the US, Germany and France, the figure is also above 2.00%. China's input intensity was 2.06% in 2015, which was higher than that of some developed countries such as the UK, Italy and Canada and the 28 EU states, but still lower than the average 2.40% of OECD states, and lagging far behind developed countries like the US, Japan and Germany (Figure 2-4).

Among the BRICS countries, China's input intensity of R&D expenditure was the highest, as compared to Brazil (1.67%), Russia (1.13%), India (0.80%) and South Africa (0.73%).

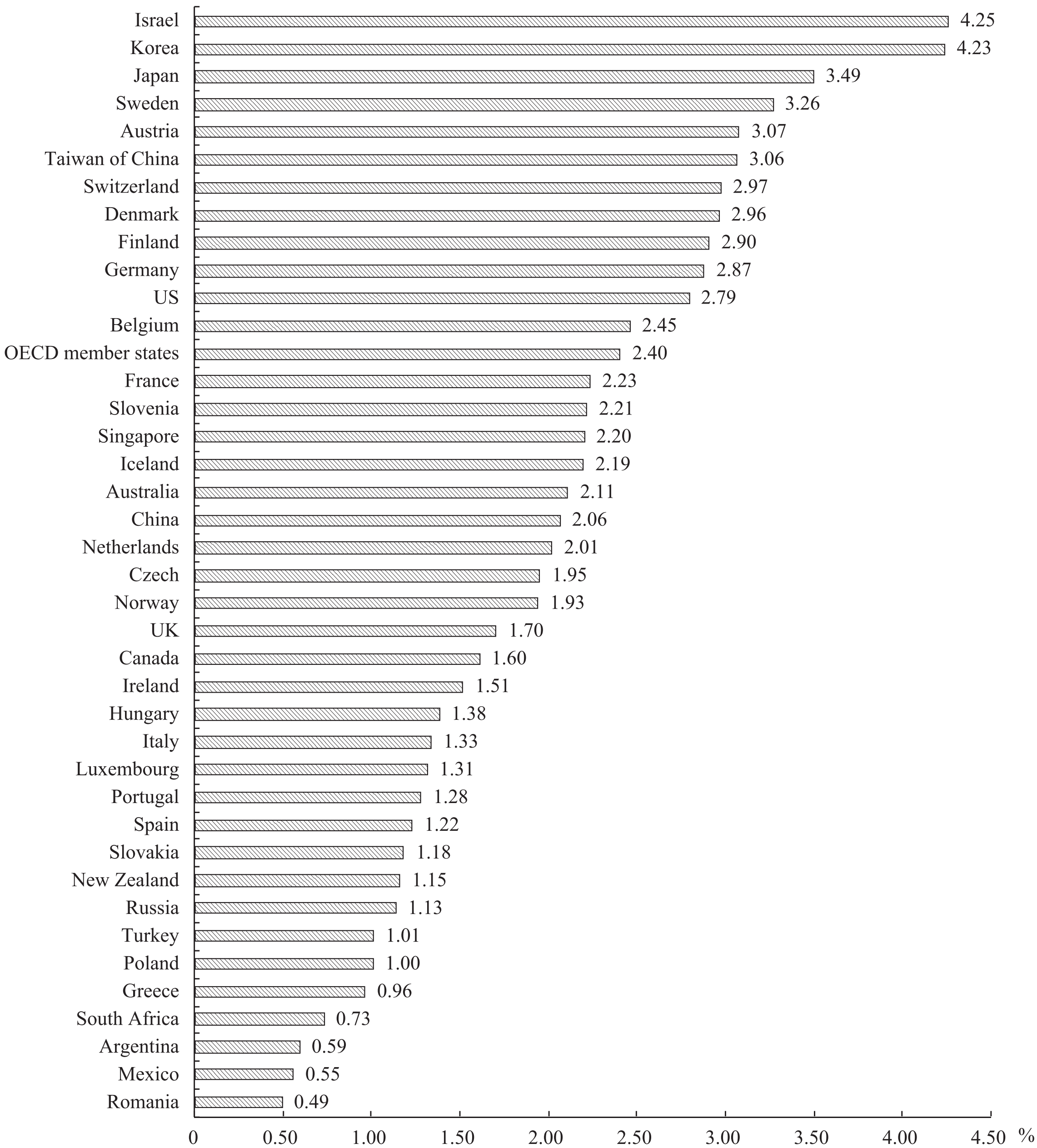

Figure 2-4 R&D intensity of selected countries/regions (2015)

Source: OECD, Main Science and Technology Indicators 2016-2.

See Annexed Table 2-4

Section 2 Structure of R&D Expenditure

The structure of R&D expenditure mainly concerns its distribution in various R&D activities like basic research, applied research and experimental development, distribution in various sectors of performance like enterprises, government research institutes, higher education institutions and other agencies, as well as the distribution and the trend of changes according to the purposes of spending such as labor costs, other routine expenses, instrument and equipment purchases, land and construction expenses.

1 Distribution of R&D expenditure by type of activity

In 2015, China spent 71.6 billion yuan on basic research, 152.9 billion yuan on applied research, and 1192.5 billion yuan on experimental development, accounting for 5.1%, 10.8% and 84.2% respectively of the total R&D expenditure (Figure 2-5).

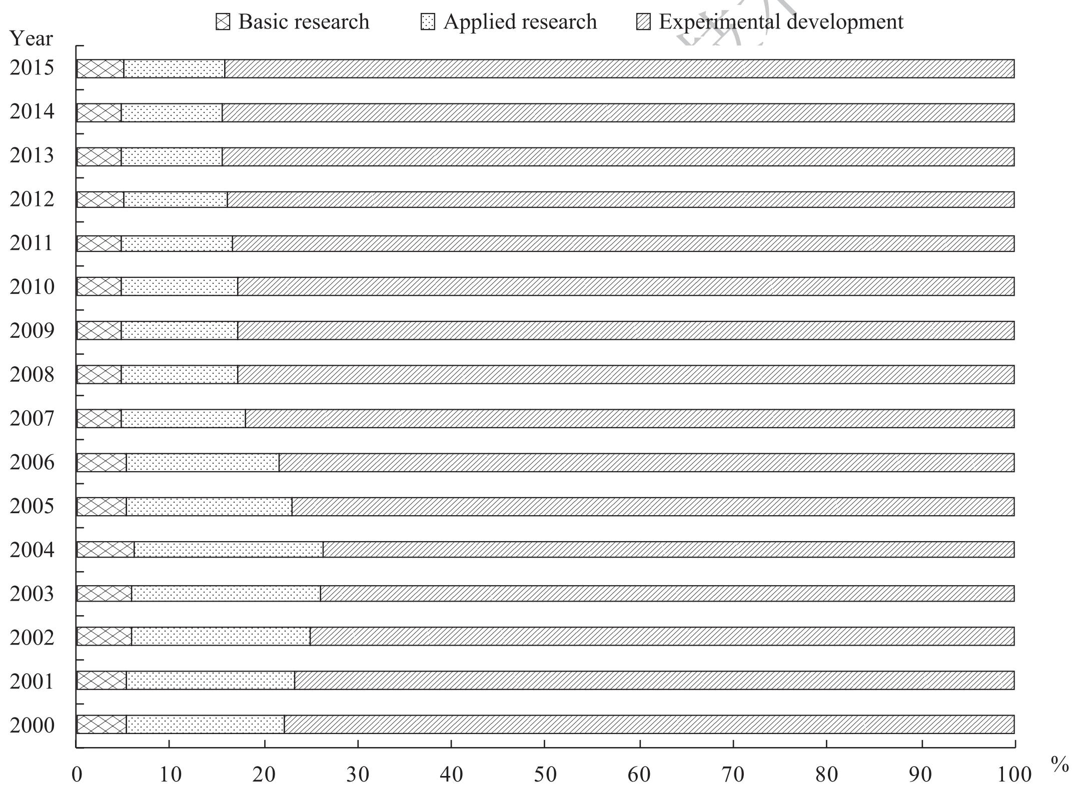

Figure 2-5 R&D expenditure by type of R&D activity (2000–2015)

See Annexed Table 2-2

China Science and Technology Indicators 2016

In 2015, the expenditure on basic research continued to expand and as a percentage of R&D expenditure reached 5.1%, surpassing 5.0% for the first time in recent years. The expenditure on applied research as a percentage of R&D expenditure increased slightly by 0.1 percentage point, and the expenditure on experimental development as a percentage of R&D expenditure continued to decrease and fell by 0.3 percentage point to 84.2%.

Compared to some countries, China's expenditure on scientific research (including basic research and applied research) as a percentage of its total R&D expenditure was rather low, at 15.8% in 2015, versus over 30% for the majority of developed countries and emerging industrialized countries and, strikingly, 70.0% for Italy (Figure 2-6). It can be seen that China should not only increase its R&D expenditure but also continuously optimize its R&D expenditure structure by, among others, increasing investment in basic research and applied research, in order to strengthen China's capacity of original innovation.

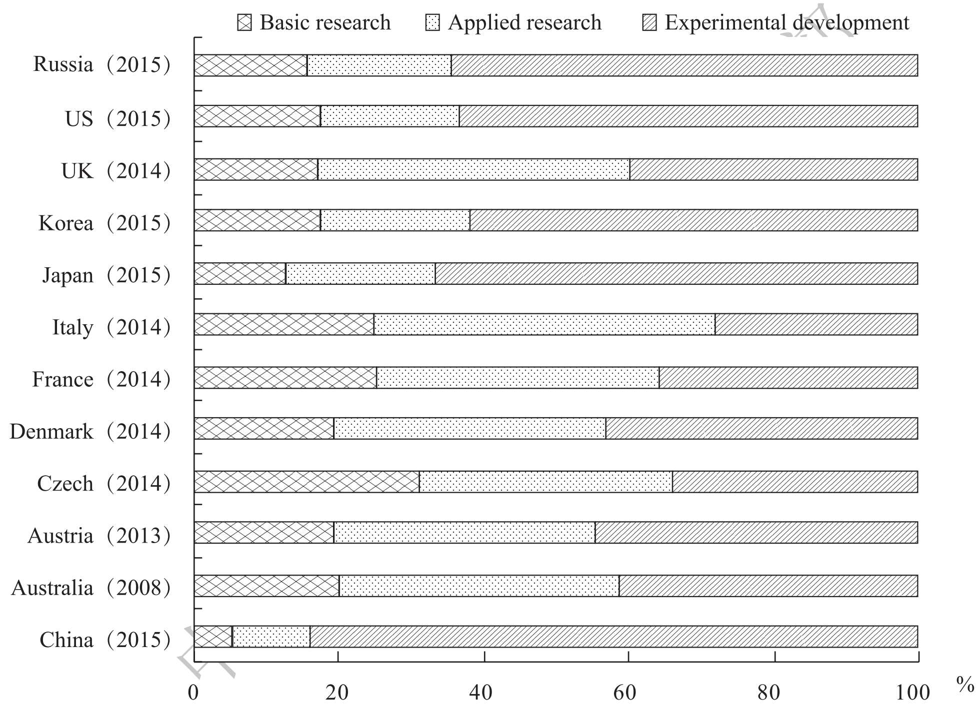

Figure 2-6 R&D expenditure of selected countries by type of R&D activity

See Annexed Table 2-6

China Science and Technology Indicators 2016

R&D expenditure allocation sheds light on the characteristics of the R&D activity of different sectors of performance. In 2015, government research institutes spent 13.8% of the R&D expenditure on basic research, 28.9% on applied research and 57.2% on experimental development. The ratio of higher education R&D expenditure on the three types of R&D activity was 4∶5∶1, with 90.9% of the expenditure being allocated to scientific research and

9.1% to experimental development. Enterprise R&D activity mainly focused on experimental development, which accounted for 96.9% of R&D expenditure, versus 3.0% for applied research and only 0.1% for basic research (Table 2-1).

Table 2-1 R&D expenditure by type of R&D activity and sector of performance (2015)

		Total		Basic research		Applied research		Experimental development	
		Billion yuan	%	Billion yuan	%	Billion yuan	%	Billion yuan	%
Nationwide	Billion yuan	1416.99	100%	71.61	100%	152.86	100%	1192.51	100%
	%	100%		5.1%		10.8%		84.2%	
Enterprises	Billion yuan	1088.13	76.8%	1.14	1.6%	32.93	21.5%	1054.07	88.4%
	%	100%		0.1%		3.0%		96.9%	
Government research institutes	Billion yuan	213.65	15.1%	29.53	41.2%	61.84	40.5%	122.28	10.3%
	%	100%		13.8%		28.9%		57.2%	
Higher education institutions	Billion yuan	99.86	7.0%	39.10	54.6%	51.63	33.8%	9.13	0.8%
	%	100%		39.2%		51.7%		9.1%	
Other organizations	Billion yuan	15.35	1.1%	1.84	2.6%	6.47	4.2%	7.04	0.6%
	%	100%		12.0%		42.1%		45.9%	

See Annexed Table 2-3

China Science and Technology Indicators 2016

As shown in the distribution of R&D activities in different sectors of performance, basic research is concentrated in higher education and research institutes. Since 2006, higher education institutions have been the largest spender on basic research, while the proportion of government research institutes has also been on the rise. In 2015, of all the expenditure on basic research, 54.6% came from higher education institutions, 41.2% from government research institutes, and only 1.6% from enterprises. In terms of the expenditure on applied research, government research institutes, higher education institutions and enterprises accounted for 40.5%, 33.8% and 21.5% of the total, respectively. Experimental development activities are mainly carried out by enterprises, which represent 88.4% of the expenditure on experimental development.

2 R&D expenditure by sector of performance

In 2015, enterprises, government research institutes and higher education institutions spent

1.09 trillion yuan, 213.7 billion yuan and 99.9 billion yuan, respectively, internally on R&D, accounting for 76.8%, 15.1% and 7.0%, respectively, of the national R&D expenditure (Table 2-1). At constant price, their R&D expenditure increased 8.1%, 10.8% and 11.1%, respectively, over the previous year (Table 2-2).

Table 2-2 China's R&D expenditure growth at constant price by sector of performance (2006–2015)

Unit: %

Organization	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Nationwide	17.9	14.6	15.4	25.9	13.8	13.7	15.8	12.6	9.0	8.8
Enterprises	22.7	16.5	17.0	25.8	14.1	17.3	16.5	13.3	9.9	8.1
Government research institutes	6.4	12.4	9.4	22.9	11.4	1.8	15.8	12.6	7.2	10.8
Higher education institutions	9.9	5.4	15.0	20.2	19.3	6.6	10.7	7.4	4.0	11.1
Other organizations	13.3	−2.7	18.8	172.1	−2.3	10.9	10.4	2.4	−2.2	17.3

Note: Calculated based on GDP deflator.

See Annexed Table 2-2

China Science and Technology Indicators 2016

Since 2000, there has been a notable change in the distribution pattern of R&D expenditure across various sectors of performance in China. In 2015, the share of enterprises in the total R&D expenditure reached 76.8%, 16.8 percentage points higher than that in 2000. The share of government research institutes, 15.1%, was down by about 13.7 percentage points compared to 2000. The share of higher education institutions, 7.0%, also dropped by 1.6 percentage points over that in 2000 (Figure 2-7).

In terms of international comparison, the share of enterprises in China's R&D expenditure, which reached 76.8% in 2015, has already surpassed that of most OECD countries. Meanwhile, the share of government research institutes is larger, while the share of higher education institutions is relatively small. The difference between countries in the relative proportion of the R&D expenditures of government research institutes and higher education institutions is mainly impacted by the way that their science and technology systems were established. Most developed countries in the west have a long history of developing higher education institutions and the tradition of promoting scientific research. Therefore, in these countries, the R&D expenditure of higher education institutions is often larger than that of government research institutes. On the other hand, China and Russia both developed robust research institutes under the planned economy. Although these research institutes have been reformed over the years, they still occupy an important position in the country's scientific research system. In 2015, the R&D expenditure of government research institutes and higher education institutions each accounted for 15.1% and 7.0% of China's R&D expenditure (Figure 2-8).

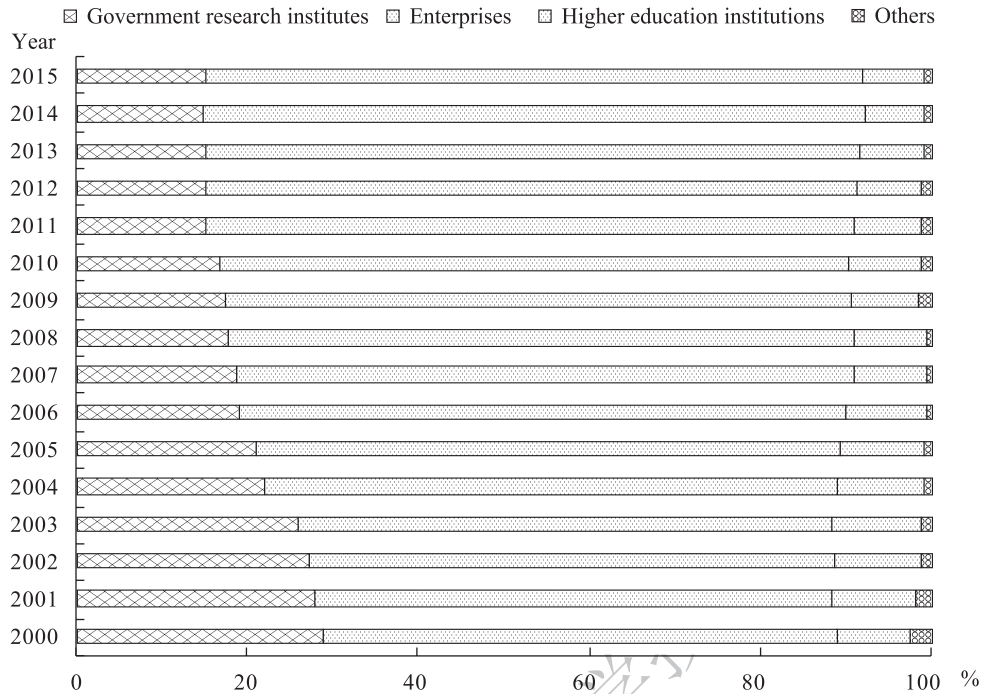

Figure 2-7 R&D expenditure by sector of performance (2000–2015)

China Science and Technology Indicators 2016

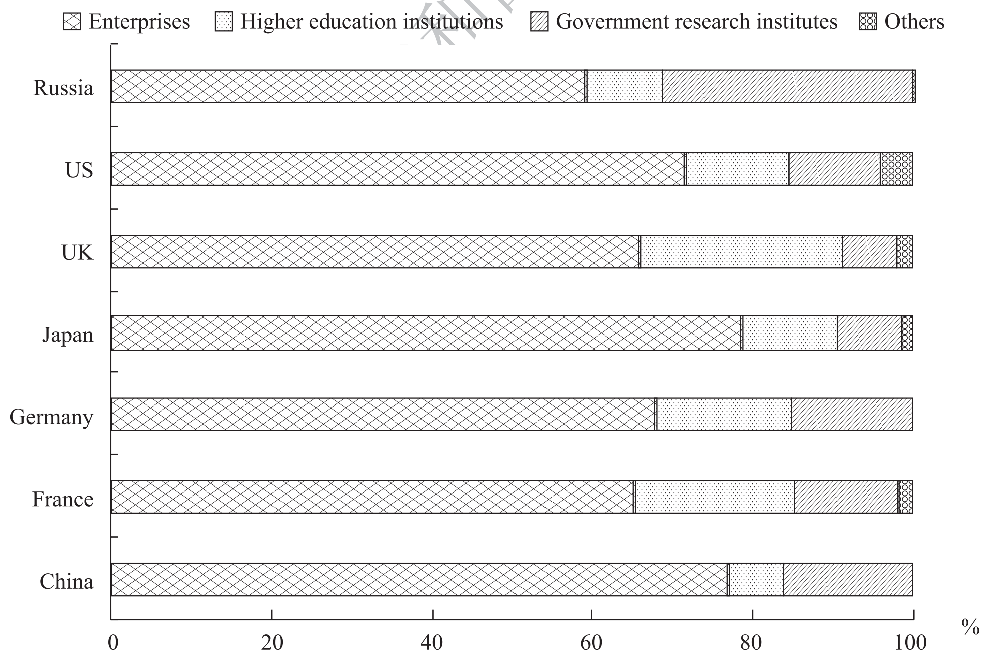

Figure 2-8 R&D expenditure of select countries by sector of performance (2015)

See Annexed Table 2-5

China Science and Technology Indicators 2016

3 R&D expenditure by type of expenditure

According to type of expenditure, R&D expenditure can be divided into such categories as labor costs, other current costs, instrument and equipment purchases, and other capital costs. Other current costs refer to all the actual purchase expenses required for carrying out R&D activities, including raw material fees, utility fees, processing and testing fees, equipment usage fees, travel allowances, house rental fees, etc. With the reform of China's compensation system and the establishment of various kinds of social insurance schemes, the statistics of labor costs in China now include not just remunerations paid in cash and in kind, but also entitlement programs such as medical services, housing and transportation allowances and insurance.

Of China's R&D expenditure in 2015, 28.1% were spent on labor costs, 58.7% on other current costs, 11.3% on instrument and equipment purchases, and 1.8% on other capital costs. In recent years, China's labor costs have steadily increased, with the per capita labor costs of R&D personnel rising from 63 000 yuan/person-year in 2009 to 106 000 yuan/person-year in 2015. Higher labor costs for the R&D personnel can help attract more HRST to take part in R&D activities (Table 2-3).

Table 2-3 R&D expenditure by type of expenditure (2009–2015)

Year	R&D expenditure (%)	Labor costs (%)	Other current costs (%)	Instrument and equipment purchase (%)	Other capital costs (%)	Per capita labor costs of R&D personnel (10 000 yuan/person-year)
2009	100	24.7	59.2	12.9	3.2	6.3
2010	100	23.6	60.3	13.2	2.9	6.5
2011	100	24.2	60.2	13.2	2.3	7.3
2012	100	25.7	59.8	12.1	2.3	8.1
2013	100	26.7	59.2	11.9	2.2	8.9
2014	100	27.2	58.9	11.7	2.1	9.6
2015	100	28.1	58.7	11.3	1.8	10.6

Source: National Statistics Bureau, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology (2010–2016).*

China Science and Technology Indicators 2016

Despite an increase in average labor costs of R&D personnel, China remains a country with lower R&D labor costs, with labor costs accounting for a lower percentage in the R&D expenditure. R&D labor costs as a percentage of R&D expenditure was approximately 40% in Japan and Korea and more than 60% in Spain and France (Figure 2-9).

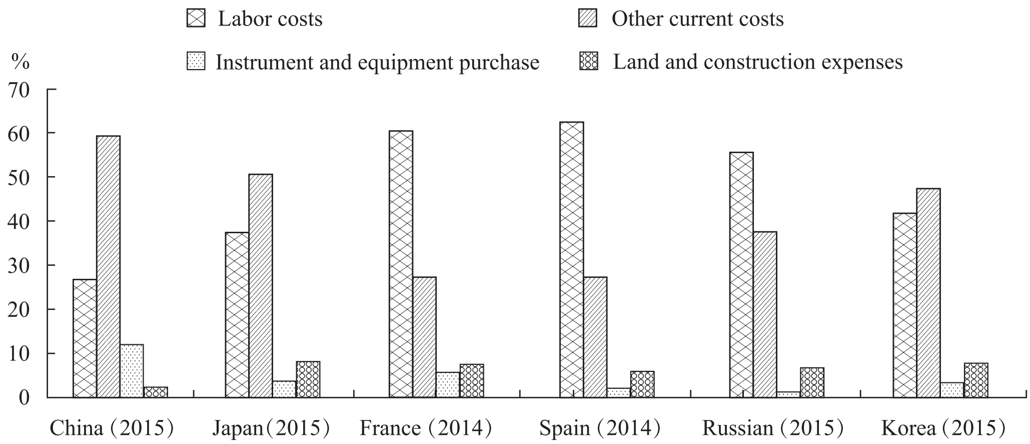

Figure 2-9 R&D labor costs as a percentage of R&D expenditure of selected countries

See Annexed Table 2-7

China Science and Technology Indicators 2016

Section 3 Source and Destination of R&D Funds

This section analyzes the source of China's R&D funds including government funding, enterprise funding, foreign funding and other funding, as well as the utilization of funds by enterprises, government research institutes, higher education institutions and other organizations.

1 Sources of R&D funds

China's R&D expenditure amounted to 1.42 trillion yuan in 2015, including 301.3 billion yuan, or 21.3%, from government, 1.06 trillion yuan, or 74.7%, from enterprises, 10.5 billion yuan, or 0.7%, from foreign entities, and 46.3 billion yuan, or 3.3%, from other sources (Figure 2-10). It can be seen that enterprises are a main source of R&D funds in China.

Following the implementation of the *Outline of the National Program for Medium- and Long-Term Scientific and Technological Development (2006–2020)*, the Chinese government has increased its spending on basic research, national defense and strategic high technology research, as well as research for public benefits. In 2015, the government spending on R&D amounted to 301.3 billion yuan, which was 1.8 times that in 2010. Despite the rapid increase in R&D expenditure financed by government, its share in the total R&D expenditure dropped from 33.4% in 2000 to 21.3% in 2015.

Internationally, the proportion of R&D expenditure financed by government is under 25.0% in Japan and Korea, while the figure in Germany and the UK is between 25.0% and 30.0%, around 35.0% in France and up to 69.5% in Russia (Figure 2-11).

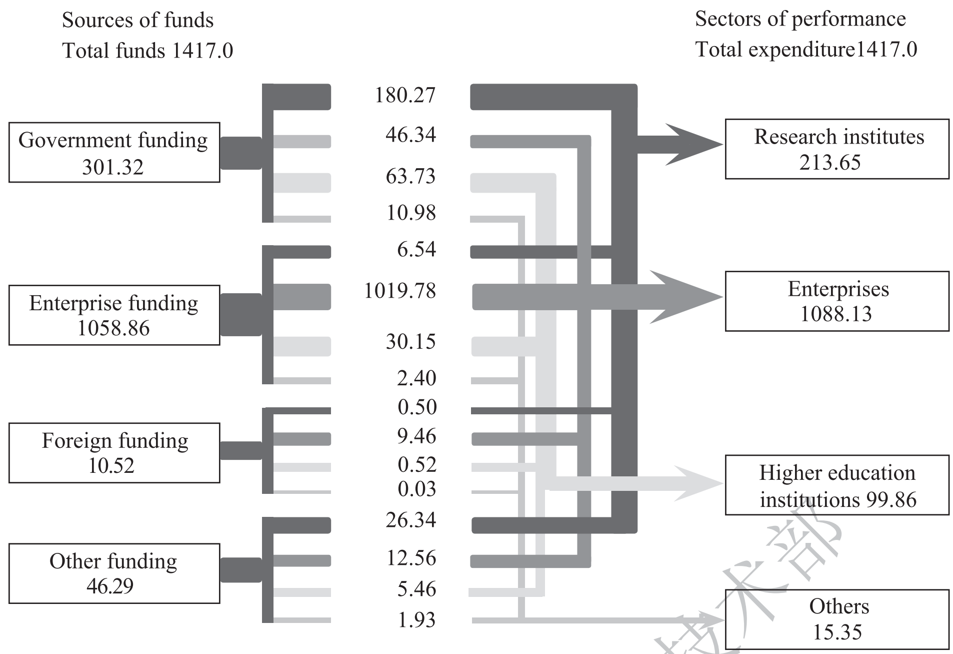

Figure 2-10 Sources and uses of R&D funding (2015) (Unit: Billion yuan)

See Annexed Table 2-3

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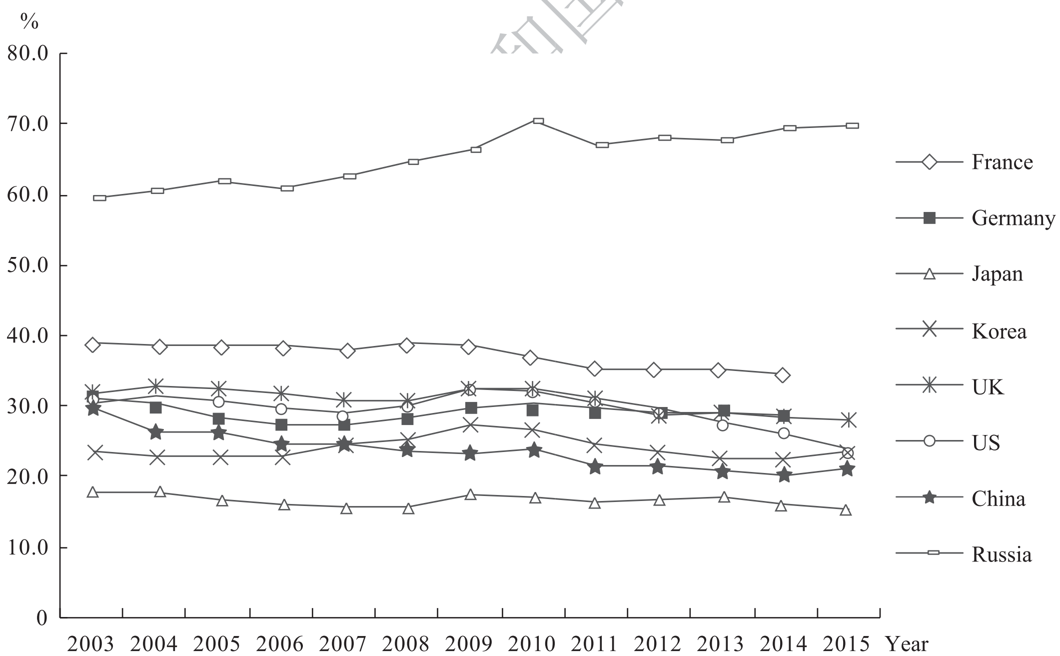

Figure 2-11 Government R&D funding as a percentage of national R&D expenditure of selected countries (2003–2015)

See Annexed Table 2-8

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2 Uses of R&D funding

China R&D expenditure is spent on enterprises, government research institutes, higher education institutions and other sectors. Government R&D funding is mainly spent on centrally administered research institutes and some research universities undertaking research projects of national S&T programs. In 2015, R&D funding financed by government reached 301.3 billion yuan. 59.8% was spent on government research institutes, 21.1% on higher education institutions, 15.4% on enterprises and 3.6% on other sectors.

Enterprises are a main investor as well as a main performer of R&D activity in China. Of the 1.06 trillion yuan of R&D funding financed by enterprises in 2015, 1.02 trillion yuan, or 96.3%, was used internally, with only less than 4.0% going to higher education institutions, government research institutes and other sectors. 89.9% of R&D funding financed by abroad went to enterprises, with the rest going to higher education institutions, government research institutes and other sectors.

Chapter 3 Output of Science and Technology Activity

The output of science and technology (S&T) activity refers to various kinds of outcome produced in the course of scientific research and technological innovation, mainly in the form of S&T papers and patents. S&T papers embody outcome of creating knowledge, and mainly serve as an indicator of the output of scientific research. Patents generally serve as an indicator of the output of technological innovation, and reflect the outcome of technology invention.Trade in technology refers to the transfer and dissemination of technological achievements through the market mechanism and is an important way for innovators to acquire technological know-how and upgrade their technological level quickly.

Section 1 S&T Papers

S&T papers, as an important means of S&T activities, reflect a country's S&T output from basic research and applied research, and indicate a country's S&T capabilities and international competitiveness. Based on statistics gathered from the SCI database, the section analyzes SCI papers, internationally co-authored papers and the output of S&T papers per research investment. When we compare China's output of SCI papers with that of other countries, we include papers contributed by researchers from Hong Kong and Macau. When we break down the number of SCI papers by academic disciplines, institutions and geographic regions, we only count SCI papers with the first authors coming from mainland China. When we analyze internationally co-authored papers, we count papers published by authors from mainland China.

1 SCI papers

Three retrieval systems, namely Science Citation Index (SCI), Engineering Index (EI), and Conference Proceedings Citation Index-Science (CPCI-S, formerly known as ISTP), have been adopted to collect statistics on international S&T papers for many years. SCI mainly reflects situations of basic scientific research. EI primarily presents scientific researches of engineering technology. CPCI-S is an important supplement to journals and relevant literature, recording a majority of proceedings of scientific conferences published all over the world. Because there is overlapping between SCI and EI papers, and the indicator of SCI papers is a general standard in international comparison, this section only analyzes SCI papers.

1.1 SCI papers and distribution

With the steady improvement in international competitiveness of China's scientific research in recent years, the number of China's SCI papers has been steadily increasing. In 2015, China published a total of 297 thousand SCI papers, representing an increase of 229 thousand papers from 2005 and an average annual growth of 15.8%. This put China in the second place globally in the number of SCI papers published for the 7th consecutive year, only behind the United States, with the other three countries in the top five being the United Kingdom, Germany and Japan. China's SCI papers as a percentage of the world total rose to 16.3% in 2015 from 5.3% in 2005 (Figure 3-1).

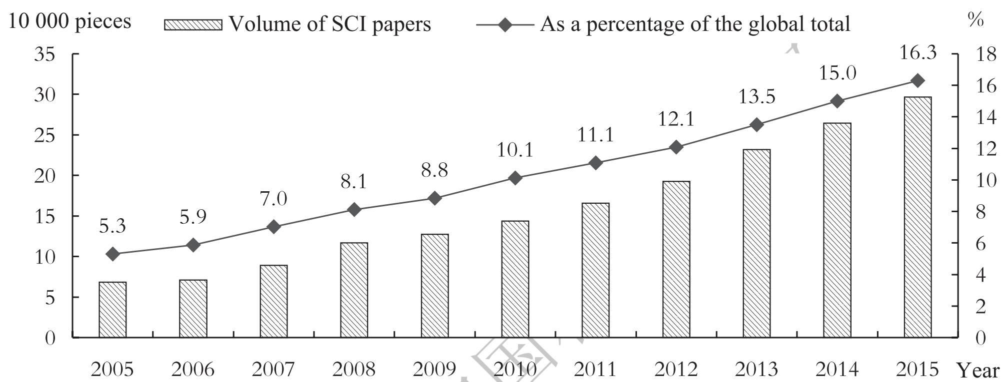

Figure 3-1 Chinese SCI papers and as a percentage of the global total (2005–2015)

See Annexed Table 3-1

China Science and Technology Indicators 2016

China's SCI papers were highly concentrated in basic disciplines and industrial technology. In 2015, China published 126 thousand papers in basic disciplines, accounting for 47.3%, down 1.5 percentage point over the previous year; and 72 thousand in industrial technology, accounting for 27.2%, down 0.6 percentage point over the previous year.

With the exception of few years, the period between 2005 and 2015 saw an overall growth of SCI papers in all subject areas. Among the fields of science and technology, medical and health sciences recorded the highest average annual growth of 27.1% during the period, with papers published in the field in 2015 as a percentage of the total papers jumping up by 14.0 percentage points from 2005, versus 12.4% of average annual growth and a decrease of 14.5 percentage points for basic disciplines, and 15.3% of average annual growth for industrial technology, with papers in industrial technology as a percentage of all Chinese SCI papers hitting the highest point in nearly ten years at 28.4% in 2011, then slightly going down in subsequent several years (Figure 3-2).

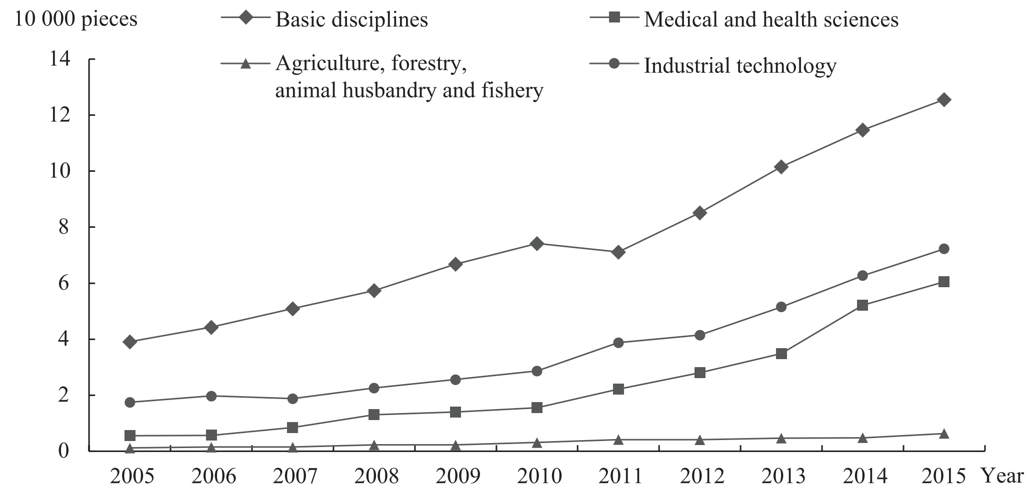

Figure 3-2　Number of Chinese SCI papers by subject area (2005–2015)

See Annexed Table 3-2

China Science and Technology Indicators 2016

Between 2006 and 2016 (up to September 2016), Chinese SCI papers were most represented by chemistry with 352 thousand papers, with the other four disciplines that recorded more than 150 thousand papers being physics (212 thousand), engineering technology (197 thousand), materials science (190 thousand) and clinical medicine (171 thousand), respectively. In 14 disciplines, the total number of Chinese SCI papers accounted for more than 10%, with materials science and chemistry accounting for more than 20% and mathematics, physics, engineering technology, as well as computer science accounting for more than 15%. Compared to the previous year, a varying degree of growth was recorded for all disciplines with the exception of economy and trade, psychiatry and psychology, and general science. Among them, chemistry registered the highest growth rate of 9.7% over the previous year, with the number as a percentage of the global total increased to 22.8% from 22.0% in the previous year. Engineering technology, materials science and clinical medicine also recorded a fairly fast growth at 12.4%, 12.1% and 11.7%, respectively, over the previous year (Table 3-1).

Table 3-1　Chinese SCI papers in the world by discipline (2006–September 2016)

Discipline	Papers		Citations				Citations per paper	
	Number of SCI papers	As a percentage of the world (%)	Citation count	As a percentage of the world (%)	Rank in the world	Rank change	Citation count	Percentage in the world average (%)
Agricultural science	38696	10.33	300596	9.96	2	—	7.77	97
Biological and biochemistry	79790	11.75	773863	7.05	5	—	9.7	60

Continued

Discipline	Papers		Citations				Citations per paper	
	Number of SCI papers	As a percentage of the world (%)	Citation count	As a percentage of the world (%)	Rank in the world	Rank change	Citation count	Percentage in the world average (%)
Chemistry	352109	22.80	3917186	19.30	2	—	11.12	85
Clinical medicine	171294	6.92	1280931	4.17	10	—	7.48	60
Computer science	55334	16.77	249260	12.85	2	—	4.5	77
Economy and trade	9804	4.07	50166	2.81	10	↓3	5.12	69
Engineering technology	196909	18.12	1214103	17.07	2	—	6.17	94
Environment and ecology	49744	12.56	445508	9.20	3	—	8.96	73
Earth science	59699	15.00	540697	11.96	4	↑1	9.06	80
Immunology	15834	6.70	164202	3.70	11	↑1	10.37	55
Materials science	189505	27.61	1731826	24.50	2	—	9.14	89
Mathematics	72138	18.54	279135	17.66	2	—	3.87	95
Microbiology	19326	10.34	159238	5.74	5	↑1	8.24	56
Molecular biology and genetics	50982	12.17	572041	5.64	7	↑1	11.22	46
General science	2217	12.33	23664	9.79	3	↑3	10.67	79
Neuroscience and behavior	31123	6.52	292201	3.50	10	—	9.39	54
Pharmacy and toxicology	44518	12.59	381108	8.69	2	—	8.56	69
Physics	211831	19.18	1808558	15.20	2	↑1	8.54	79
Botany and Zoology	58347	8.65	445271	7.50	4	↑2	7.63	87
Psychiatry and psychology	6961	1.93	49849	1.17	16	↓2	7.16	61
Space science	11215	8.05	127115	5.32	13	—	11.33	66
Social science	15550	1.96	91891	1.84	12	↓3	5.91	94

Source: Institute of Scientific and Technical Information of China.

China Science and Technology Indicators 2016

1.2 Citations of SCI papers

Scientists cite papers as an endorsement of the work of peers. Citation count is an effective indicator of the quality and impact of papers. The impact buildup of a paper is a lagging and accumulative process. It is because of the accumulation of Chinese SCI papers over the last decade that Chinese papers have received steadily increasing citations in recent years.

Between 2006 and 2016 (up to September 2016), Chinese researchers published a total of 1.7 million SCI papers, representing an increase of 10.2% from the period between 2006 and 2015. Up to September 2016, China continued in the second place globally in SCI papers published; and the papers received 14.9 million citations, up 15.7%, ranking the fourth worldwide as that in the previous year. China registered 8.55 citations per paper, up 5.0% from the previous year, though still being significantly behind the world average of 11.5, but the gap was steadily narrowing. As citations per paper are subject to factors such as the base of papers published and the language, this indicator has to be applied with a precondition, that is, it is significant that we compare and judge the impact of papers of countries with a similar scale of paper output. Countries with a small number of papers may have more citations per paper because of a few highly cited papers and thus have a high ranking in the world. Among the 21 countries and regions with more than 200 thousand paper published, China ranked the 15th in citations per paper; there were 12 countries whose citations per paper exceeded the world average, with Switzerland, the Netherlands, the United States, the United Kingdom, Sweden, Germany and Canada recording more than 15 citations per paper (Table 3-2).

Table 3-2 SCI papers and citations of major countries (2006– September 2016)

Country/region	SCI papers		Total citations		Average citations per article	
	Number of papers	Ranking	Citations	Ranking	Citations	Ranking
US	3687391	1	63143934	1	17.12	3
Germany	968336	3	15076164	2	15.57	6
UK	878899	4	15006328	3	17.07	4
China	1742926	2	14898454	4	8.55	15
France	682356	6	10098359	5	14.80	8
Japan	807599	6	9402863	6	11.64	12
Canada	597641	7	9217186	7	15.42	7
Italy	577054	8	8076626	8	14.00	10
Australia	467675	11	6558372	9	14.02	9

Continued

Country/region	SCI papers		Total citations		Average citations per article	
	Number of papers	Ranking	Citations	Ranking	Citations	Ranking
Spain	496241	9	6419339	10	12.94	11
Netherlands	343697	14	6311767	11	18.37	2
Switzerland	249897	17	4864850	12	19.47	1
Korea	456242	12	4187681	13	9.18	14
Sweden	228091	19	3761245	14	16.49	5
India	478250	10	3710262	15	7.76	17
Brazil	352455	13	2645679	16	7.51	18
Taiwan of China	256642	16	2412849	17	9.40	13
Poland	220541	20	1756235	18	7.96	16
Russia	299670	15	1737229	19	5.80	21
Turkey	239280	18	1563832	20	6.54	19
Iran	202253	21	1258712	21	6.22	20

Source: Institute of Scientific and Technical Information of China.

China Science and Technology Indicators 2016

As shown in Table 3-1, in terms of citation count, China has published widely influential SCI papers in the world in some disciplines. Between 2006 and 2016, China entered the top ten globally in 18 disciplines and the top three in 10 disciplines in terms of citation count. Among them, materials science received 1.7 million citations (24.5% of the global total), chemistry 3.9 million (19.3%), mathematics 279 thousand (17.7%), engineering technology 1.2 million (17.1%), physics 1.8 million (15.2%), computer science 249 thousand (12.9%), agricultural science 301 thousand (10.0%), and pharmacology and toxicology 381 thousand (8.7%), all ranking in the second place, the same as the previous year with the exception of physics which improved by one place; and general science 24 thousand (9.8%) and environment and ecology 446 thousand (9.2%), both ranking the third globally with the former improving by three places and the latter retaining its place compared to the previous year.

Although China leads the world in terms of the number and citations of papers in disciplines such as materials science and chemistry, China's overall citation count per paper was only 77.2% of the world average[①], and the citation count per paper varied significantly from discipline to

① As the global distribution of citations per article is skewed, the world average is higher than the median.

discipline compared to the world average. Of the 11 disciplines where China reached 77.2% of the world average in citations per paper, 4 (agricultural science, mathematics, engineering technology, and social science) reached 90% of the world average and 4 (materials science, botany and zoology, chemistry, and earth science) reached 80%. China had the greatest gap with the world average in biological and medical fields such as immunology, microbiology, and neuroscience and behavior, with the citations per paper being only approximately 55% of the world average.

2 Internationally co-authored papers

By publishing papers in international journals and presenting proceeding papers at international academic conferences, Chinese researchers can make themselves known in the international academic community and stand a better chance of holding important positions in international academic organizations while broadening their levels and extending international research collaboration.

According to statistics, China's SCI papers in 2015 included 75 thousand internationally co-authored papers, with an increase of 9872, or 15.2%, from 2014, and accounting for 25.4% of China's total SCI papers. They included 52 006 papers with Chinese researchers as the first author, accounting for 69.1% of China's total internationally co-authored papers, which involved collaborators coming from 148 countries (regions) around the world. The top six countries were the United States, Australia, the United Kingdom, Canada, Japan and Germany. There were a total of 23 259 papers co-authored by Chinese researchers and overseas collaborators from 177 countries (regions), with papers co-authored with collaborators from the top six countries — the United States, the United Kingdom, Germany, Australia, Japan and Canada — accounting for 95.8% of China's all internationally co-authored papers (Figure 3-3).

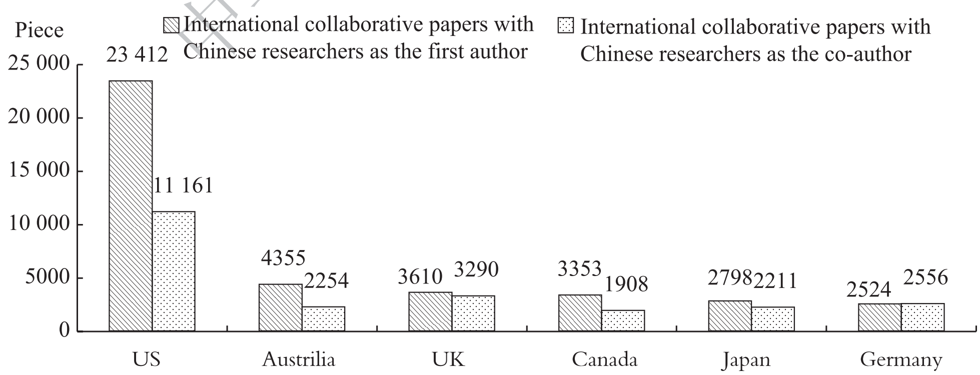

Figure 3-3 Major countries involved in international collaborative papers with Chinese researchers as the first author or co-author (2015)

Source: Institute of Scientific and Technical Information of China, *China S&T Papers Statistics and Analysis 2015.*

The top six disciplines where Chinese researchers published the greatest number of international collaborative papers as the first author in 2015 were chemistry, biology, clinical medicine, physics, computer technology and materials science, respectively (Table 3-3). The top six disciplines where Chinese researchers published the greatest number of international collaborative papers as the co-author in the year were biology (3372), clinical medicine (3364), chemistry (2857), physics (2390), basic medicine (1483) and materials science (1261).

Table 3-3 Top six disciplines in terms of international collaborative papers published by Chinese researchers as the first author (2015)

Discipline	International collaborative papers (Piece)	As a percentage of all papers published in the discipline (%)
Chemistry	6583	14.72
Biology	6441	21.09
Clinical medicine	4789	15.58
Physics	4544	16.53
Computing technology	3538	36.16
Materials science	3510	17.50

Source: Institute of Scientific and Technical Information of China, *China S&T Papers Statistics and Analysis 2015.*

China Science and Technology Indicators 2016

Column 3-1 EI, CPCI-S and Scopus

Engineering Index (EI), founded in 1884, is a famous engineering and technical search tool published by Engineering Information Inc. (now known as Elsevier). EI collects over 5100 journals and more than 2000 kinds of proceedings reports in engineering and technical field worldwide, the data of which from more than 50 countries and regions, covering disciplines like chemical engineering, mechanics, civil engineering, electronics & electrical, materials, bioengineering and etc. About 22% of the data are conference papers including keywords and abstract and 90% are English literatures. EI database collected 680 thousand papers in 2015, up 19.5% from 2014, including 217 thousand from China, up 20.4% from 2014. China accounted for 32.0% of the total papers collected by EI in 2015, more than any other country.

Conference Proceedings Citation Index-Science (CPCI-S) is another paper search tool edited and published by Institute for Scientific Information (ISI) (now known as Clarivate Analytics), which was founded in 1978. CPCI-S collects a variety of important conference papers around the world, including the internationally famous institute conferences, first-class meetings, as well as important scientific magazine conferences. Conference papers are an important part of academic papers, in which many innovative ideas, concepts or experiments often appear firstly, so CPCI-S becomes an important supplement to academic journals. CPCI-S reports 80%~90% of the important conferences worldwide and collects conference papers covering natural science, agricultural science, medicine, engineering technology and etc. CPCI-S database collected 467 thousand papers in 2015, up 26.6% from 2014, including 71 thousand from China, up 25.8% from 2014. China accounted for 15.2% of the total papers collected by CPCI-S in 2015, taking the second place in the world.

Scopus is the world’s largest abstract and citation database of peer-reviewed literature. Launched by Elsevier in late 2004, Scopus covers a broad range of literatures, references and indexes in science, technology and medicine, and collects more than 19 500 journals from over 5000 publishing houses worldwide, such as Elsevier, Kluwer, Institution of Electrical Engineers, John Wiley, Springer, Nature, Science and etc. Scopus collected 2.8 million scientific papers worldwide in 2015, including 439 thousand from China, or 15.8% of the total, the second most in the world. The US, China, the UK, Germany and India were on the top five lists.

3 Output of scientific papers per research investment

Scientific papers are an important output of scientific research activities (including basic research and applied research). The output of scientific papers per unit of R&D input can reflect the efficiency of scientific research activities to some extent. Given the fact that the output of scientific research activities has some time lag, according to international practice, the output of scientific research activities in a year is measured by the number of scientific papers published two years later①.

Since 2000, there has been a wavy growth of SCI papers per unit of scientific research expenditure. The number peaked at 24.9 per billion yuan in 2013, representing an increase of 21.4% from 2000. The period saw a steady increase of SCI papers per researcher, reaching 4290.1 per ten thousand researchers in 2013, representing an increase of 2.1 times from 2000 (Figure 3-4).

Measured by the SCI papers per unit of scientific research expenditure, China is not only higher than big R&D spenders like the US, Japan, France and the UK, but higher than emerging countries like Korea and Russia. Calculated by current prices, China churned out 819.3 SCI papers in 2013 for every USD 100 million spent on scientific research. The UK is an efficient paper producer in the developed world, and it produced 507.0 SCI papers, 61.9% of China’s output, for the same amount of spending in scientific research in 2013. In the same year, Korea and Russia published 317.0 and 473.3 papers, or 38.7% and 57.8% of China’s output, respectively.

① For example, papers per unit of scientific research expenditure in 2013 is the number of papers published in 2015 divided by the scientific research expenditure in 2013.

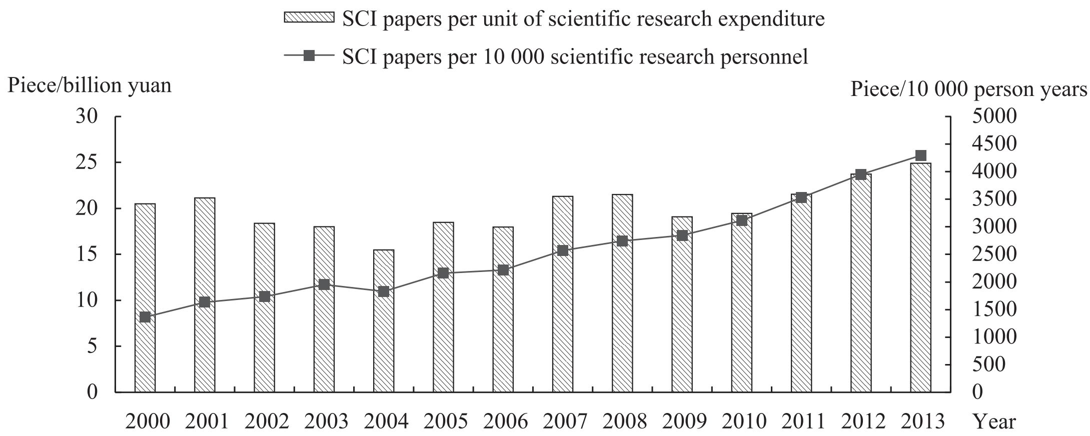

Figure 3-4 SCI papers per unit of scientific research input in China (2000–2013)

See Annexed Table 3-5

China Science and Technology Indicators 2016

Column 3-2 Information About International Top Papers

1. Highly Cited Papers

In the ten years between 2006 and 2016, China published a total of 16 961 highly cited papers, defined as papers that perform in the top 1% based on the number of citations received, accounting for 12.8% of all highly cited papers in the world and an increase of 13.0% from 2015, with its rank improving by one spot to the third place and its share in the world increasing by nearly one percentage point. The United States ranked the first with 67 612 highly cited papers, or 51.0% of the world, decreasing 0.6 percentage point from a year earlier, followed by the United Kingdom in the second place with 18 307 highly cited papers, Germany ranking the fourth with 16 160 and France ranking the fifth with 10 764.

2. Hot Papers

Hot papers are papers published in the last two years that have been cited enough times in the most recent bimonthly period,which was in the top 1‰ based on the number of citations received. According to statistics up to September 2016, China had 495 hot papers, or 18% of all hot papers in the world, with its rank improving by one spot from 2015 to the third place. The United States had the greatest number of hot papers with 1493, or 54.3% of the world total, followed by the United Kingdom with 561, Germany ranking the fourth with 473 and France in the fifth place with 341.

3. CNS Papers

Cell, *Nature* and *Science* are internationally recognized as the world's three most prestigious academic journals. Papers published in them are generally high-quality top papers reviewed and rigorously refined by world-leading experts. The three journals carried a total of 6011 papers in 2015, representing an increase of

237 papers compared to 2014. They included 290 published by Chinese researchers, representing an increase of 44, and ranking the fifth in the world with the improvement of two places from 2014. The United States ranked the first with 2656, accounting for 44.2%. The United Kingdom, Germany and France were in the second, the third and the fourth place, respectively. If only the two document types of Article and Review are counted, then China had 202, still ranking the fifth in the world.

4. Papers Published in Top Journals

Journals with the highest impact factor are recognized as the most influential journals in their subject area. In 2015, there were six international journals which received more than 100 thousand citations and whose impact factor was more than 30, and they were *Nature*, *Science*, *Chem Rev*, *New Engl J Med*, *Lancet* and *JAMA-JAM MED ASSOC*, respectively. They published a total of 10 770 papers in 2015, including 508 by Chinese researchers, or 4.7%, putting China in the sixth place in the world. If only the two document types of Article and Review are counted, then China had 270, remaining in the sixth place in the world.

Section 2 Patents

Patents are an important indicator of technological strength, research output and market competitiveness which is often used to measure the innovation capacity of a country, industry or enterprise and also serves as an important basis for analyzing China's patenting work, assessing inventive and creative powers, and predicting technological and economic development.

1 Invention patents filed and granted

In China, patents are of three types, namely, invention patents, utility model patents and design patents. In 2015, China filed 2.8 million patent applications, up 18.5% year on year. They included 1.1 million invention patent applications, up 18.7% year on year, accounting for 39.4%; 1.1 million utility model patent applications, up 29.8% year on year; and 569 thousand design patent applications, up 0.8% year on year. In 2015, a total of 1.7 million patents were granted in China, up 31.9% year on year. They included 359 thousand invention patents, up 54.1% year on year; 876 thousand utility model patents, up 23.8% year on year; and 483 thousand design patents, up 33.5% year on year.

1.1 Resident and non-resident inventions filed and granted

The number of resident invention patent applications exceeded the number of non-resident invention patent applications in 2003 and has left the latter increasingly behind with a steady strong growth since then (Figure 3-5). In 2015, resident invention patent applications as a percentage of the total invention patent applications increased by 1.6 percentage points from a year earlier to 87.9%. This points to the significant success of China's effort to build a global power in intellectual property, as indicated by the stable and rapid improvement in independent innovation capacity and technological development. In 2015, non-resident patent applications in China reached 134 thousand, an increase of 5.2% over the previous year.

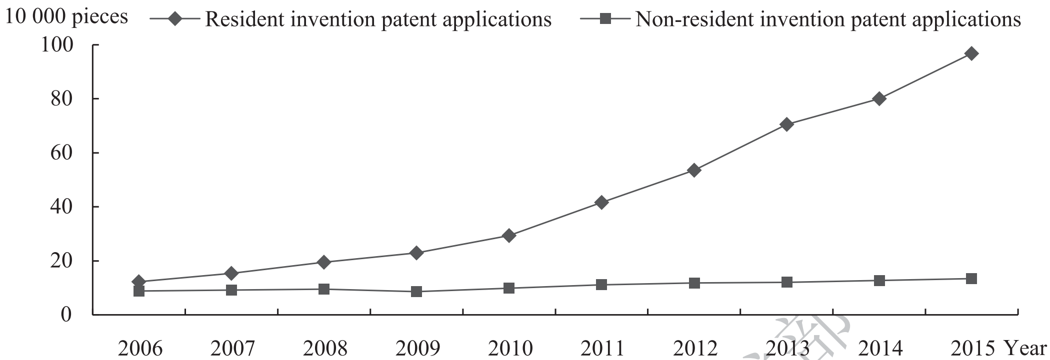

Figure 3-5 Resident and non-resident invention patent applications in China (2006–2015)

See Annexed Table 3-6

China Science and Technology Indicators 2016

With the exception of 2013, the number of resident patents granted has maintained a trend of high-speed growth and, after overtaking non-resident patents granted in 2009, continued to expand their share. In 2015, resident invention patents granted posted a significant growth from the previous year, with invention patents granted as a share of all patents granted continuing to rise and reaching 73.3%, representing an increase of 3.6 percentage points from the previous year (Figure 3-6).

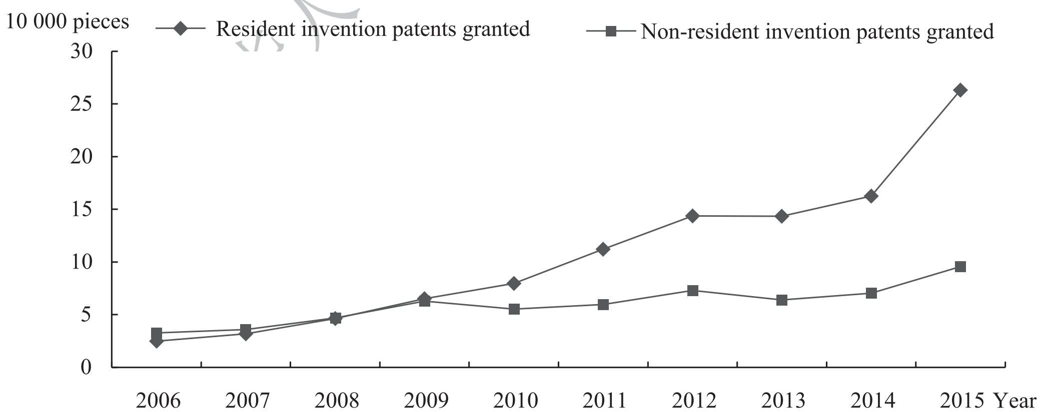

Figure 3-6 Resident and non-resident invention patents granted (2006–2015)

See Annexed Table 3-6

China Science and Technology Indicators 2016

1.2 Non-resident invention patents filed and granted in China by country

With China's steady opening-up and increasing protection of intellectual properties, many countries, especially developed countries, have strengthened protection of their technological inventions by patenting them in China.

There is a clear concentration in the distribution of countries represented by invention patent applicants and assignees in China. Between 2001 and 2015, Japan, the United States, Germany and Korea were the top four countries of non-resident invention patent applications in China, and their patent applications represented approximately 80% of all non-resident invention patent applications in China. Japan is the top in non-resident invention patent applicants in China, followed by the United States in the second place. In 2015, Japan filed 40 thousand invention patent applications in China, and the United States 37 thousand, and their combined invention patent applications accounted for 57.9% of all non-resident invention patent applications in China (Figure 3-7).

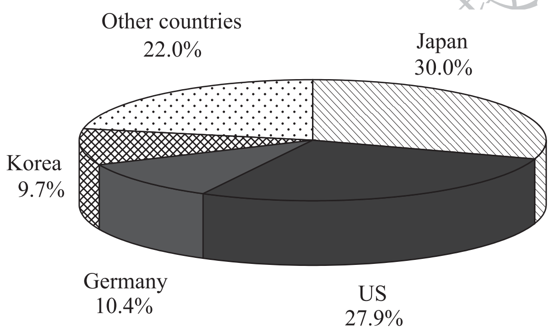

Figure 3-7 Number of non-resident patent applications by country (2015)

See Annexed Table 3-7

China Science and Technology Indicators 2016

There was also a high concentration of non-resident invention patent assignees in China by country. In 2015, the top four country assignees of invention patents in China were Japan (36 418), the United States (23 157), Germany (10 533) and Korea (6262), whose total non-resident invention patents granted accounted for 79.7% of all non-resident invention patents in China. Among them, the invention patents granted to Japanese and the US assignees accounted for 62.1% of all non-resident invention patents granted in China (Figure 3-8).

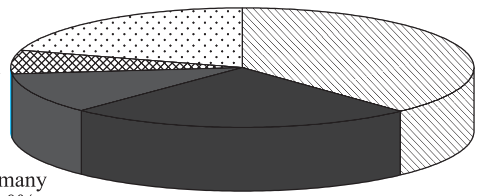

Figure 3-8 Number of non-resident patents granted in China by country (2015)

See Annexed Table 3-8

China Science and Technology Indicators 2016

2 Service invention patents filed and granted by institution

Driven by China's efforts to transform its pattern of economic development, Chinese enterprises have played an increasing role as the principal actor of innovation with steadily increasing innovation capabilities and contributed the majority of service invention patents granted in China. In 2015, enterprises filed 583 thousand invention patent applications, up 20.2% year on year, accounting for 75.1% of all service invention patent applications in China. The year also saw a varying degree of increase of service invention patent applications among other types of institutions, with universities filing 134 thousand applications, up 19.0% year on year, research institutes filing 45 thousand applications, up 12.4% year on year, and government agencies and organizations filing 15 thousand, up 32.2%.

In 2015, the top ten resident invention patent applicants were all domestic-funded enterprises. State Grid Corporation of China ranked the first for the third consecutive year with 6111 invention patent applications. China Petroleum & Chemical Corporation came the second with 4372 invention patent applications, up 7.3% year on year. Among the foreign enterprise applicants of invention patents in China, the top ten were dominated by Japanese and Korean enterprises (Table 3-4).

Table 3-4 Top ten domestic and foreign enterprise applicants of invention patents in China (2015)

Unit: Piece

	Enterprise Name	Enterprise Type	Applications
Domestic	State Grid Corporation of China	Domestic-funded enterprises	6111
	China Petroleum & Chemical Corporation	Domestic-funded enterprises	4372
	ZTE Corporation	Domestic-funded enterprises	3516
	Guangdong Oppo Mobile Telecommunications Co., Ltd	Domestic-funded enterprises	3338
	Huawei Technologies Co., Ltd.	Domestic-funded enterprises	3216

Continued

	Enterprise Name	Enterprise Type	Applications
Domestic	Xiaomi Corporation	Domestic-funded enterprises	3183
	Qihoo 360 Technology Co., Ltd.	Domestic-funded enterprises	2777
	BOE Technology Group Co., Ltd.	Domestic-funded enterprises	2761
	Gree Electric Appliances Inc.	Domestic-funded enterprises	1981
	Lenovo (Beijing) Limited	Domestic-funded enterprises	1826
Overseas	Enterprise Name	Country	Applications
	Alibaba Group Holding Limited	Cayman Islands	2742
	Samsung Electronics Co., Ltd.	Korea	2117
	Qualcomm Incorporated	US	1943
	Toyota Motor Corporation	Japan	1921
	Robert Bosch GmbH	Germany	1480
	Hyundai Motor Company	Korea	1441
	Intel Corporation	US	1258
	Mitsubishi Electric Corporation	Japan	1210
	Canon Inc.	Japan	1167
	Royal Philips NV	Netherlands	1161

Source: State Intellectual Property Office.

China Science and Technology Indicators 2016

In 2015, enterprises were granted a total of 159 thousand service invention patents in China, a substantial increase of 72.6% over the previous year. Other types of institutions also saw a significant increase in service invention patents granted, with universities receiving 57 thousand, up 49.3%, research institutes receiving 19 thousand, up 41.8%, and government agencies and organizations receiving 3759, up 56.1%. Service invention patents granted to enterprises accounted for 66.4% of all service invention patents granted in China.

Statistics of service invention patents granted to various types of institutions over the years showed a steady increase of service invention patents granted to enterprises as a percentage of the total which had exceeded 60% for eight consecutive years from 2008 (Figure 3-9), highlighting enterprises as the principal owner of service invention patents in China and their increasingly consolidated position as the principal actor of technological innovation.

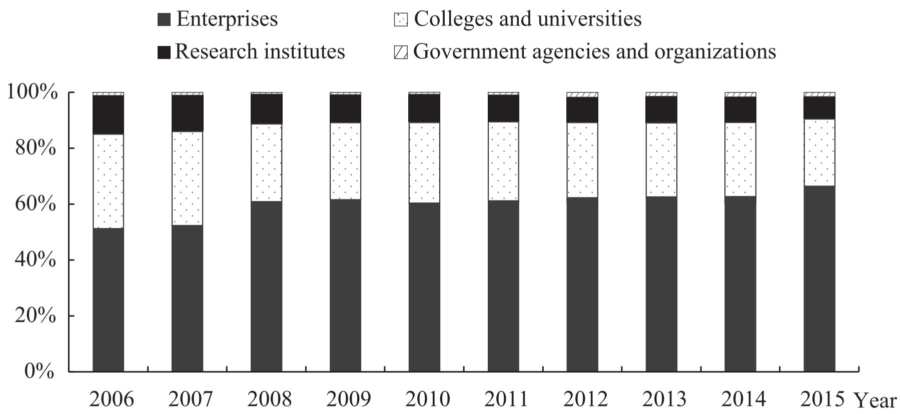

Figure 3-9 Number of service invention patents granted by type of institution (2006–2015)

See Annexed Table 3-9

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In 2015, the top ten enterprise assignees of invention patents in China were all domestic-funded enterprises as well. China Petroleum & Chemical Corporation emerged on top with 2844 invention patents granted. ZTE Corporation came the second with 2673 and Huawei Technologies Co., Ltd came the third with 2413. Among the top ten foreign enterprise assignees, there were four Japanese enterprises, and all in the top five, highlighting their significant advantage (Table 3-5).

Table 3-5 Top ten domestic and foreign assignees of invention patents in China (2015)

	Enterprise Name	Enterprise Type	Grants
Domestic	China Petroleum & Chemical Corporation	Domestic-funded enterprises	2844
	ZTE Corporation	Domestic-funded enterprises	2673
	Huawei Technologies Co., Ltd.	Domestic-funded enterprises	2413
	State Grid Corporation of China	Domestic-funded enterprises	2081
	BOE Technology Group Co., Ltd.	Domestic-funded enterprises	1115
	Shenzhen Huaxing Photoelectric Technology Co., Ltd.	Domestic-funded enterprises	728
	PetroChina Company Limited	Domestic-funded enterprises	641
	Zoomlion Heavy Industry Science and Technology Co., Ltd.	Domestic-funded enterprises	596
	Tencent Technology (Shenzhen) Co., Ltd.	Domestic-funded enterprises	581
	BYD Co., Ltd.	Domestic-funded enterprises	509
	Enterprise Name	Country	Grants
Overseas	Qualcomm Incorporated	US	1350
	Canon Inc.	Japan	1273
	Toyota Motor Corporation	Japan	1240

Continued

	Enterprise Name	Country	Grants
Overseas	Panasonic Corporation	Japan	1117
	Mitsubishi Electric Corporation	Japan	1095
	GM Global Technology Operations LLC	US	1005
	Robert Bosch GmbH	Germany	940
	Royal Philips Electronics BV	Netherlands	920
	Siemens AG	Germany	915
	Samsung Electronics Co., Ltd.	Korea	912

Source: State Intellectual Property Office.

China Science and Technology Indicators 2016

3 Invention patents in force

As of the end of 2015, China had a total of 1.5 million invention patents in force. They included 922 thousand resident invention patents in force, up 30.1% year on year, accounting for 62.6%. However, resident invention patents as a share of all resident patents in force remained low at 19.2%. In comparison, there were 551 thousand non-resident invention patents in force, accounting for as high as 80.4% of all non-resident patents in force.

Among the resident invention patents in force in 2015, 585 thousand (63.5%) were held by enterprises, 174 thousand (18.9%) by colleges and universities, 82 thousand (8.9%) by individuals, 70 thousand (7.6%) by research institutes and 10 thousand (1.1%) by government agencies and organizations.

Among the 35 technical fields classified by the World Intellectual Property Organization, there were 28 where resident invention patents outnumbered non-resident invention patents in China in 2015, representing an increase of 6 from 2014. In seven fields, namely, optics, engine, transportation, semiconductor, basic communication procedure, audio-visual technology, and medical technology, however, China was still significantly behind foreign countries, especially in optics and engine, where non-resident invention patents outnumbered resident invention patents by 1.6 times and 1.5 times, respectively. Among invention patents in force for more than ten years, non-resident invention patents were 2.2 times resident invention patents, and the multiplier was 6.4 in transport. Therefore, China still needs to strengthen patenting in some technical fields.

4. International comparison of invention patents filed and granted

Patents are an important instrument to protect inventors and an effective means for enterprises to compete internationally and expand in overseas markets. Analyzing Chinese patent applications in foreign countries and comparing with foreign countries can provide a good picture of China's innovation capacity and technological development compared to developed countries.

4.1 Resident and non-resident invention patents filed and granted

The number of invention patents filed and granted reflects a country's overall technological strength, where resident invention patents filed and granted represent the country's innovation capacity and the level of technological development while non-resident invention patents filed and granted reflect the attractiveness of the country's market to foreign enterprises and the technological advantage foreign enterprises have over domestic enterprises.

In 2015, China continued to rank the first globally in invention patent applications and resident invention patent applications. China's invention patent applications were close to that of the United States, Japan and Korea combined and its resident invention patent applications were greater than that of the United States, Japan, Korea and Germany combined. China also overtook the United States and Japan to rank the first globally in both total invention patents granted and resident invention patents granted. China continued to be in the third place globally in total invention patents in force and resident invention patents in force (Table 3-6).

Table 3-6 Top ten countries in invention patents filed, granted and invention patents in force (2015)

Unit: Piece

Category	Ranking	Country	Total	Domestic	Foreign
Applications	1	China	1101864	968252	133612
	2	US	589410	288335	301075
	3	Japan	318721	258839	59882
	4	Korea	213694	167275	46419
	5	Germany	66893	47384	19509
	6	India	45658	12579	33079
	7	Russia	45517	29269	16248
	8	Canada	36964	4277	32687
	9	Brazil	30219	4641	25578
	10	Australia	28605	2291	26314
Grants	1	China	359316	263436	95880
	2	US	298407	140969	157438
	3	Japan	189358	146749	42609
	4	Korea	101873	76319	25554
	5	Russia	34706	22560	22560

Continued

Category	Ranking	Country	Total	Domestic	Foreign
Grants	6	Australia	23098	1614	21484
	7	Canada	22201	2858	19343
	8	Germany	14795	10411	4384
	9	France	12699	11043	1656
	10	Mexico	9338	410	8928
Invention patents in force	1	US	2644697	1335001	1309696
	2	Japan	1946568	1624596	321972
	3	China	1472374	921757	550617
	4	Korea	912442	676991	235451
	5	Germany	602013		
	6	France	520069	159269	360800
	7	UK	458422	39500	418922
	8	Russia	218974	147606	71368
	9	Canada	166771	21272	145499
	10	Switzerland	162761	20281	142480

Source: WIPO Statistics Database, February 2017.

China Science and Technology Indicators 2016

4.2 PCT applications

In 2015, a total of 217 thousand patent applications were filed under the Patent Co-operation Treaty (PCT), representing an increase of 1.4% from 2014. Among the top ten countries of application, China and Korea posted a two-digit growth and the United States and Sweden registered a negative growth. Among middle-income countries, Thailand, Peru, Turkey and Mexico saw a significant growth of PCT applications at 94.1%, 47.1%, 19.1% and 12.7%, respectively.

In 2015, China's PCT applications retained a two-digit growth and reached 30 thousand, up 16.8% year on year. China continued to rank the third globally in PCT applications (Figure 3-10). In terms of PCT applications by enterprises, Huawei Technologies Co., Ltd ranked the first globally for the second consecutive year with 3898 PCT applications, followed by ZTE Corporation in the second place, for the second consecutive year as well, with 2155.

4.3 Triadic patent families

According to OECD statistics of 41 countries (regions) with triadic patent families, triadic patent families totaled 55 thousand in 2015, including 51 thousand owned by 35 OECD member countries, or 93.6%, and 14 thousand owned by the 28-member EU bloc, or 24.8%. In terms of the distribution of triadic patent families among countries, Japan had 17 thousand and the United States had 15 thousand, with their triadic patent families combined accounting for 58.8% of all triadic patents.

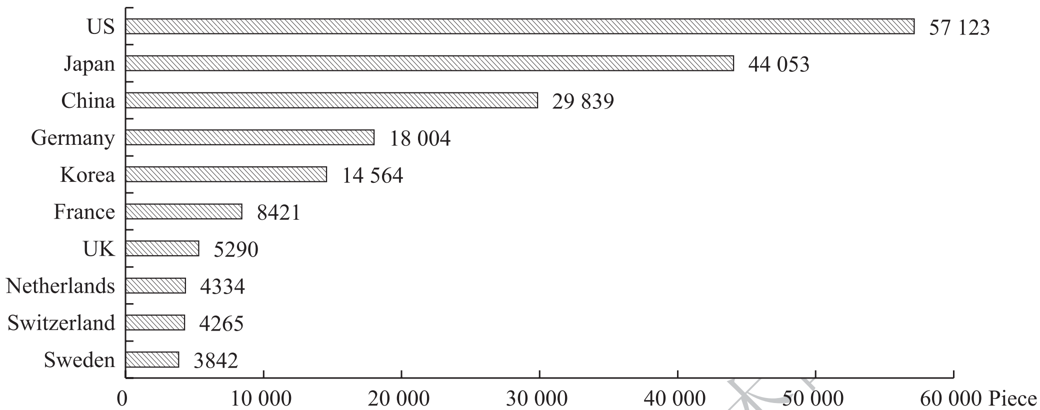

Figure 3-10　Top 10 countries of PCT applications (2015)

See Annexed Table 3-10

China Science and Technology Indicators 2016

In 2015, China had 2889 triadic patent families, up 16.6% from a year earlier, and accounting for 5.3% of all triadic patent families, with its international rank rising two spots to the fourth (Figure 3-11).

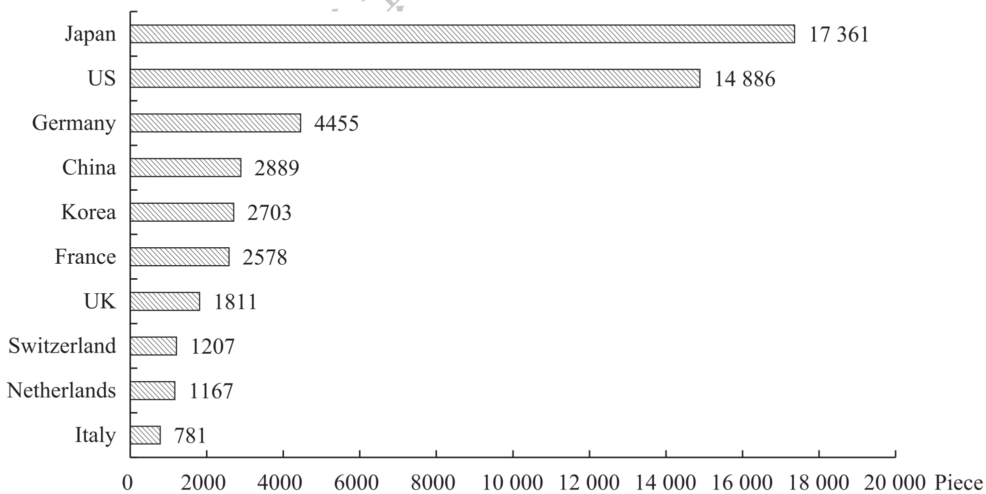

Figure 3-11　Top 10 countries of triadic patent families owned (2015)

See Annexed Table 3-11

China Science and Technology Indicators 2016

Section 3 Trade in Technology

Trade in technology is a bridge that connects R&D and production and reflects the ability of a country (region) to absorb and diffuse technology. Geographically, trade in technology can be divided as domestic technology transfer and technology balance of payments.

1 Domestic technology transfer

The technology market plays an important role in optimizing allocation of domestic S&T resources, accelerating knowledge flow and technology transfer, and promoting the integration of technology and economy. In 2015, China's technology market signed a total of 307 thousand technology contracts with a turnover of 983.6 billion yuan, up 3.4% and 14.7% respectively over the previous year. The average transaction value per contract reached 3.2 million yuan, an increase of 10.9% over the previous year. The turnover of technology contracts accounted for 1.45% of the gross domestic product, up 0.1 percentage point from a year earlier (Figure 3-12).

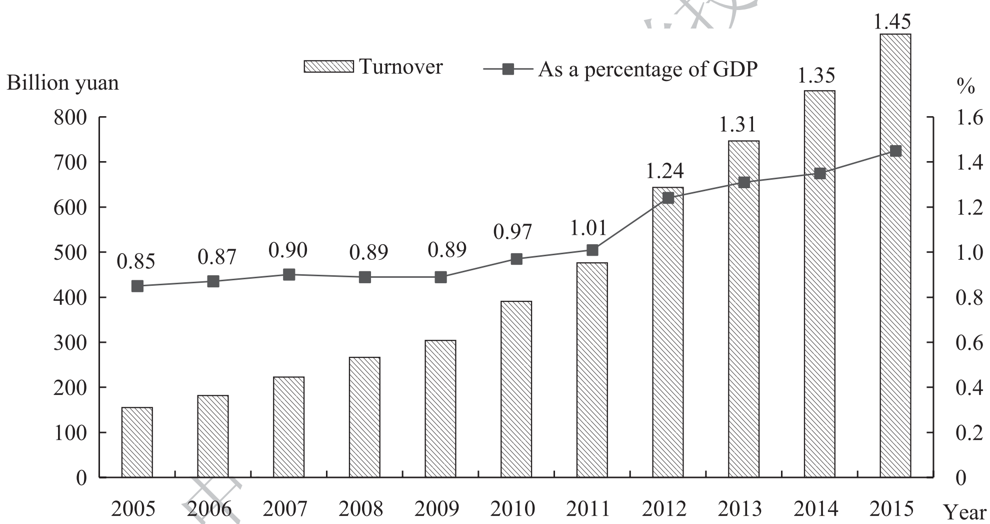

Figure 3-12 National technology contract turnover and as a percentage of GDP (2005–2015)

See Annexed Table 3-12

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1.1 Breakdown of technology contracts

Technology contracts are divided into four categories — technology development, technology transfer, technology consulting and technology service. In 2015, the turnover of technology service contracts continued to rank the first among the four categories with 505.9 billion yuan, accounting for 51.4% of China's technology transaction market. Technology transfer came the second with 153 thousand contracts signed and a turnover of 304.7 billion yuan, accounting for 31.0%. As the main forms of technology transaction, technology service and technology transfer combined to account for more than 80% of China's technology transaction market. There were 13 thousand technology transfer contracts signed with a turnover of 146.65 billion yuan, accounting for 14.9% of the market. And there were 34 thousand technology consulting contracts signed with a turnover of 26.3 billion yuan, accounting for 7.7% of the market.

1.2 Distribution of technology contracts by field

In 2015, the top three technology fields in terms of the turnover of contracts signed were electronic and information technology, advanced manufacturing technology, and urban construction and social development, which combined to account for more than 50% of all technology contracts and the total turnover.

Transactions in electronic and information technology continued in the first place with a turnover of 249.7 billion yuan, accounting for 25.4% of the turnover of all technology contracts nationwide. Computer software represented the largest segment by posting a total of 99 thousand contracts signed with a turnover of 157.2 billion yuan (Figure 3-13).

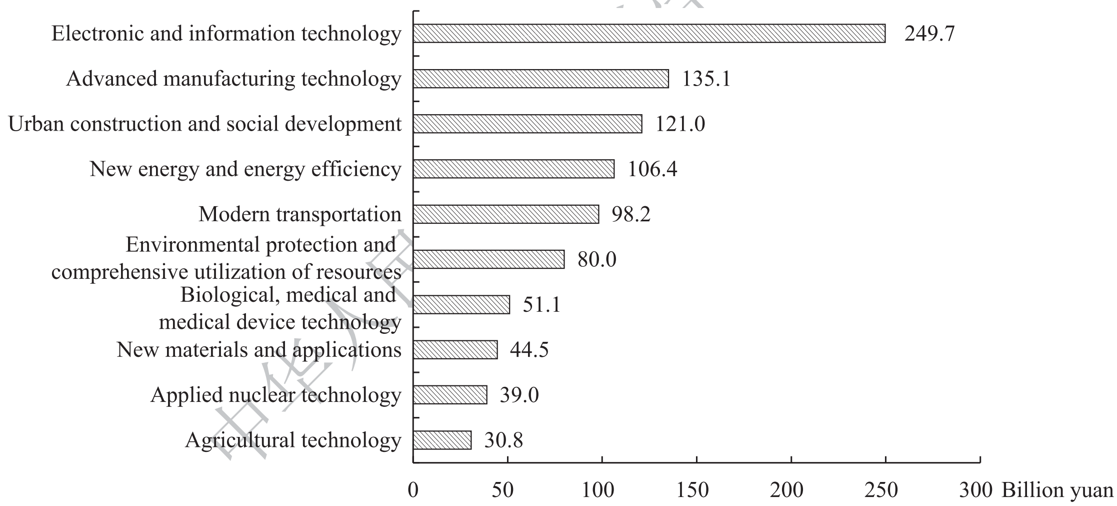

Figure 3-13 China's technology contract turnover by technology field (2015)

Source: China Technology Market Management and Promotion Center, *Annual Statistical Report on the National Technology Market 2016*.

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1.3 Contractual parties of technology contracts

Enterprises represent the largest group of contractual parties of technology contracts. With the advancement of the innovation-driven development strategy and the steady improvement of innovation incentivization mechanisms and intellectual property protection, enterprises have shown an unprecedented enthusiasm for innovation activity. In 2015, enterprises signed 197 thousand technology transfer contracts with a turnover of 847.7 billion yuan, accounting for 86.2% of the national turnover of technology transfer contracts, and 209 thousand technology absorption contracts with a turnover of 746.4 billion yuan, accounting for 75.9% of the national turnover of technology absorption contracts.

1.4 Technology outflow

As the national technology market gradually matures, there has been an increasing amount of technology transactions and technology transfer services to meet enterprise demand and regional economic transformation. The technology market has flourished further as a result. In 2015, most provinces and municipalities of China experienced a stable growth of technology transaction volume. The top ten regions in terms of the turnover of their technology outflow contracts were Beijing, Hubei, Shaanxi, Shanghai, Guangdong, Jiangsu, Tianjin, Shandong, Sichuan, and Liaoning. The top three region — Beijing, Hubei and Shaanxi — closed a total of 117 thousand technology contracts, accounting for 38.2% of all technology contracts closed nationwide, and their turnover reached 496.5 billion yuan, accounting for 50.5% of the national turnover of technology contracts (Figure 3-14).

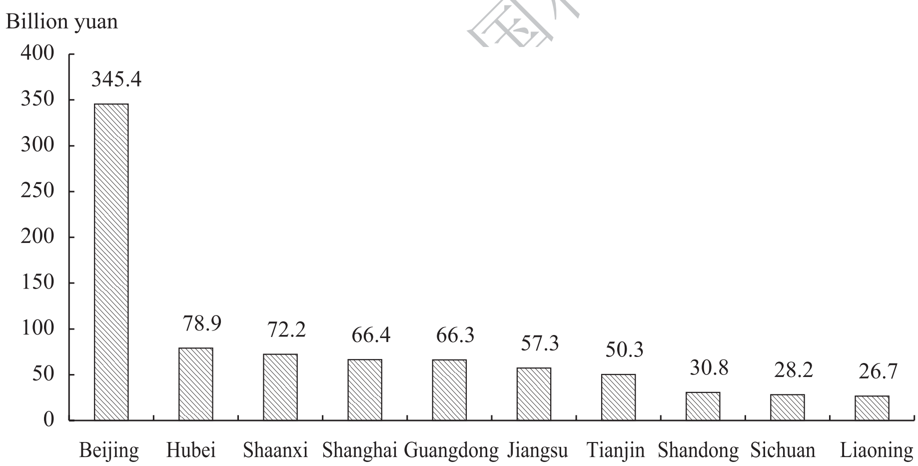

Figure 3-14 China's top 10 regions by turnover of outbound technology contracts (2015)

See Annexed Table 3-13

China Science and Technology Indicators 2016

1.5 Technology absorption

In 2015, Beijing, Jiangsu and Guangdong led the nation in technology absorption. The top ten provinces and municipalities in terms of the turnover of technology absorption contracts were Beijing, Jiangsu, Guangdong, Shanghai, Hubei, Shandong, Fujian, Tianjin, Shaanxi and Sichuan, which combined to represent 207 thousand technology absorption contracts, accounting for

67.5% of all technology contracts nationwide, and their turnover reached 549.9 billion yuan, accounting for 55.9% of the national technology contract turnover (Figure 3-15).

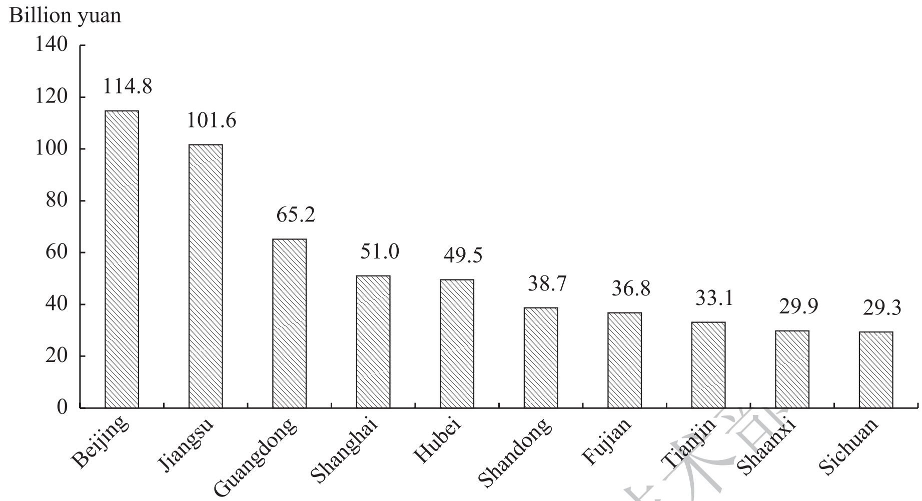

Figure 3-15 China's top 10 regions by turnover of technology absorption contracts (2015)

See Annexed Table 3-13

China Science and Technology Indicators 2016

2 Technology balance of payments

The technology balance of payments (TBP) may be defined as a sub-division of the balance of payments (BOP) used to collate invisible transactions relating to trade in technical knowledge and technology-related services between partners in different countries. The TBP registers four main categories — trade in technology, technology-related services, transactions inclusive of industrial rights, and industrial and technological R&D. Among them, trade in technology includes licenses for the use of outcomes of R&D and other intellectual properties, and transfer of non-produced, non-financial assets such as brands, trademarks, titles and license ownership; technology-related services include computer services, information services, architectural and engineering technology services and other technical services; transactions inclusive of industrial rights include franchises and trademarks licensing fees; and industrial and technological R&D includes transfer of R&D outcomes and contracted R&D.

2.1 Overview of China's technology balance of payments

In 2015, China's TBP was in good shape overall, with the payments reaching USD 46.2 billion, down 0.8% year on year, and the receipts reaching USD 42.5 billion, up 8.6% year on year, the payments exceeding the receipts by USD 3.7 billion, slightly down over the previous year.

China's technology payments overseas included USD 21.0 billion for technology-related services, accounting for 45.5%, and USD 11.6 billion for trade in technology, accounting for 25.1%, in addition to payments for transactions inclusive of industrial rights (19.1%) and industrial and technological R&D (10.3%) (Figure 3-16). Payments for technology-related services were 44.5% represented by computer services and 19.8% by architectural engineering technology services. Payments for trade in technology were 99.0% represented by the use of R&D outcomes, with payments for transfer of non-produced non-financial assets such as brands, trademarks, titles and license ownership accounting for 1.0%.

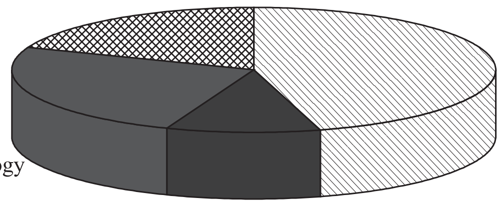

Figure 3-16 China's technology payments by category (2015)

Source: State Administration of Foreign Exchange.

China Science and Technology Indicators 2016

China's technology receipts included USD 34.6 billion from technology-related services, or 81.4%, and USD 7.1 billion from industrial and technological R&D, or 16.6%, with the receipts from trade in technology and transactions inclusive of industrial rights accounting for 1.0% and 0.9%, respectively. The receipts from technology-related services were 64.6% contributed by computer services and 6.7% by architectural engineering technology services (Figure 3-17).

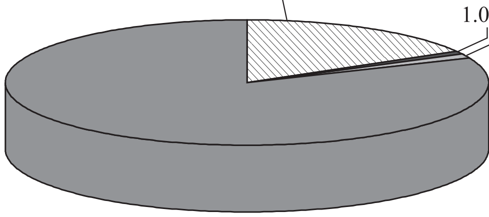

Figure 3-17 China's technology receipts by category (2015)

Source: State Administration of Foreign Exchange.

China Science and Technology Indicators 2016

2.2 China's technology payments and receipts by industry

China's technology payments focused on the manufacturing industry. In 2015, China's technology payments on manufacturing reached USD 28.4 billion, accounting for 61.4% of China's total technology payments. The manufacturing technology payments were 13.3% represented by computer, communications and other electronic equipment manufacturing and 11.7% by railway, shipbuilding, aviation and other transport equipment manufacturing. The second largest industry in terms of technology payments was information transmission, software and information technology services, accounting for 12.0%.

China's technology receipts from overseas were mainly from manufacturing, information transmission, software and information technology services, and scientific research and technical services. In 2015, manufacturing contributed the largest share of China's technology receipts at USD 13.1 billion, or 30.7%, followed by information transmission, software and information technology services with USD 12.5 billion, or 29.4%, and scientific research and technical services with USD 7.0 billion, or 16.4%.

2.3 China's technology payments and receipts by trade partner

Although the United States has always been China's largest trade partner in China's technology balance of payments, approximately 40% of China's technology payments and receipts were with Asian and European regions, mainly including countries and regions such as Japan, Hong Kong of China, Singapore, Germany and the United Kingdom (Table 3-7).

Table 3-7 China's top ten trade partners in technology payments and receipts (2015)

Country/Region	Technology payments (Billion US dollars)	Technology payments as a percentage (%)	Country/Region	Technology receipts (Billion US dollars)	Technology receipts as a percentage (%)
US	10.89	23.6	US	10.86	25.5
Japan	6.17	13.4	Hong Kong of China	7.44	17.5
Germany	5.81	12.6	Singapore	3.51	8.2
UK	3.82	8.3	Japan	2.93	6.9
Hong Kong of China	3.82	8.3	Germany	1.67	3.9
Korea	3.64	7.9	Netherlands	1.59	3.7
Netherlands	1.78	3.9	UK	1.54	3.6
France	1.46	3.2	Luxembourg	1.38	3.3
Switzerland	1.27	2.7	Switzerland	1.34	3.2
Singapore	1.13	2.5	France	1.02	2.4

Source: State Administration of Foreign Exchange.

In terms of China's technology payments by trade partner, China's technology payments in 2015 include USD 17.9 billion to European countries, or 38.7%; USD 16.6 billion to Asian countries, or 36.0%; and USD 11.4 billion to American countries, or 24.7%. In terms of country and region, the United States was the largest receiver of China's technology payments in 2015 by receiving USD 10.9 billion, or 23.6%. Japan and Germany were China's second and third largest technology payment receivers, accounting for 13.4% of China's technology payments with USD 6.2 billion and 12.6% with USD 5.8 billion, respectively.

In terms of China's technology receipts by trade partner, Asian countries were the top source of China's technology receipts in 2015 by contributing USD 17.5 billion, or 41.2%, followed by American countries with USD 12.2 billion, or 28.7%, and European countries with USD 11.8 billion, or 27.7%. In terms of country and region, the United States was the largest source of China's technology receipts in 2015 by contributing USD 10.9 billion, or 25.5% of China's total technology receipts, followed by Hong Kong of China with USD 7.4 billion, or 17.5% and Singapore with USD 3.5 billion, or 8.3%.

Chapter 4 Research and Development Activity and Innovation of Enterprises

Enterprises are the principal actor of innovation in China and a core driving force of China’s innovation development. This chapter analyzes the overall situation of China’s enterprise R&D activity and the R&D activity, the technology innovation activity and the technology acquisition of industrial enterprises, and examines the enterprise innovation activity based on the data of the Enterprise Innovation Survey in 2014.

Section 1 R&D Activity of Enterprises

Conducting R&D activity is a basic precondition for enterprises to achieve technology innovation. R&D activity can be measured by R&D personnel and expenditure. This section analyzes Chinese enterprise R&D activity from the dimensions of enterprise R&D personnel, internal R&D expenditure and R&D expenditure structure.

1 R&D personnel

Enterprise R&D personnel are an enabling factor of enterprise innovation. To meet their increasing demand for innovation, Chinese enterprises have committed an increasing amount of R&D resources with a steadily expanding R&D workforce. In 2015, China had 2.9 million enterprise R&D personnel in FTE, 6.1 times that in 2000, rising as a percentage of the national total to 77.4% from 52.1% in 2000 (Figure 4-1).

The structure of China’s enterprise R&D personnel has the following characteristics. Firstly, the activity of enterprise R&D personnel has strong continuity and specialty. In 2015, full-time R&D personnel accounted for 69.5% of all enterprise R&D personnel, standing between government research institutes and higher education institutions. Secondly, female R&D personnel have a low percentage in enterprise R&D personnel. In 2015, enterprise female R&D personnel reached 891 thousand, accounting for 22.2% of all enterprise R&D personnel. The percentage was significantly lower than that for government research institutes (32.8%) and higher education institutions (41.4%). Thirdly, the education level of enterprise R&D personnel is significantly lower than that of government research institutes and higher education institutions. Enterprise R&D personnel included 43 thousand with a PhD degree, accounting for 1.1%, versus 16.7% for government research institutes and 27.5% for higher education institutions (Table 4-1).

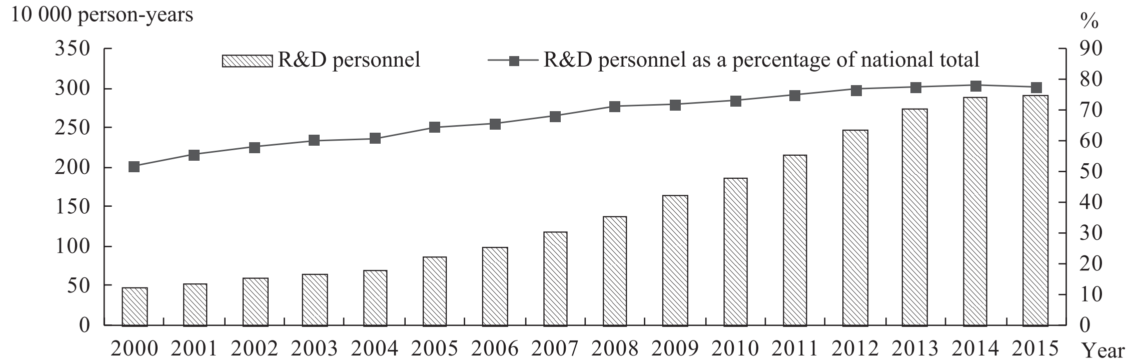

Figure 4-1 Enterprise R&D personnel in FTE and as a percentage of national total (2000–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2001–2016).

See Annexed Table 4-1

China Science and Technology Indicators 2016

Table 4-1 Composition of R&D personnel of enterprises, government research institutes and higher education institutions (2015)

Type of institutions	R&D personnel	Full-time personnel		Females		Doctors		Masters		Undergraduates	
	10 000 persons	10 000 persons	%	10 000 persons	%	10 000 persons	%	10 000 persons	%	10 000 persons	%
Enterprises	401.8	279.2	69.5	89.1	22.2	4.3	1.1	30.4	7.6	118.6	29.5
Government research institutes	43.6	34.7	79.6	14.3	32.8	7.3	16.7	14.6	33.5	14.9	34.2
Higher education institutions	83.9	31.1	37.1	34.7	41.4	23.1	27.5	32.4	38.6	24.0	28.6

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016.*

China Science and Technology Indicators 2016

2 R&D expenditure

Between 2000 and 2015, China's enterprise R&D expenditure saw a steady increase. In 2015, China's enterprise R&D expenditure reached 1.09 trillion yuan, 20.3 times that in 2000, rising as a percentage of the national R&D expenditure to 76.8% from 60.0% in 2000. This trend has highlighted the increasing role played by enterprises as the principal actor of innovation (Figure 4-2).

By type of activity, enterprise R&D expenditure was mainly spent on experimental development, with expenditure on basic research and applied research taking up very low percentages. In 2015, enterprise R&D expenditure on basic research and applied research stood at 1.1 billion yuan and 32.9 billion yuan, accounting for 0.1% and 3.0% of the total enterprise R&D expenditure respectively; between 2010 and 2015, enterprise R&D expenditure on basic research and applied research showed no significant trend of growth, either (Table 4-2).

Table 4-2 Enterprise R&D expenditure by type of activity (2010–2015)

Year	R&D expenditure	Basic research		Applied research		Experimental development	
	Billion yuan	Billion yuan	%	Billion yuan	%	Billion yuan	%
2010	518.55	0.43	0.1	12.62	0.24	505.49	97.5
2011	657.93	0.73	0.1	19.10	0.29	638.11	97.0
2012	784.22	0.71	0.1	23.89	0.30	759.63	96.9
2013	907.58	0.86	0.1	24.92	0.27	881.80	97.2
2014	1006.06	1.00	0.1	31.52	0.31	973.55	96.8
2015	1088.13	1.14	0.1	32.93	0.30	1054.07	96.9

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2011–2016).

China Science and Technology Indicators 2016

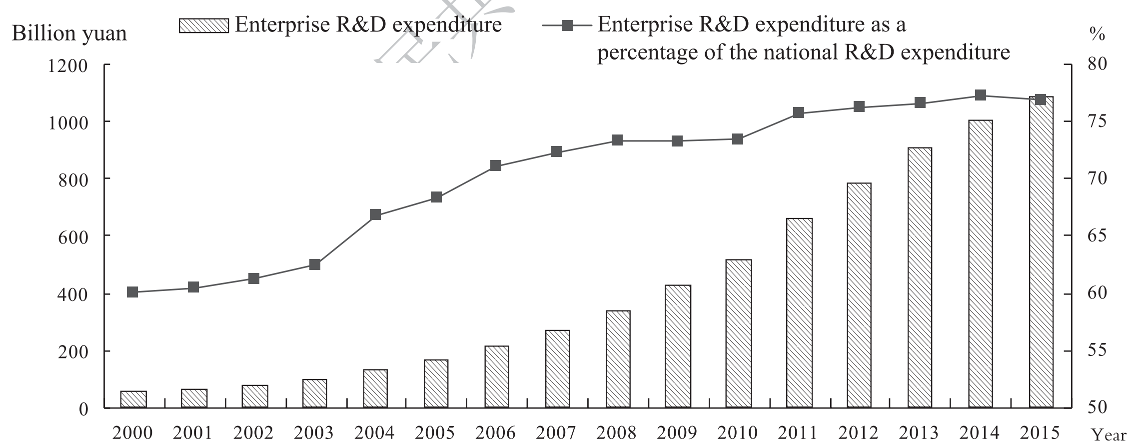

Figure 4-2 Enterprise R&D expenditure and as a percentage of national total (2000–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2001–2016).

See Annexed Table 4-1

China Science and Technology Indicators 2016

In terms of the structure of enterprise R&D expenditure, current expenses constituted the main part, accounting for more than 80%. In 2015, labor costs accounted for 30.7% of internal R&D expenditure, and other current expenses accounted for 58.3%; capital costs accounted for 11.0% of enterprise R&D expenditure, instrument and equipment purchases 10.6%, and other assets expenses 0.4% (Table 4-3). The data for the period between 2010 and 2015 showed an overall stable structure of enterprise R&D expenditure.

Table 4-3 Breakdown of enterprise R&D expenditure (2010–2015)

Year	Internal R&D expenditure	Current expenses				Assets expenses			
		Labor costs		Others		Instrument and equipment purchases		Others	
	Billion yuan	Billion yuan	%	Billion yuan	%	Billion yuan	%	Billion yuan	%
2010	518.55	132.63	25.6	320.42	61.8	61.77	11.9	3.72	0.7
2011	657.93	170.31	25.9	401.58	61.0	81.55	12.4	4.50	0.7
2012	784.22	217.51	27.7	473.84	60.4	88.40	11.3	4.48	0.6
2013	907.58	263.16	29.0	539.84	59.5	99.84	11.0	4.74	0.5
2014	1006.06	298.23	29.6	594.28	59.1	108.69	10.8	4.86	0.5
2015	1088.13	334.39	30.7	634.54	58.3	115.33	10.6	3.87	0.4

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2011–2016).

China Science and Technology Indicators 2016

In terms of the sources of R&D funds, enterprise funds was the principal source, accounting for approximately 93% between 2010 and 2015, followed by government funds at 4%, and foreign funds and other funds at approximately 1% (Figure 4-3).

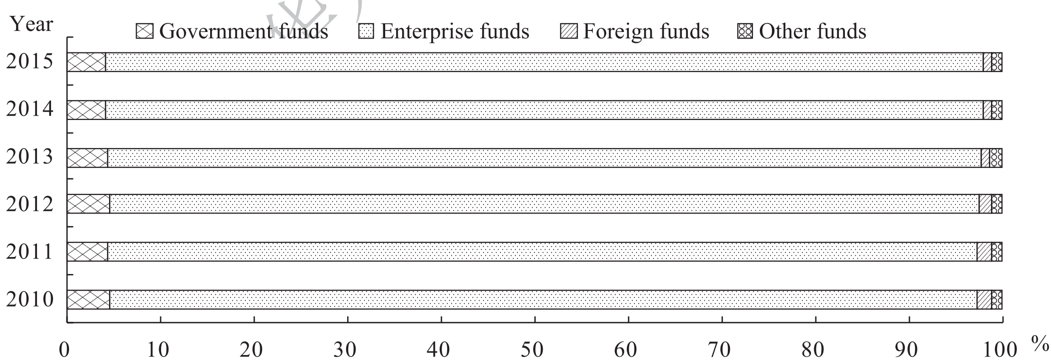

Figure 4-3 Enterprise R&D expenditure by source (2010–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2011–2016).

See Annexed Table 4-2

China Science and Technology Indicators 2016

Section 2　R&D Activity of Industrial Enterprises

Industrial enterprises are the mainstay of China’s enterprise technology innovation, whose R&D activity to a large extent reflects the overall innovation capacity of Chinese enterprises at large. Industrial enterprises above designated size constitute the main force of industrial enterprises and to a large extent represent the innovation capacity of industrial enterprises at large. Based on data availability, this section analyzes the R&D activity of industrial enterprises above designated size.

1　R&D organizations

R&D organizations established by enterprises are an important vehicle of enterprise R&D activity. In 2015, China had 74 thousand industrial enterprises above designated size that had R&D activity, 4.3 times that in 2000. Enterprises with R&D activity as a percentage of industrial enterprises reached 19.2% in 2015, representing an increase of 8.6 percentage points over 2000. Among the industrial enterprises, 53 thousand had R&D organizations, accounting for 13.8%, up 8.8 percentage points over 2004 (Table 4-4).

Table 4-4　Overview of R&D activity of industrial enterprises (2000–2015)

Indicator	2000	2004	2008	2009	2011	2012	2013	2014	2015
Number of industrial enterprises	—	276474	418880	429378	325753	343769	369741	377868	383153
Number of enterprises with R&D activity	17272	17075	27278	36387	37467	47204	54832	63676	73570
Enterprises with R&D activity as a percentage of all industrial enterprises (%)	10.6	6.2	6.5	8.5	11.5	13.7	14.8	16.9	19.2
Number of enterprises with R&D organization	—	13906	22156	25391	25454	38864	43055	47689	52833
Enterprises with R&D organization as a percentage of all industrial enterprises (%)	—	5.0	5.3	5.9	7.8	11.3	11.6	12.6	13.8

Source: National Office of R&D Census, *National Industrial Statistics on the 2000 R&D Census*; National Bureau of Statistics, *China Economic Census Yearbook 2004* and *China Economic Census Yearbook 2008*; National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2012–2016).

In 2015, enterprises with R&D organization reached 63 thousand, 4.1 times that in 2000. Enterprise R&D organization personnel reached 2.7 million, 4.4 times that in 2000. Enterprise R&D organization expenditure reached 679.4 billion yuan, 15.6 times that in 2000. As fully demonstrated by their number and commitment of R&D resources, enterprise R&D organizations have become an important vehicle of innovation activity of enterprises (Table 4-5).

Table 4-5 Industrial enterprises with R&D organization (2000–2015)

Indicator	2000	2004	2008	2009	2011	2012	2013	2014	2015
Number of enterprise R&D organizations	15529	17555	26177	29879	31320	45937	51625	57199	62954
Number of enterprise R&D organization personnel (10 000 persons)	60.1	64.4	130.4	155	181.6	226.8	238.8	246.4	266.8
Enterprise R&D organization expenditure (Billion yuan)	43.58	84.16	263.48	298.36	395.70	523.34	594.15	625.76	679.39

Source: The same as Table 4-4.

China Science and Technology Indicators 2016

2 R&D personnel

High-caliber R&D personnel is the engine of enterprise innovation. In 2015, China's industrial enterprises above designated size had 3.6 million R&D personnel, 5.2 times that in 2000, including 2.7 million in large and medium-sized enterprises, 5 times that in 2000. Overall, large and medium-sized enterprises are the mainstay of innovation activity of industrial enterprises above designated size, whose R&D personnel account for more than 70% of R&D personnel of industrial enterprises above designated size. In 2015, industrial enterprises above designated size had 2.6 million person-years of R&D personnel in FTE, 6.0 times that in 2000, including 2.0 million person-years in large and medium-sized enterprises, 6.0 times that in 2000. Between 2000 and 2015, large and medium-sized enterprises contributed more than 70% of all R&D personnel of industrial enterprises above designated size, serving as a leading force of enterprise innovation (Table 4-6).

Table 4-6 Industrial enterprise R&D personnel (2000–2015)

Year	R&D personnel (10 000 persons)	Large and medium-sized enterprise R&D personnel (10 000 persons)	Percentage (%)	R&D personnel in FTE (10 000 person-years)	Large and medium-sized enterprise R&D personnel in FTE (10 000 person-years)	Percentage (%)
2000	70.0	54.3	77.6	43.9	32.9	74.9
2004	81.2	65.4	80.5	54.2	43.8	80.8
2008	152.0	124.1	81.6	123.0	101.4	82.4
2009	191.4	151.9	79.4	144.7	115.9	80.1
2011	254.7	205.2	80.6	193.9	158.7	81.8
2012	305.1	243.5	79.8	224.6	181.9	81.0
2013	337.6	263.4	78.0	249.4	197.7	79.3
2014	363.3	275.4	75.8	264.2	203.8	77.1
2015	364.6	270.1	74.1	263.8	198.6	75.3

Source: The same as Table 4-4.

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3 R&D expenditure

3.1 R&D expenditure and intensity

R&D expenditure of industrial enterprises above designated size in China had shown a trend of steady increase. In 2015, industrial enterprises above designated size recorded 1001.4 billion yuan in internal R&D expenditure, 20.4 times that in 2000. The amount included 779.2 billion yuan from large and medium-sized industrial enterprises, 22.1 times that in 2000. In 2015, large and medium-sized enterprise R&D expenditure as a percentage of R&D expenditure of industrial enterprises above designated size reached 77.8%, representing the mainstay of enterprise R&D investment (Figure 4-4).

R&D intensity (ratio of R&D expenditure to revenue from principal business) is an important indicator of enterprise innovation capacity. Between 2000 and 2015, the R&D intensity of China's industrial enterprises above designated size increased from 0.58% to 0.90%; and that of large and medium-sized industrial enterprises, which was generally higher than the average level of industrial enterprises above designated size, reached 1.1%, representing an increase of 0.4 percentage point compared to 2000. The increasing R&D intensity shows the increasing investment of Chinese industrial enterprises in independent innovation and the increasing importance they attach to technology innovation (Figure 4-5).

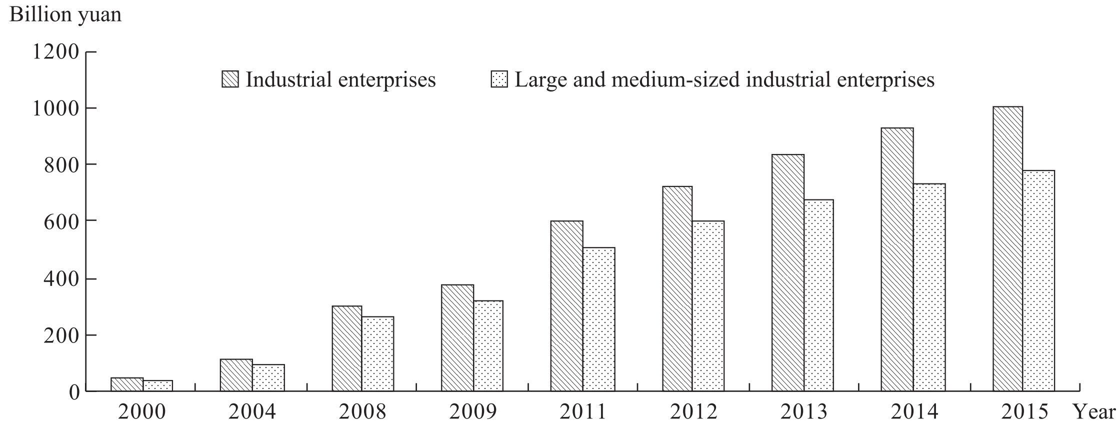

Figure 4-4 R&D expenditure of industrial enterprises and large and medium-sized industrial enterprises (2000–2015)

Source: The same as Table 4-4.

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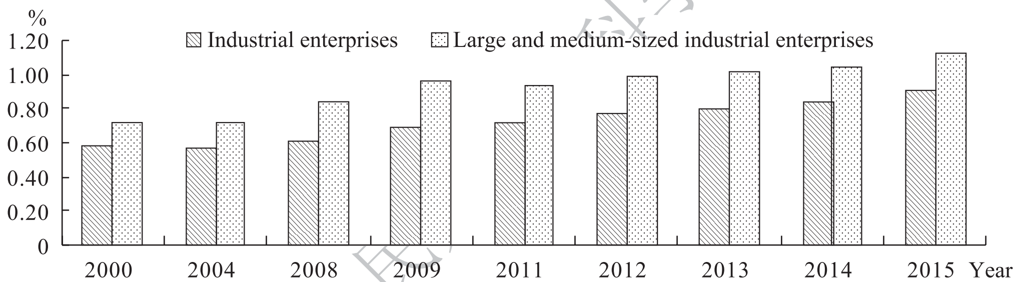

Figure 4-5 R&D intensity of industrial enterprises (2000–2015)

Source: The same as Table 4-4.

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3.2 R&D expenditure by type of activity

R&D activity of China's industrial enterprises above designated size focused on experimental development with insignificant investment in basic research and applied research. In 2015, the R&D expenditure of China's industrial enterprises above designated size on experimental development reached 975.5 billion yuan, 19.6 times that in 2000, accounting for 97.4% of their total R&D expenditure, up 4.9 percentage points over 2000 (Figure 4-6).

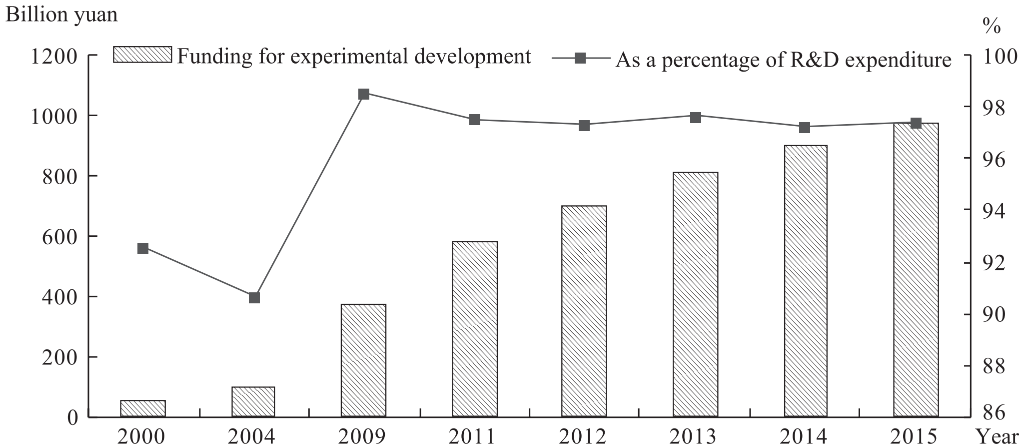

Figure 4-6 R&D expenditure of industrial enterprises on experimental development (2000–2015)

Source: The same as Table 4-4.

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3.3 R&D expenditure by type of enterprise

In terms of R&D expenditure by type of enterprise, the R&D expenditure of large enterprises reached 552.6 billion yuan in 2015, accounting for 55.2% of R&D expenditure of industrial enterprises above designated size, overshadowing medium-sized enterprises (22.6%) and indicating a positive correlation between enterprise size and R&D expenditure. In terms of R&D expenditure by type of ownership system, domestic-funded enterprises recorded 771.2 billion yuan, accounting for 77.0% of R&D expenditure of industrial enterprises above designated size, versus 9.5% for Hong Kong, Macao and Taiwan-funded enterprises and 13.5% for foreign-funded enterprises. Domestic-funded enterprises are the mainstay of R&D expenditure of industrial enterprises in China (Table 4-7).

Table 4-7 R&D expenditure by type of industrial enterprise

Type of enterprises	R&D expenditure (Billion yuan)	R&D expenditure as a percentage of that of industrial enterprises above designated size (%)
Large enterprises	552.58	55.2
Medium-sized enterprises	226.66	22.6
Domestic-funded enterprises	771.24	77.0
Hong Kong, Macao and Taiwan-funded enterprises	94.77	9.5
Foreign-funded enterprises	135.39	13.5

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016.*

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3.4 R&D expenditure by industry

The R&D expenditure of China's industrial enterprises above designated size had a high degree of concentration of industries. In 2015, the computer, communications and other electronic equipment manufacturing industry recorded the highest R&D expenditure with 161.2 billion yuan, accounting for 16.1%, followed by electrical machinery and equipment manufacturing with 10.1% and automotive manufacturing with 9.0%. In the 4th through 10th spots were chemical raw materials and chemical products manufacturing, general equipment manufacturing, special equipment manufacturing, ferrous metal smelting and rolling processing, pharmaceutical manufacturing, railway, shipbuilding, aviation and other transport equipment manufacturing, and non-ferrous metal smelting and rolling processing, respectively (Table 4-8).

Table 4-8 Top ten industries by R&D expenditure (2015)

Industry	R&D expenditure (Billion yuan)	R&D expenditure as a percentage of that of industrial enterprises above designated size (%)
Computer, communications and other electronic equipment manufacturing	161.17	16.1
Electrical machinery and equipment manufacturing	101.27	10.1
Automotive manufacturing	90.42	9.0
Chemical raw materials and chemical products manufacturing	79.45	7.9
General equipment manufacturing	63.26	6.3
Special equipment manufacturing	56.71	5.7
Ferrous metal smelting and rolling processing	56.12	5.6
Pharmaceutical manufacturing	44.15	4.4
Railway, shipbuilding, aviation and other transport equipment manufacturing	43.59	4.4
Non-ferrous metal smelting and rolling processing	37.15	3.7

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016.*

Section 3 Patents and New Product Development of Industrial Enterprises

In the age of the knowledge economy, know-what and know-how is a core asset of enterprises that needs to be effectively protected. Their value is mainly shown in the form of new products developed and sold.

1 Patents

The number of patents owned by an enterprise is a direct proof of an enterprise's innovation activity and a core indicator of its innovation capacity. The number of invention patent applications and the number of invention patents granted, in particular, are important indicators of innovation strength.

1.1 Patent applications

Patent applications of industrial enterprises above designated size in China rose sharply from 26 thousand in 2000 to 639 thousand in 2015, representing an increase of 23.4 times. At the same time, the number of invention patent applications also showed a trend of rapid growth. Industrial enterprises above designated size filed less than 10 thousand invention patents in 2000, which, however, quickly leaped to 246 thousand in 2015, representing an increase of 29.8 times. The structure of patent applications of industrial enterprises showed an improvement as well, with invention patent applications as a percentage of all patent applications rising from 30.4% in 2000 to 38.5% in 2015 (Table 4-9).

Table 4-9 Patent applications by industrial enterprises (2000–2015)

Indicator	2000	2004	2008	2009	2011	2012	2013	2014	2015
Patent applications (Piece)	26184	64569	173573	265808	386075	489945	560918	630561	638513
Including: invention patents	7970	20456	59254	92450	134843	176167	205146	239925	245688
Invention patent applications as a percentage of all patent applications (%)	30.4	31.7	34.1	34.8	34.9	36.0	36.6	38.0	38.5

Source: The same as Table 4-4.

China Science and Technology Indicators 2016

1.2 Invention patents in force

Patents in force owned by industrial enterprises above designated size in China rose sharply from 15 thousand in 2000 to 574 thousand in 2015, representing an increase of 37.3 times, with the advantage of industrial enterprises in terms of their greater number of invention patents gradually emerging (Figure 4-7).

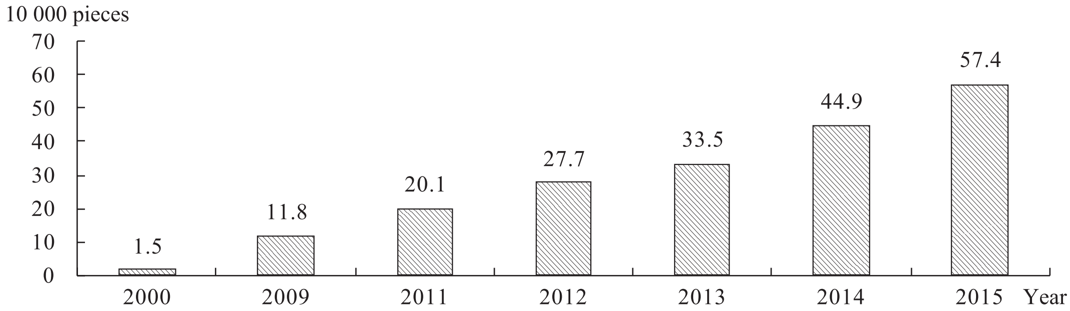

Figure 4-7 Patents in force of industrial enterprises (2000–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016.*

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2 New product development

With the deepening of innovation-driven development and transformation in China's industrial sector, there has been a steady improvement in product innovation activity and operation efficiency of industrial enterprises, as prominently demonstrated by the increasing amount of new product development and sales.

2.1 New product development projects

The number of new product development projects of China's industrial enterprises saw a steady increase from 92 thousand in 2000 to 326 thousand in 2015, representing a growth of 2.6 times. By the type of enterprise, domestic-funded enterprises had the greatest number of new product development projects, which reached 258 thousand in 2015, or 79.0% of all new product development projects of industrial enterprises above designated size, representing the core force of new product development in China (Table 4-10).

Table 4-10 Number of new product development projects of industrial enterprises by type of registration (2000–2015)

Unit: Piece

Type of Enterprise	2000	2004	2008	2009	2011	2012	2013	2014	2015
Total	91880	76176	184859	237754	266232	323448	358287	375863	326286
Domestic-funded enterprises	76840	62706	140645	181305	205080	247015	274397	295229	257633
Hong Kong, Macao and Taiwan-funded enterprises	7707	5404	17189	22261	25518	30947	34247	33181	30416
Foreign-funded enterprises	7333	8066	27025	34188	35634	45486	49643	47453	38237

Source: The same as Table 4-4.

China Science and Technology Indicators 2016

2.2 New product development expenditure

The new product development expenditure of China's industrial enterprises above designated size steadily increased from 52.9 billion yuan in 2000 to 1.03 trillion yuan in 2015, representing a growth of 18.4 times. At the same time, new product development expenditure intensity (defined as the ratio of new product development expenditure to revenue from principal business) also showed a steady trend of growth. In 2015, the new product development expenditure intensity of industrial enterprises above designated size reached a historical high of 0.93% with a strong momentum to move even higher (Figure 4-8).

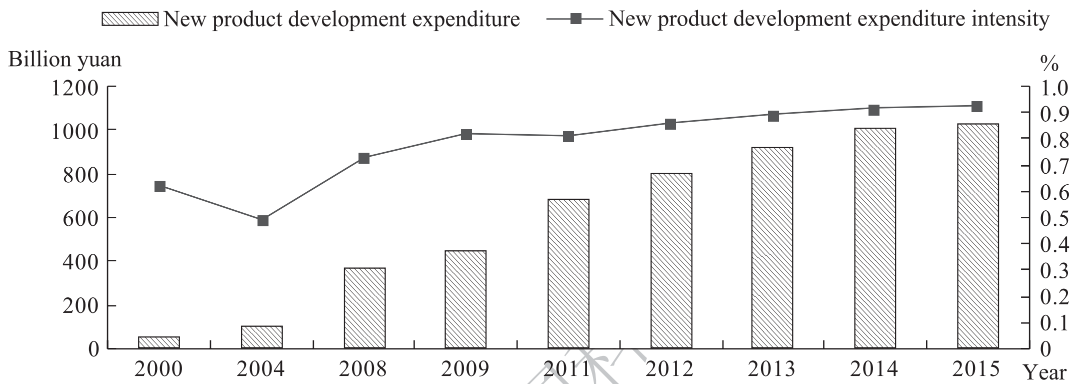

Figure 4-8 New product development expenditure of industrial enterprises (2000–2015)

Source: The same as Table 4-4.

China Science and Technology Indicators 2016

2.3 New product sales revenue

The new product sales revenue of China's industrial enterprises above designated size saw a steady increase from 2000, rising from less than 1 trillion yuan to 15.1 trillion yuan in 2015. New product sales intensity (defined as the ratio of new product sales revenue to total sales revenue) is an important indicator of the effectiveness of innovation activity of enterprises. The new product sales intensity of China's industrial enterprises above designated size showed an overall upward trend, improving from 11.0% in 2000 to 13.6% in 2015.

Section 4 Innovation Activity of Enterprises

This section examines China's enterprise innovation, entrepreneur understanding of innovation, and related developments based on the findings of the Enterprise Innovation Survey in 2014. The analysis of enterprise innovation covers enterprise innovation overview, innovation collaboration, factors hindering innovation; and protection of intellectual properties underlying innovations; and the analysis of entrepreneur understanding of innovation and related developments scrutinizes the effects of innovation on enterprises and factors contributing to successful innovation.

1 Innovation activity overview

According to the *Statistics of the 2014 National Enterprise Innovation Survey*, China had 266 thousand enterprises with innovation activity in 2014, accounting for 41.3% of all enterprises. They included 256 thousand which achieved innovation, accounting for 39.7%; and 58 thousand which achieved innovation in all the four categories of innovation i.e. product innovation, process innovation, organizational innovation and marketing innovation, accounting for 9.1%.

In 2014, there were 121 thousand enterprises which achieved product innovation (18.7%) and 129 thousand which achieved process innovation (20.0%), with those which achieved both product innovation and process innovation accounting for 14.4%; and 218 thousand which achieved organizational innovation and/or marketing innovation (33.8%), with those which achieved organizational innovation accounting for 27.9%, those which achieved marketing innovation accounting for 25.8%, and those which achieved both organizational innovation and marketing innovation accounting for 19.9%.

Among enterprises with product or process innovation activity, 56.8% had internal R&D activity which was their most frequently conducted type of innovation activity; 51.3% had innovation activity in the form of equipment and software purchase, with 45.4% providing related training; in addition, enterprises with market promotion accounted for 24%, those performing related design activity 22.5%, those resorting to external R&D 13%, and those acquiring related technology externally 5.7%. These data showed that China's innovation enterprises turn more to internal R&D and do not much rely on externally acquired technology or knowledge.

2 Innovation model and collaborative innovation

Among enterprises which achieved product innovation, 76% chose independent development, followed by those turning to collaborative development with domestic higher education institutions (11.3%), those which performed adjustment or improvement on the basis of third-party development (8.9%), and those which chose collaborative development with other domestic enterprises or other subsidiaries within the same group (8%).

Among enterprises which achieved process innovation, 66.9% chose independent development, followed by those which performed adjustment or improvement on the basis of third-party development (12.2%), those which chose collaborative development with other domestic enterprises (10.5%), those which outsourced development to other enterprises or organizations (10.2%), those which chose collaborative development with domestic higher education institutions (9.7%), and those which conducted collaborative development with other subsidiaries within the same group (8.5%).

In collaborative innovation, there were 130 thousand enterprises adopting this model in 2014, accounting for 20.1% of all enterprises. Among enterprises engaged in collaborative innovation, those which partnered with customers accounted for 45.4% and those which partnered with suppliers accounted for 36.1%, representing the two most common forms of innovation partnership; those which collaborated with higher education institutions accounted for 29.2%, and those with other subsidiaries within the same group 29.1%; those with industry associations 20.2%, those with research institutes 19.6%, and those with competitors or industry peers 18.9%; meanwhile, approximately 11% collaborated with market research agencies and government departments; and those which collaborated with venture capital firms represented the smallest group, accounting for only 1.5%.

Among enterprises engaged in collaborative innovation, 26.9% believed that collaboration with customers played a valuable role in their innovation activity; 19.2% believed that the collaboration with suppliers had a positive effect on their innovation; 13.8% stated that the collaboration with other subsidiaries in the same group and higher education institutions drove their innovation; and approximately 10% said that competitors, industry peers and industry associations had a significant influence on their innovation.

In 2014, enterprises that were engaged in industry-university collaboration reached 48 thousand, accounting for 36.9% of all enterprises engaged in collaborative innovation. Among enterprises engaged in industry-university collaboration, 62.7% chose the joint research model; 31.1% chose to engage researchers at higher education institutions or research institutes on a part-time basis; 29.6% chose to establish internal R&D organizations; and 13% chose to establish R&D organizations at higher education institutions, showing the diversified ways in which industry-university collaboration took place.

3 Factors hindering product or process innovation

Among all the 646 thousand enterprises, 22.4% considered the lack of high-caliber personnel as a main factor hindering innovation; 18.3% considered the lack of necessity to innovate as a core factor that stood in the way of innovation; 16.1% cited the high cost of innovation and 14.1% cited the lack of technical information; and 12% pointed to the lack of financial support and uncertainty of market demand. Market being dominated and innovation being easily imitated were generally not considered as main factors hindering innovation.

4 Intellectual property and related conditions

In 2014, enterprises that took measures to protect intellectual property reached 293 thousand, accounting for 45.4% of all enterprises; 17.0% benefited from technological outcomes that they achieved earlier than others; 12.3% took measures to protect their innovation by way of know-how protection; 11.4% applied for registered trademarks; 7.3% filed invention patents and 7.8% filed other patents; and 6.3% formed national or industry technical standards. Only 2.1% filed copyrights and only 2.5% applied inimitable sophisticated technology.

5 Innovation activity and enterprise development

According to the survey, enterprises which considered innovation as playing an important role in business survival and development reached 25.9%, enterprises which considered innovation as playing some role accounted for 59.4%, though there were still 14.6% which did not think that innovation played any role in business development.

Among entrepreneurs whose enterprises had innovation activity, 45.3% considered high-caliber personnel to be crucial for successful innovation; 42.6% considered innovative spirit on the part of the entrepreneur, and 40.3% considered identification of employees with the enterprise, to be the most important factor of successful innovation; 35% cited internal incentives, adequate funding, effective technology strategy or plan, and smooth internal flow of information; 33.3% cited favorable policy; and 32.5% cited reliable innovation partners.

Among entrepreneurs whose enterprises had innovation activity, approximately 58% considered policy encouraging enterprises to attract and develop talent and create and protect intellectual property to be fairly effective; more than 50% cited financial support policy, policy giving support to prioritized industries, and tax incentives for R&D; and more than 40% cited corporate income tax incentives for high-tech enterprises, accelerated depreciation of R&D equipment and VAT exemption for income from technology transfer and technology development.

Chapter 5 Science and Technology Activity of Higher Education Institutions

Higher education institutions are an important component of the national innovation system and serve as main actors of R&D and innovation activity and major bases of innovation talent development. Based on statistics, this chapter presents an overview of China's higher education development with the focus on R&D organizations and personnel, R&D expenditure and R&D output and provides comparative analysis on different indicators as they relate to higher education institutions at different levels, of different types and in different countries.

Section 1 Overview of Higher Education Institutions

As higher education steadily expands, the number of higher education institutions (hereafter referred to as HEIs) in China continues to grow stably. The increasing number of full-time teachers and postgraduate students in HEIs has provided a strong foundation for their R&D activity.

1 Number of higher education institutions

With the increasing demand for higher education and continued higher education expansion, the period between 2006 and 2015 saw a gradual increase of HEIs in China from 693 to 2560 (Figure 5-1). With the exception of 2008 which saw more than 300 independent colleges affiliated with public universities converted to private HEIs, the recent years had an annual increase of 30~40.

2 Number of full-time teachers and postgraduate students

Full-time teachers are a main group of R&D actors in HEIs, supplemented by postgraduate students who conduct R&D activity under the direction of their supervisors and who are an important source of future R&D personnel.

2.1 Number of full-time teachers

In 2015, full-time teachers in China's HEIs reached 1.6 million, representing an increase of 497 thousand or 46.4% from 2006. With the gradual stabilization of the scale of higher education enrollment, the number of full-time teachers in HEIs, while still increasing, has experienced a marked slowdown of growth. The growth rate, which stood at 11.4% in 2006, began to slow down sharply in 2007 and fell all the way to 2.5% in 2015 (Figure 5-2).

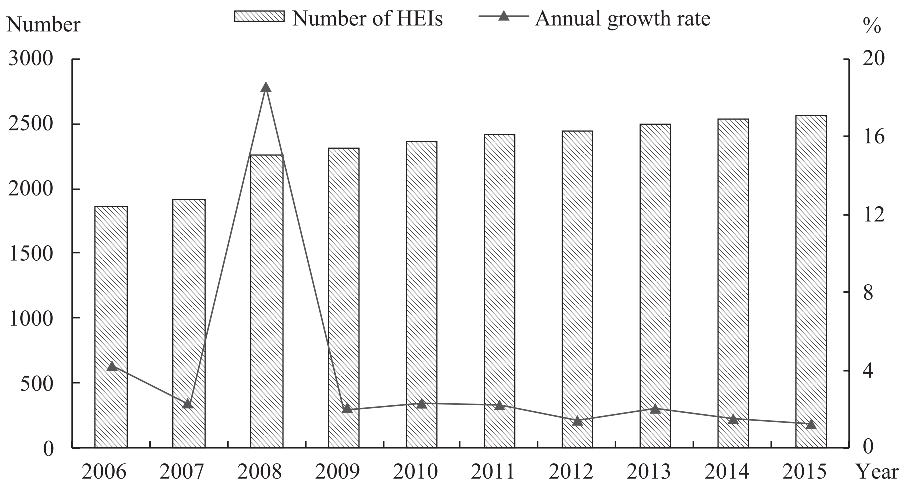

Figure 5-1　Number of HEIs in China (2006–2015)

Source: Department of Development Planning of the Ministry of Education, *China Statistical Yearbook on Education* (2006–2015).

See Annexed Table 5-1

China Science and Technology Indicators 2016

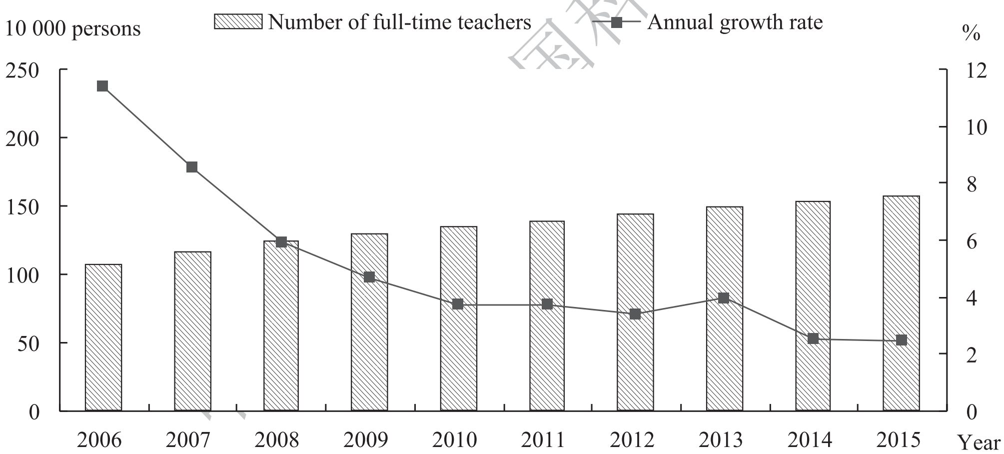

Figure 5-2　Number and growth of full-time teachers in HEIs (2006–2015)

Source: Department of Development Planning of the Ministry of Education, *China Statistical Yearbook on Education* (2006–2015).

China Science and Technology Indicators 2016

The last nearly ten years have seen a rapid improvement of education level of full-time teachers in HEIs. In 2015, full-time teachers in HEIs included 338 thousand with a PhD degree, accounting for 21.5%; 569 thousand with a master's degree (36.2%); 645 thousand with a bachelor's degree (41.0%); and 20 thousand with an associate degree or lower (1.3%). Compared to 2006, the percentage of full-time teachers with a PhD degree and a master's degree increased 11.4 percentage points and 6.7 percentage points respectively in 2015, while the percentage of full-time teachers with a bachelor's degree and an associate degree or lower decreased 16.6 percentage points and 1.5 percentage points in the same year.

2.2 Number of postgraduate students

In 2015, there were a total of 1.9 million postgraduate students in HEIs in China, representing an increase of 830 thousand or 78.6% from 2006. Between 2006 and 2015, the growth of postgraduate students in HEIs gradually slowed down due to the slowdown of higher education expansion. Before 2011, the annual growth was always above 7%, but the growth slowed down sharply after that and fell to 3.5% in 2015 (Figure 5-3).

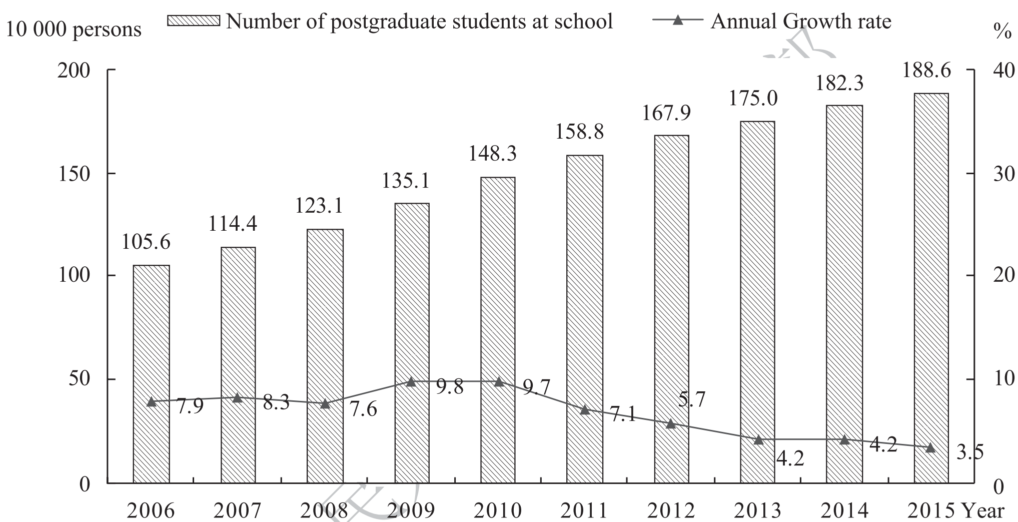

Figure 5-3 Number of postgraduate students in HEIs (2006–2015)

Source: Department of Development Planning of the Ministry of Education, *China Statistical Yearbook on Education* (2006–2015).

China Science and Technology Indicators 2016

Section 2 R&D Organizations and Personnel

From 2006, the number of R&D organizations in China's HEIs and personnel saw a steady growth with an increasingly optimized structure. Compared to developed countries, China had a large scale of R&D personnel in HEIs, but their share in the national R&D personnel remained low.

1 Number of R&D organizations

R&D organizations are an important part of the higher education R&D and innovation system and an important vehicle of knowledge innovation and innovation talent development. Between 2006 and 2015, the number of China's R&D organizations in HEIs increased steadily from 4,154 to 11,732, representing an increase of 1.8 times in ten years. The year 2010, in particular, registered the highest increase of 28.8% over the previous year (Figure 5-4).

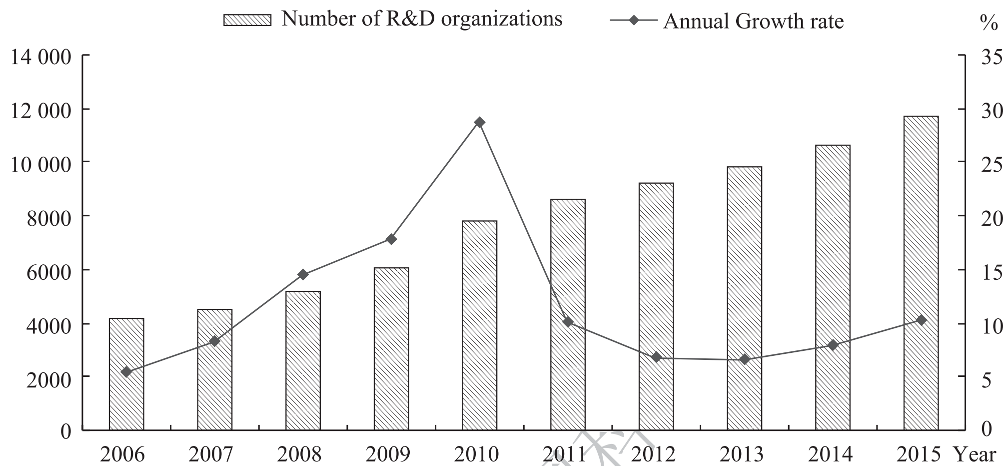

Figure 5-4 Number of R&D organizations in HEIs (2006–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2007–2016).

See Annexed Table 5-1

2 R&D personnel in higher education institutions

2.1 R&D personnel

In recent years, R&D personnel in China's HEIs steadily increased, reaching 839 thousand in 2015, representing an increase of 245 thousand or an average annual growth of 8.7% from 2010. R&D personnel in China's HEIs as a percentage of national total showed a trend of decreasing before increasing, which fell from 16.8% in 2010 to 14.2% in 2013 and then rose to 15.3% in 2015 (Figure 5-5).

2.2 R&D personnel in FTE

In 2015, R&D personnel (FTE) in HEIs reached 355 thousand person-years, with an increase of 113 thousand person-years or an average annual growth of 4.3% from 2006. Between 2006 and 2015, R&D personnel (FTE) in HEIs saw a steady increase, but as a percentage of national total, the trend was overall downward, falling from 16.1% in 2006 to 9.4% in 2015 (Figure 5-6).

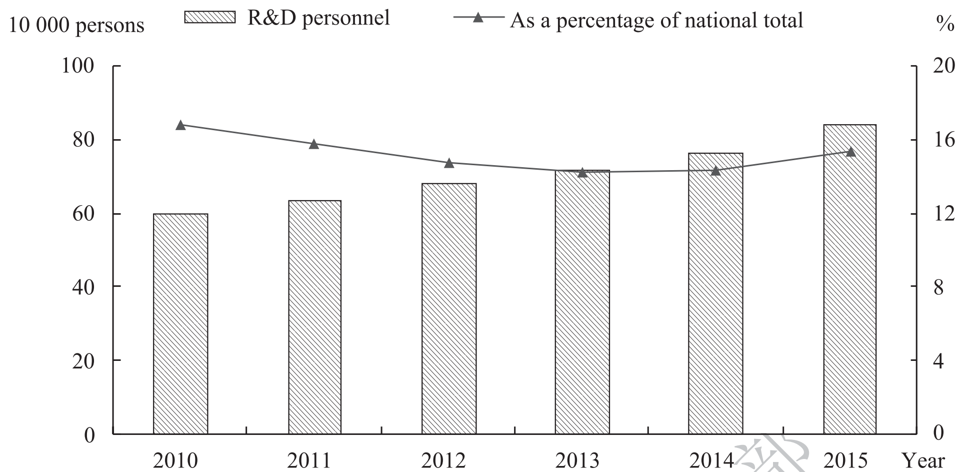

Figure 5-5 R&D personnel in HEIs and as a percentage of national total (2010–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2007–2016).

See Annexed Table 5-1

China Science and Technology Indicators 2016

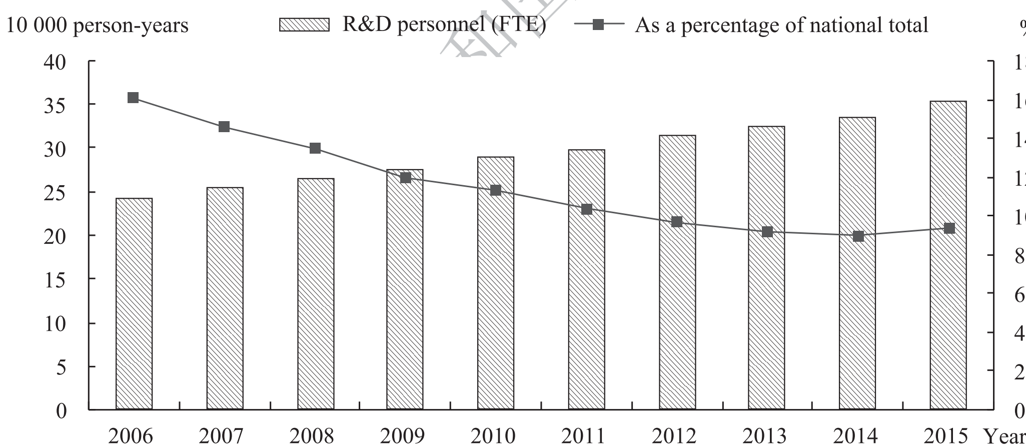

Figure 5-6 R&D personnel (FTE) in HEIs and as a percentage of national total (2006–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2007–2016).

See Annexed Table 5-1

China Science and Technology Indicators 2016

3 International comparison of R&D personnel

Worldwide, the number of China's R&D personnel (FTE) was large in scale, but still significantly behind developed countries as a percentage of national total. In 2015, R&D personnel (FTE) in China's HEIs reached 355 thousand person-years, versus 209 thousand for Japan, and 120~190 thousand for the United Kingdom, Germany, Russia and France. In terms of the scale of R&D personnel (FTE), China led these countries by a big margin. However, in terms of R&D personnel (FTE) as a percentage of national total, the percentage was as high as 45.2% for the United Kingdom in 2015, and more than 20% for countries such as Switzerland, Belgium, France, the Netherlands, Sweden, Japan and Germany, while the percentage was only 9.4% for China (Figure 5-7).

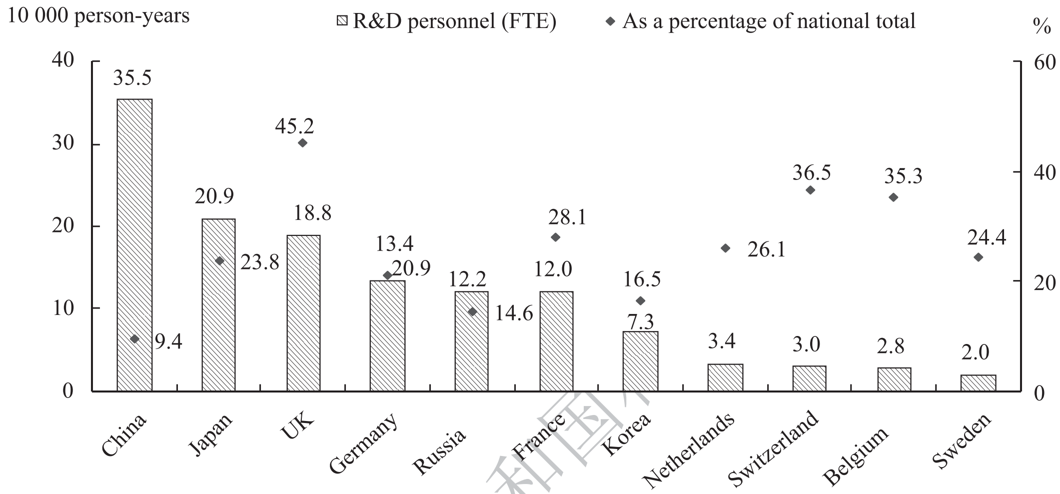

Figure 5-7 R&D personnel (FTE) in HEIs and as a percentage of national total of selected countries (2015)

Source: OECD, Main Science and Technology Indicators 2017-1.

China Science and Technology Indicators 2016

R&D personnel (FTE) as a percentage of total R&D personnel reflects the soundness of a country's R&D, personnel structure. In 2015, China had 299 thousand person-years of higher education researchers, ranking high in the world and accounting for 84.2% of the country's higher education R&D personnel. This compared to 89.5% for the United Kingdom, 86.0% for Belgium, 83.9% for Sweden, 77.0% for Germany, 76.0% for Russia, 71.9% for Switzerland and 65.7% for Japan. Compared to developed countries, China's higher education researchers are at a high level in terms of both the number and the percentage in R&D personnel (Figure 5-8).

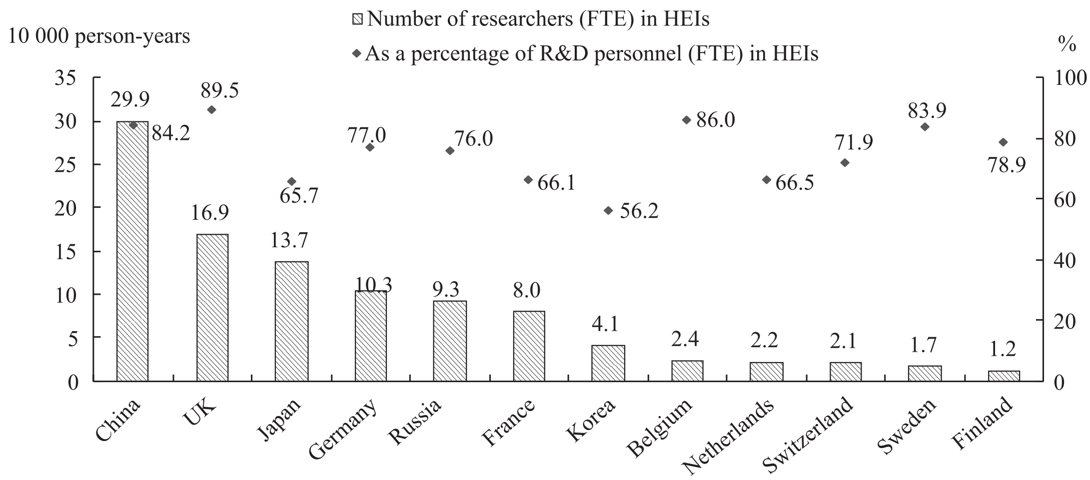

Figure 5-8 Number of researchers and as a percentage of R&D personnel in HEIs of selected countries (2015)

Source: OECD, Main Science and Technology Indicators 2017-1.

China Science and Technology Indicators 2016

Section 3 R&D Expenditure

R&D expenditure is an important guarantee for the conduction of science, technology and innovation activities in HEIs and the material foundation for enhancing R&D level. Thus, increasing the input of R&D expenditure for HEIs and enhancing the utilization efficiency of such expenditure is significant for accelerating the building of an innovation-oriented country.

1 Scale of R&D expenditure

In 2015, the higher education R&D expenditure amounted to 99.9 billion yuan, representing an increase of 10.05 billion from a year earlier. Between 2005 and 2015, China's higher education R&D expenditure steadily increased with an average annual growth of 15.2%. In the same period, the higher education R&D expenditure as a percentage of national total showed a downward trend, decreasing from 9.9% in 2005 to 7.1% in 2015 (Figure 5-9).

2 Structure of R&D expenditure

The higher education R&D expenditure in 2015 included 51.63 billion yuan of applied research expenditure, up 53.2% from 2010; 39.10 billion yuan of basic research expenditure, up 117.4% from 2010; and 9.13 billion yuan of experimental development expenditure, up 13.6% from 2010. Between 2005 and 2015, basic research expenditure as a percentage of the total higher education R&D expenditure rose significantly from 23.4% to 39.2%; applied research expenditure remained stable within the 50%~55% range; and experimental development expenditure gradually decreased from 25.0% to 9.1% (Figure 5-10).

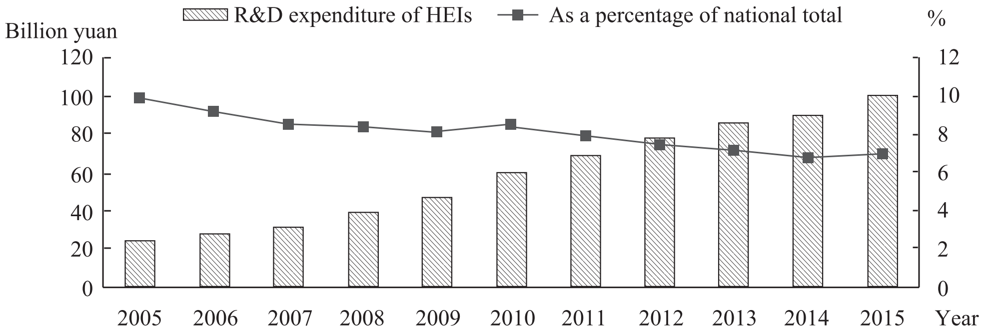

Figure 5-9 R&D expenditure in HEIs and as a percentage of national total (2005–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2006–2016).

See Annexed Table 5-1

China Science and Technology Indicators 2016

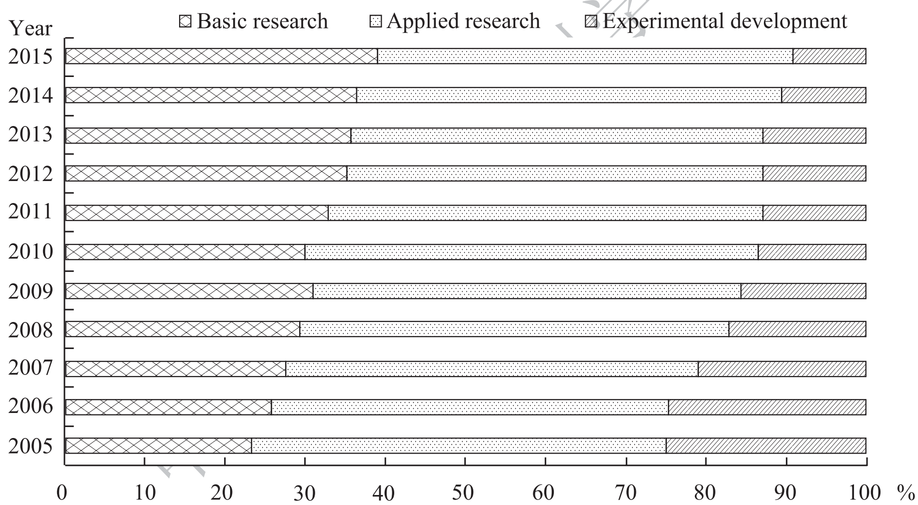

Figure 5-10 Higher education R&D expenditure by type of activity (2005–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2006–2016).

See Annexed Table 5-1

China Science and Technology Indicators 2016

Between 2005 and 2015, higher education R&D expenditure as a percentage of national total was on an overall downward trend. During this period, higher education basic research expenditure as a percentage of the national basic research expenditure and the percentage for applied research expenditure both showed an upward trend, especially the former which rose from 43.2% in 2005 to 54.6% in 2015, representing an increase of 11.4 percentage points, with the latter increasing by 5.0 percentage points from 28.8% in 2005 to 33.8% in 2015; the percentage for experimental development decreased by 2.4 percentage points from 3.2% in 2005 to 0.8% in 2015 (Figure 5-11).

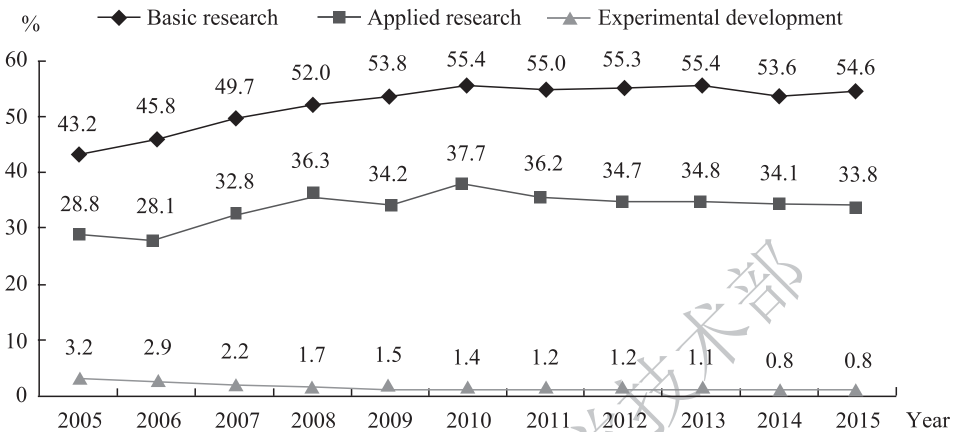

Figure 5-11　Higher education R&D expenditure as a percentage of national total (2005–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2006–2016).

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3　Sources of R&D expenditure

Government funding was the primary source of higher education R&D expenditure, which was mainly spent on explorative research on natural phenomena and social development. The higher education R&D expenditure in 2015 included 63.7 billion yuan from government funding (63.8%, representing an increase of 10.1 billion yuan from the previous year), 30.15 billion yuan from enterprise funding (30.2%) and 6.0 billion yuan from other domestic sources of funding and foreign funding (6.0%). Between 2005 and 2015, over 50% of higher education R&D expenditure funded by government, with the percentage taking on an overall upward trend from 54.9% in 2005 to 63.8% in 2015. The percentage for enterprise funding remained comparatively stable at around 35% (Figure 5-12).

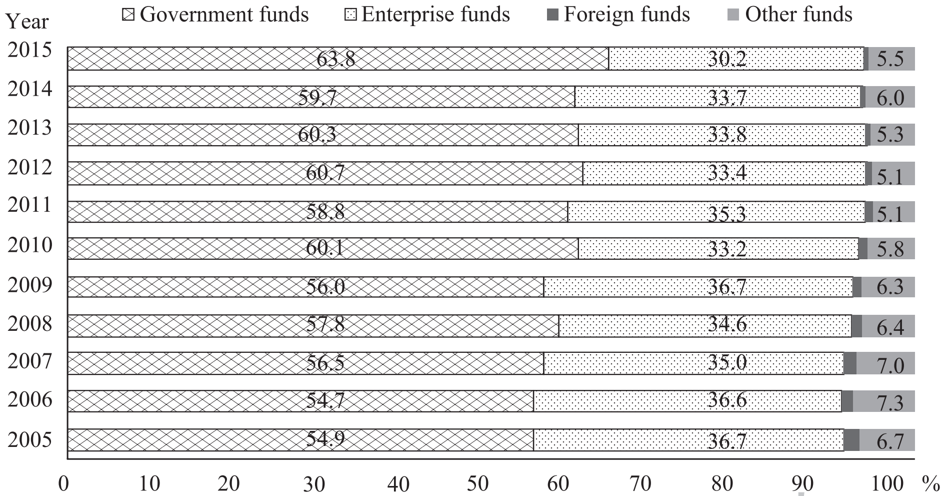

Figure 5-12 Sources of higher education R&D expenditure (2005–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2006–2016).

China Science and Technology Indicators 2016

4 International comparison of R&D expenditure

Internationally, in terms of the national R&D expenditure, the funding or China high education R&D expenditure reached 16.0 billion in 2015 which, while still far behind the United States' USD 66.5 billion, was already above the level of some developed countries such as Italy and the Netherlands and fairly close to the level of France and Canada. Japan and Germany also outperformed China in higher education R&D expenditure with USD 17.7 billion and USD 17.0 billion, respectively.

A country's higher education R&D expenditure as a percentage of its national R&D expenditure reflects the importance attached by it to higher education R&D activity. In 2015, China's higher education R&D expenditure as a percentage of national total reached 7.1%. This compared to more than 10% for most developed countries and 20%~30% for France, the United Kingdom, Italy and Sweden and more than 30% for Canada and the Netherlands in particular. The percentage was fairly low for Korea and Russia at around 9.0% (Figure 5-13).

Overall, countries' higher education R&D activity focused on basic research. Their education R&D expenditure by type of R&D varied due to their different R&D systems, but their shares of basic research expenditure in total R&D expenditure of HEIs were mostly higher than 50%. China's higher education basic research expenditure accounted for a fairly low percentage at 39.2%. China and the United Kingdom both had a rather high expenditure on applied research, accounting for around 50% (Figure 5-14).

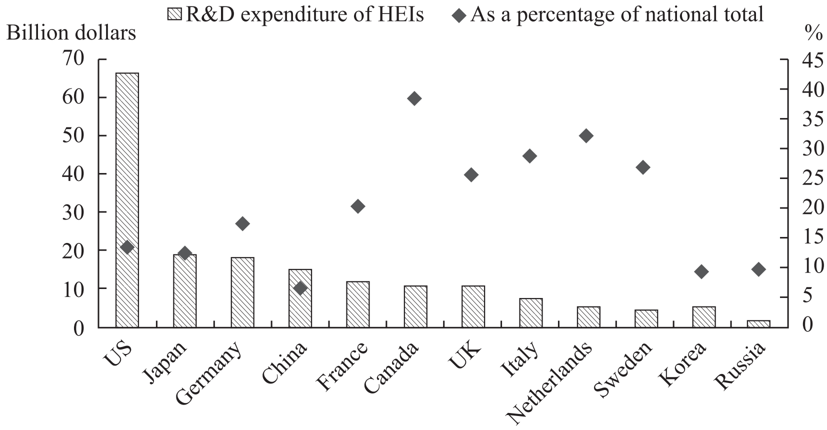

Figure 5-13 Higher education R&D expenditure and as a percentage of national total of select countries (2015)

Source: OECD, Main Science and Technology Indicators 2017-1.

See Annexed Table 5-2

China Science and Technology Indicators 2016

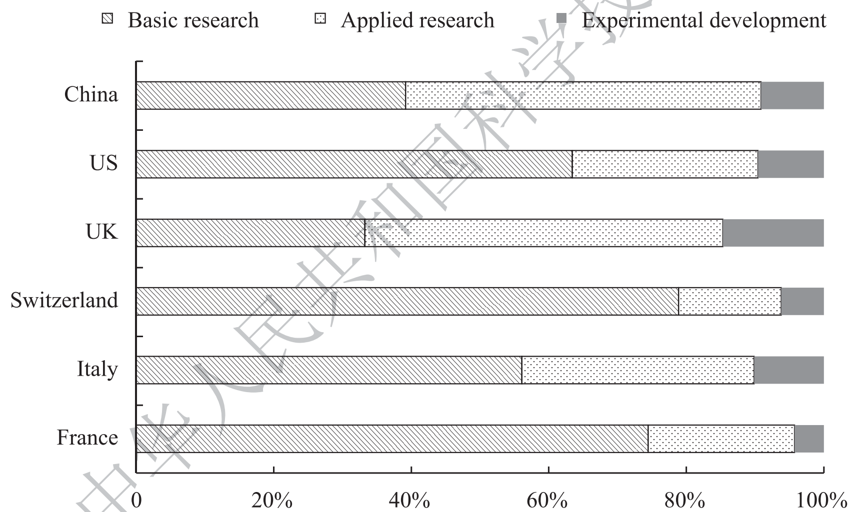

Figure 5-14 Higher education R&D expenditure by type of R&D activity of select countries in 2015

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*; OECD, R&D statistics 2017.

China Science and Technology Indicators 2016

The ratio of higher education R&D expenditure to GDP measures higher education R&D intensity. In 2015, China's higher education R&D intensity stood at 0.15%, with an increase of 0.02 percentage point from 2005, slightly higher than that of Russia (0.11%). The ratio was more than 0.40% for most developed countries including the United Kingdom, France, the United States and Japan (Figure 5-15).

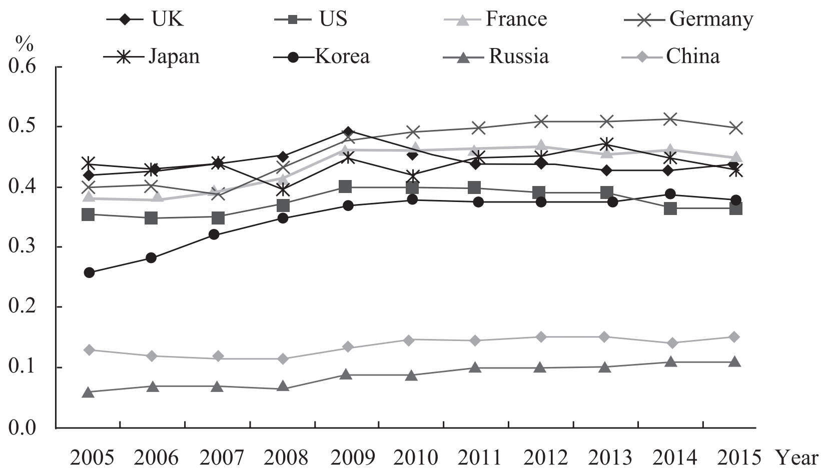

Figure 5-15 Higher education R&D intensity of selected countries (2005–2015)

Source: OECD, Main Science and Technology Indicators 2017-1.

See Annexed Table 5-3

China Science and Technology Indicators 2016

Section 4 Output and Achievement Transformation of S&T Activity

The recent years saw a steady growth of R&D output in China's HEIs such as scientific papers and patents and an acceleration of technology achievement transformation, providing a strong support for China's industrial structure transformation and upgrading.

1 S&T papers

Between 2005 and 2015, China's higher education SCI papers saw a steady increase year by year. In 2015, the number reached 220 thousand, with an increase of 171 thousand or nearly 4 times from 2005. The dominant position of HEIs in China's scientific research remained basically stable by consistently producing more than 80% of the national SCI papers every year from 2006 (Figure 5-16).

2 Patents

With the increasing awareness of intellectual property protection and rising enthusiasm for creative activity and patenting among R&D personnel, the number of patent applications of HEIs jumped from 20 thousand in 2005 to 235 thousand in 2015, representing an average annual growth of 28.0%. Among them, invention patent applications increased from 150 thousand to 133 thousand representing an average annual growth of 24.7%.

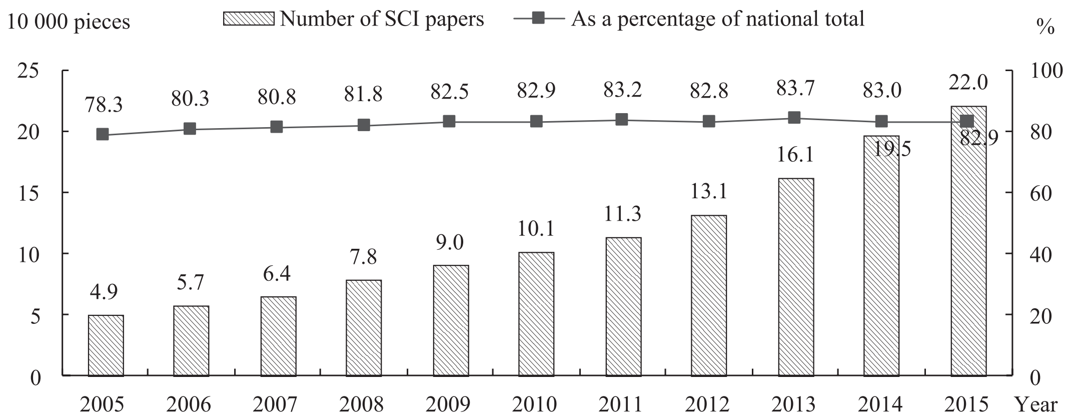

Figure 5-16 Number of higher education SCI papers and as a percentage of national total (2005–2015)

Source: Institute of Scientific and Technical Information of China, *China S&T Papers Statistics and Analysis* (2006–2016).

China Science and Technology Indicators 2016

From 2005, patent applications of HEIs as a percentage of national total maintained a slow growth and reached 8.9% in 2015, still below 10%. Between 2005 and 2015, invention patent applications as a percentage of higher education patent applications registered a downward trend, falling from 73.5% in 2005 to 56.8% in 2015 (Figure 5-17).

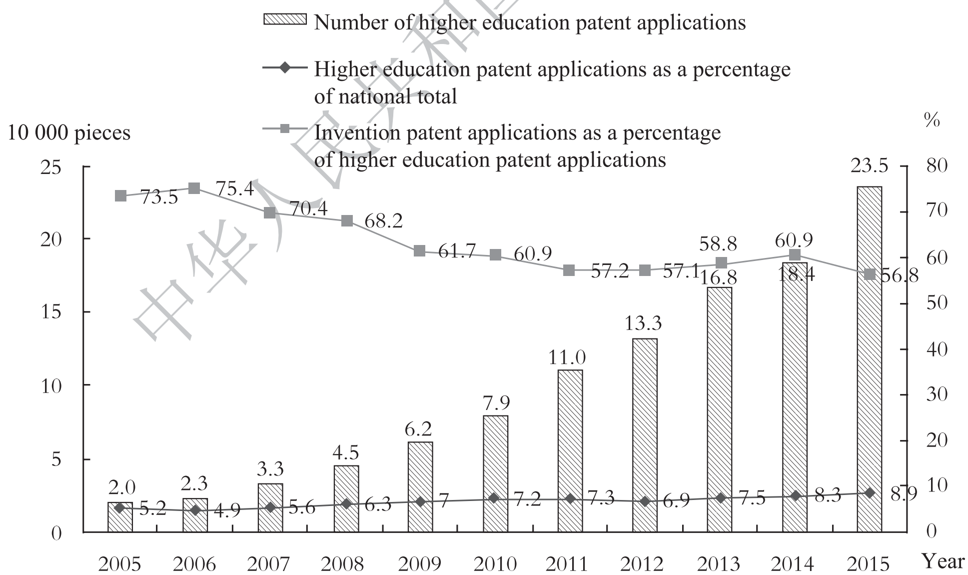

Figure 5-17 Higher education patent applications as a percentage of national total (2005–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2006–2016).

China Science and Technology Indicators 2016

Between 2005 and 2015, the number of patents granted to HEIs increased from 7399 to 136 thousand, with an average annual increase of 33.8% and invention patents granted increased from 4454 to 57 thousand, with an average annual increase of 29.1%. From 2005, higher education patents granted as a percentage of national total maintained a steady growth, increasing by 4.2 percentage points from 2005 to 8.5% in 2015. The recent years saw a decrease in higher education invention patents granted as a percentage of all higher education patents granted from 60.2% in 2005 to 42.0% in 2015, down 18.2 percentage points (Figure 5-18).

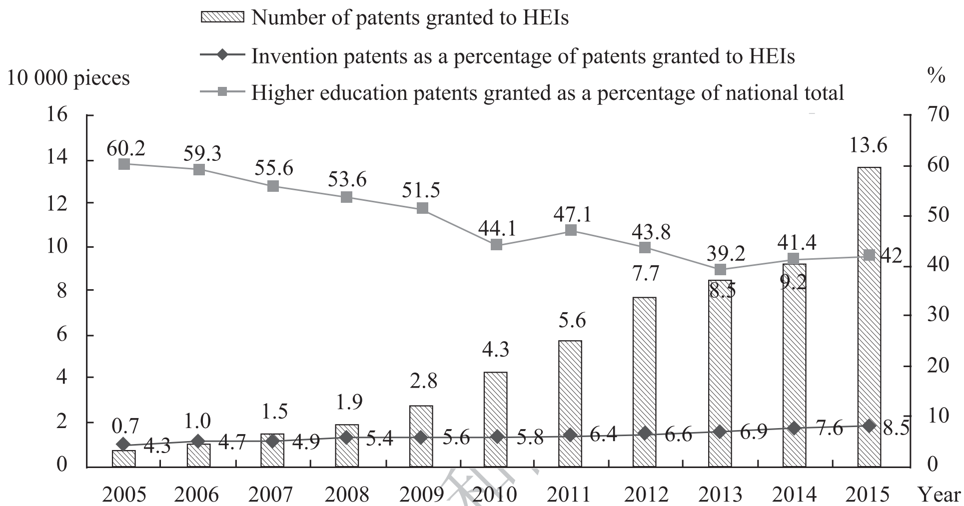

Figure 5-18 Higher education patents granted as a percentage of national total (2005–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2006–2016).

China Science and Technology Indicators 2016

3 Technology transactions

Between 2008 and 2015, the number of technology contracts with HEIs as the seller maintained a steady increase, reaching 57 thousand in 2015, an increase of 1.9 times from 2008. The number of higher education technology contracts climbed steadily from 13.3% in 2008 to 18.6% in 2008 (Figure 5-19).

In 2015, the turnover of higher education technology contracts reached 31.43 billion yuan, 2.7 times that in 2008, accounting for 3.2% of the national total (Figure 5-20).

In 2015, HEIs transferred and licensed a total of 2257 patents, representing an increase of 2.2 times from 2007. In natural science and engineering technology, patent ownership transfer and licensing by “211 Program” and province-ministry co-sponsored HEIs accounted for 53.2% of total patent ownership transfer and licensing by all HEIs, up 7 percentage points from 2007, compared to 46.2% for other bachelor's HEIs, down 7.5 percentage points from 2007 and 0.7% for associate degree HEIs, on par with the level in 2007.

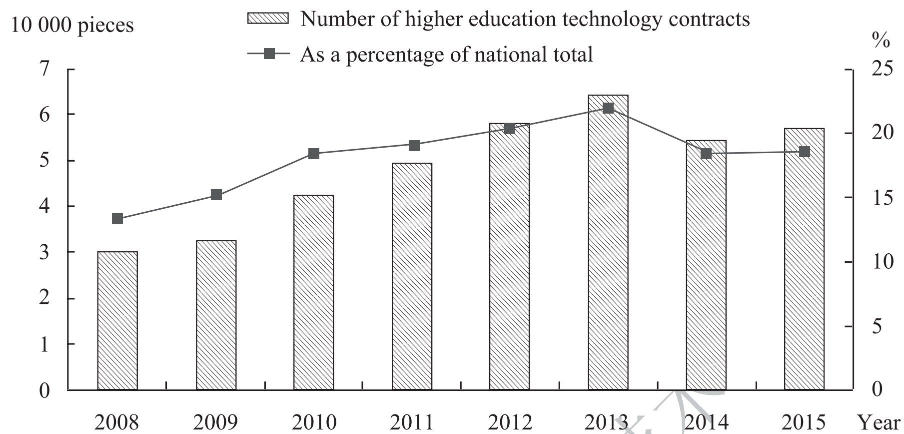

Figure 5-19 Number of higher education technology contracts and as a percentage of national total (2008–2015)

See Annexed Table 5-4

China Science and Technology Indicators 2016

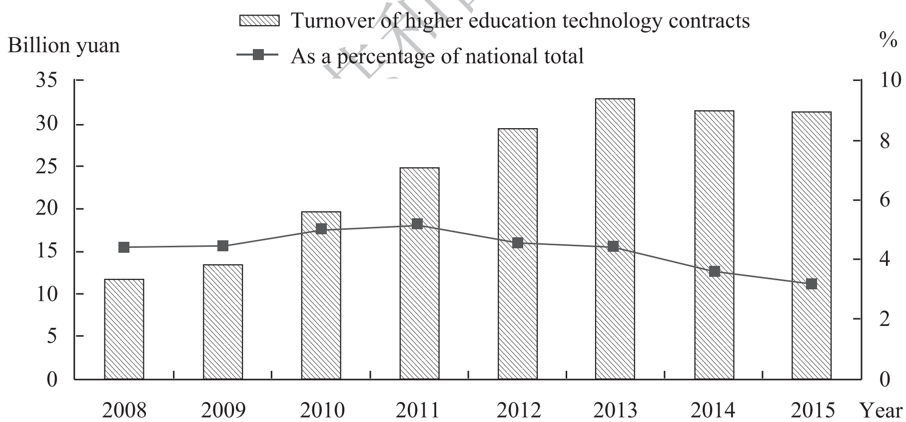

Figure 5-20 Turnover of higher education technology contracts and as a percentage of national total (2008–2015)

See Annexed Table 5-4

China Science and Technology Indicators 2016

In 2015, revenue from patent ownership transfer and licensing by HEIs reached 670 million, up 1.7 times from 2007. The lion's share of the revenue was contributed by patent ownership transfer and licensing in natural science and engineering technology. Among HEIs in natural science and engineering technology, “211 Program” and province-ministry co-sponsored HEIs represented 57.5% of actual revenue from patent sale of all HEIs, down 21.1 percentage points from 2007, versus 42.2% for other master’s degree HEIs, up 20.8 percentage points from 2007, and 0.2% for associate degree HEIs.

Chapter 6 Science and Technology Activity of Government Research Institutes

Government research institutes are independent research institutes (Hereafter referred to as "research institutes") affiliated to the departments of the State Council and local governments. They are an integral part of China's innovation system and a principal sector to carry out basic, strategic and public-interest researches. This chapter analyzes the basic situation about S&T activities carried out by research institutes in 2015 in four perspectives, including overview of research institutes, R&D personnel, R&D expenditure, and output and achievement transformation of S&T activity.

Section 1 Overview of Government Research Institutes

In recent years the number of research institutes has been decreasing, while the R&D personnel, R&D expenditure and per capita R&D expenditure have kept increasing.

1 Number of research institutes

In 2015, China had 3650 research institutes, including 715 centrally administered research institutes and 2935 locally administered research institutes. Between 2005 and 2015, research institutes in China decreased by 251 because of fewer locally administered research institutes, but there was a slight increase of centrally administered research institutes (Table 6-1).

Table 6-1 Number of research institutes (2005–2015)

Year	Research institutes		
	Total	Centrally administered research institutes	Locally administered research institutes
2005	3901	679	3222
2006	3803	673	3130
2007	3775	674	3101
2008	3727	678	3049
2009	3707	691	3016
2010	3696	686	3010

Continued

Year	Research institutes		
	Total	Centrally administered research institutes	Locally administered research institutes
2011	3673	686	2987
2012	3674	710	2964
2013	3651	711	2940
2014	3677	720	2957
2015	3650	715	2935

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

China Science and Technology Indicators 2016

2 R&D personnel

In 2015, Chinese research institutes had a total of 436 thousand R&D persons. They included 143 thousand women, 73 thousand PhD graduates and 146.7 thousand master's graduates. The period between 2005 and 2015 saw the R&D personnel of research institutes in China steadily expand at the average annual growth rate of 6.1% (Figure 6-1).

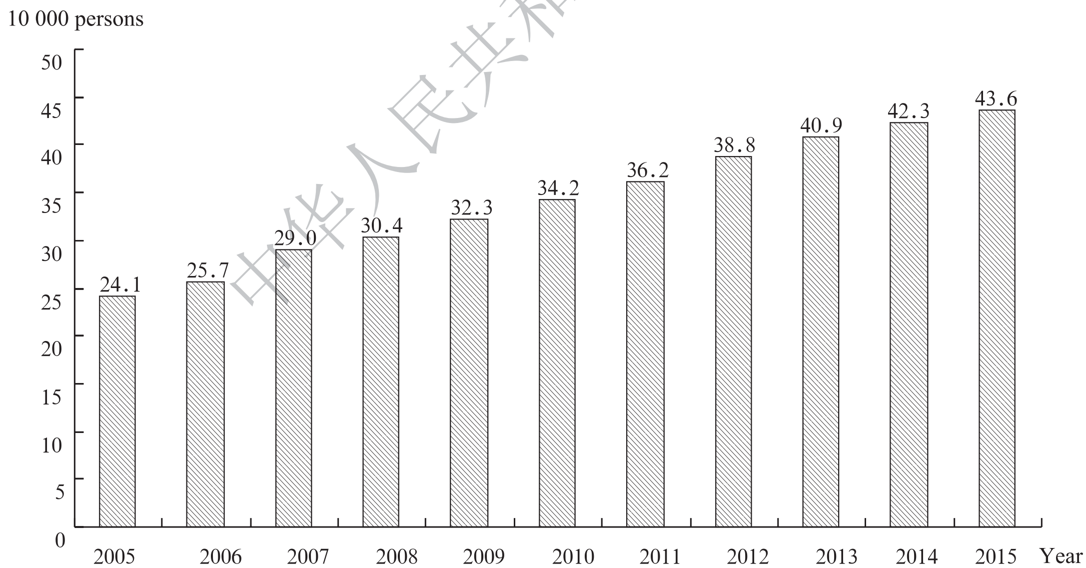

Figure 6-1 R&D personnel of research institutes (2005−2015)

See Annexed Table 6-1

China Science and Technology Indicators 2016

3 R&D expenditure

In 2015, the R&D expenditure of research institutes amounted to 213.65 billion yuan, 88.5% for centrally administered research institutes, overshadowing locally administered ones. In current prices (the same below), the R&D expenditure of research institutes saw an average annual growth of 15.3% between 2005 and 2015.

The R&D expenditure of research institutes as a percentage of national total steadily decreased from 20.9% in 2005 to 15.0% in 2011 and stayed at around 15.0% after that (Figure 6-2).

From 2005, the R&D expenditure of research institutes per personnel increased from 239 thousand yuan to 557 thousand yuan, representing an average annual growth of 8.9%. The growth was particularly high between 2008 and 2010 which posted an average annual growth of more than 12%.

Compared to some developed countries, labor costs as a percentage of total R&D expenditure of research institutes in China was rather low at around 20%, which was 19.9% in 2015; and capital costs as a percentage of the total was fairly high at above 20.0%, which was 20.9% in 2015. According to OECD statistics, the labor costs as a percentage of total R&D expenditure was always above 40% for Germany and France between 2005 and 2014 and 20%~40% for Japan and Korea. The United States' capital costs as a percentage of the total R&D expenditure remained below 5% (Figure 6-3).

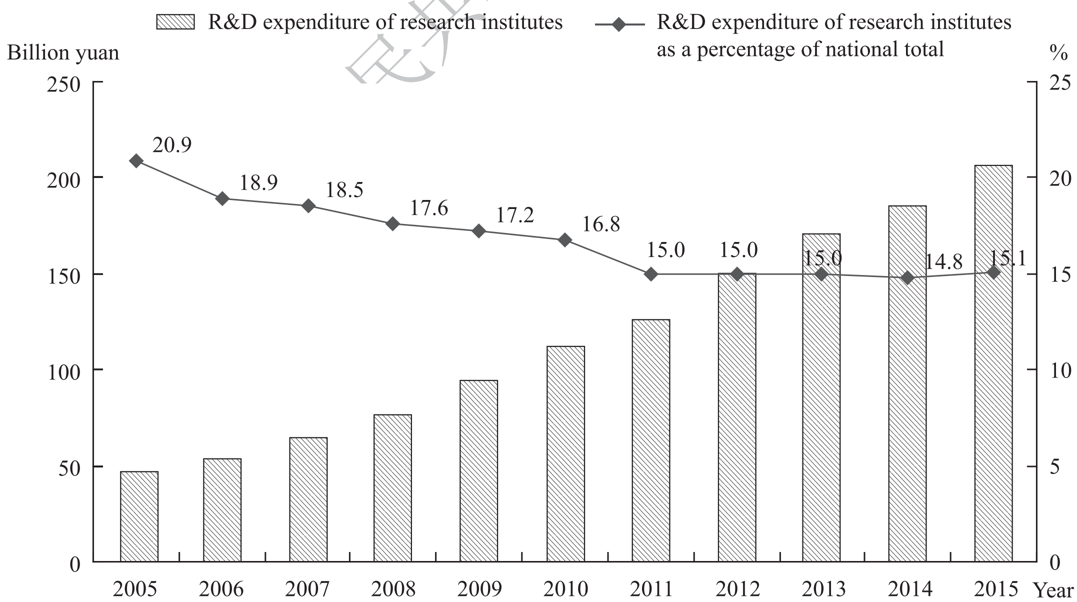

Figure 6-2 R&D expenditure of research institutes and as a percentage of national total (2005–2015)

See Annexed Table 6-2

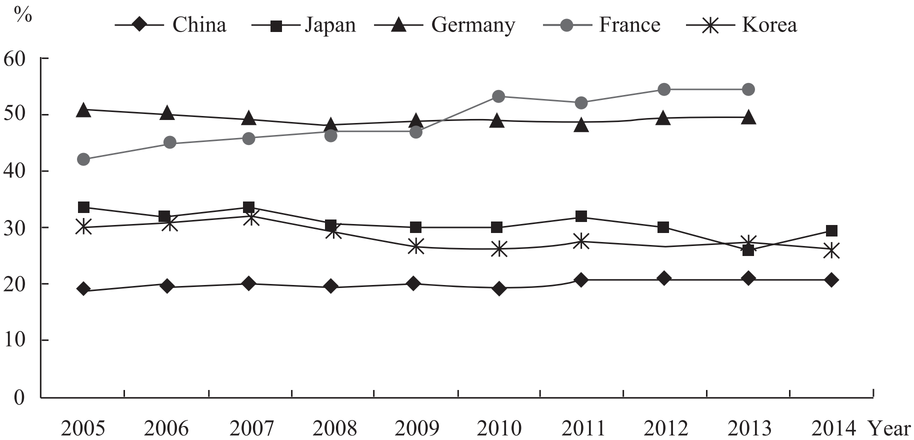

Figure 6-3 Labor costs as a percentage of R&D expenditure of selected countries (2005–2014)

Source: OECD, R&D Statistics 2016.

China Science and Technology Indicators 2016

Section 2 R&D Personnel

In 2015, the number of R&D personnel of research institutes continued to increase, but its proportion of the national total continued to decrease. The percentage of highly educated personnel continued to increase.

1 Scale of R&D personnel

In 2015, research institutes had 384 thousand person-years of R&D personnel in FTE. They included 71 thousand person-years engaged in basic research, 131 thousand in applied research, and 181 thousand in experimental development, representing an increase of 7.0%, 2.3% and 0.5%, respectively, over last year (Figure 6-4).

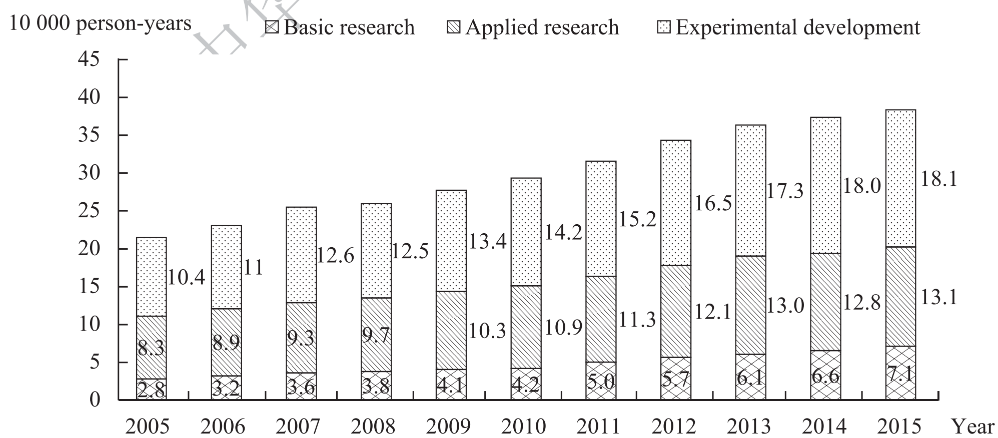

Figure 6-4 R&D personnel of research institutes by type of activity (2005–2015)

See Annexed Table 6-1

China Science and Technology Indicators 2016

Despite an increase in the number of R&D personnel of research institutes, its proportion of national total of R&D personnel decreased from 15.8% in 2005 to 10.2% in 2015. The decrease was fairly sharp between 2007 and 2009 and then more stable after that (Figure 6-5).

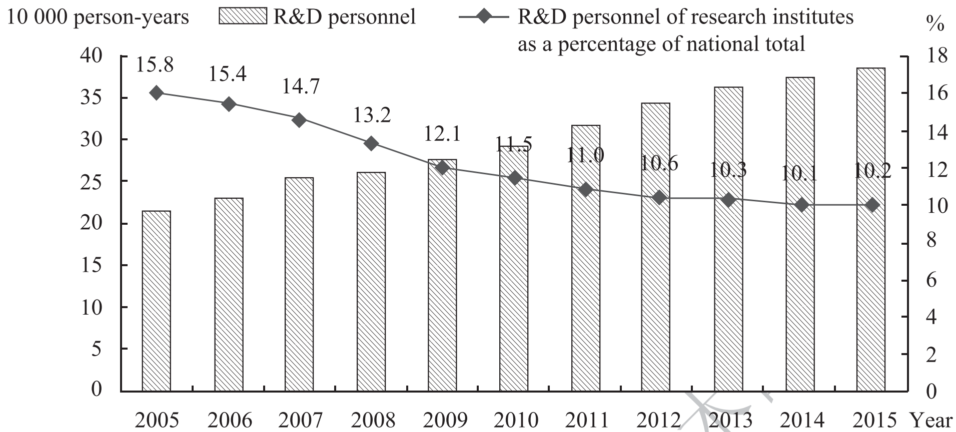

Figure 6-5 R&D personnel of research institutes and as a percentage of national total (2005–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

China Science and Technology Indicators 2016

2 Education structure

R&D personnel of research institutes in 2015 included 73 thousand with a PhD degree, with a proportion of 16.8%, and 146 thousand with a master's degree, with a proportion of 33.5%. Between 2009 and 2015, there had been a steady trend of growth of highly educated researchers represented by PhD and master's degree holders (Figure 6-6).

In terms of affiliation, centrally administered research institutes had a total of 336 thousand R&D personnel in 2015, including 62 thousand with a PhD degree, with a proportion of 18.4%, and 115 thousand with a master's degree, with a proportion of 34.1%. Locally administered research institutes had a total of 100 thousand R&D personnel, including 12 thousand PhD holders, with a proportion of 11.6%, and 32 thousand master's degree holders, with a proportion of 31.7%. Among the R&D personnel with a PhD degree of research institutes, centrally administered research institutes accounted for 84.2% (Table 6-2).

In terms of discipline, engineering and technology sciences had the greatest number of R&D personnel, accounting for 58.1%, followed by natural science with a proportion of 18.4% and agricultural science with 12.9%. Medical science and humanities and social sciences were less represented with 6.6% and 3.9%, respectively. Natural science had the greatest number of R&D

personnel with a PhD degree, accounting for 36.0%, followed by humanities and social sciences with 25.5%, medical science with 19.5%, agricultural science with 15.0%, and engineering and technology sciences with 10.3% (Table 6-3).

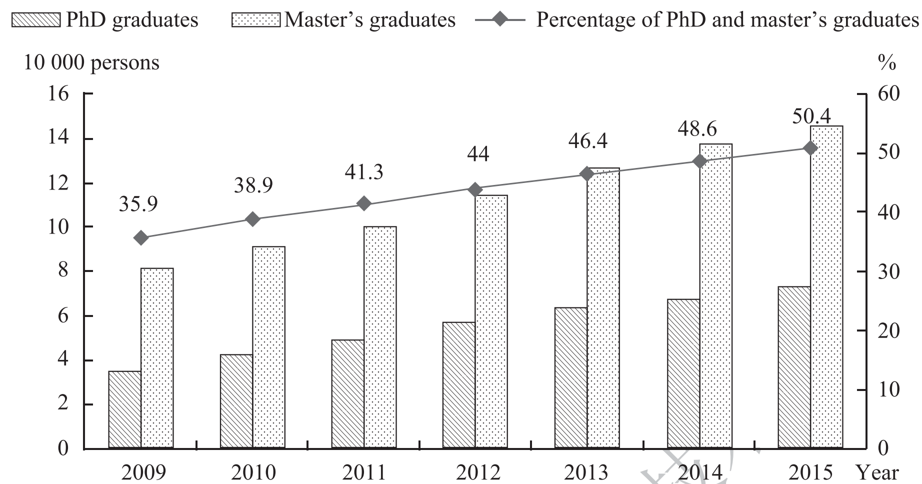

Figure 6-6 R&D personnel of research institutes by education (2009–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2010–2016).

China Science and Technology Indicators 2016

Table 6-2 Number of R&D personnel by affiliation (2015)

Unit: Persons

	R&D personnel	R&D personnel with PhD degree	R&D personnel with master's degree
Total	436284	73416	146329
Centrally administered research institutes	336020	61782	114512
Locally administered research institutes	100264	11634	31817

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

China Science and Technology Indicators 2016

Table 6-3 Number of R&D personnel by discipline (2015)

Unit: Persons

	R&D personnel	R&D personnel with PhD degree	R&D personnel with master's degree
Natural science	80306	28940	22944
Agricultural science	56354	8434	16613

Continued

	R&D personnel	R&D personnel with PhD degree	R&D personnel with master's degree
Medical sciences	28867	5642	8158
Engineering and technology sciences	253554	26014	93173
Humanities and social sciences	17203	4386	5441

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

China Science and Technology Indicators 2016

Section 3 R&D Expenditure

In recent years, the R&D expenditure of research institutes was mainly from government. In the R&D expenditure structure, expenditure on basic research increased rapidly, though expenditure on experimental development as a percentage still outshined applied research and basic research.

1 Sources of R&D expenditure

Government funding has always been the primary source of R&D expenditure of research institutes. Government funding increased from 42.47 billion yuan in 2005 to 180.27 billion yuan in 2015. Government funding as a percentage of the total R&D expenditure of research institutes stayed above 80% in spite of some fluctuations (Figure 6-7). Of the R&D expenditure in 2015, 3.1% was from enterprise funding, 0.2% from foreign funding and 12.3% from other sources of funding.

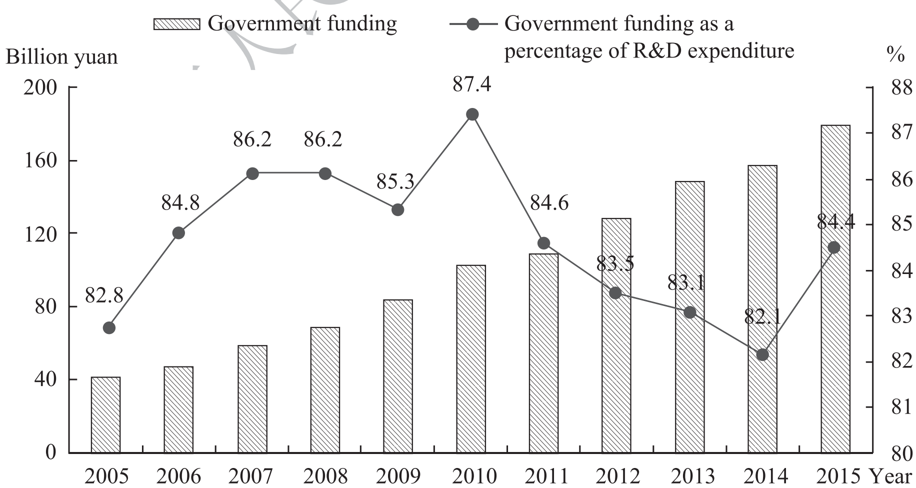

Figure 6-7 Government-funded R&D expenditure of research institutes and its percentage (2005–2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

China Science and Technology Indicators 2016

Enterprise funding as a percentage of R&D expenditure of research institutes remained low. Between 2005 and 2015, enterprise funding increased from 1.76 billion yuan to 6.54 billion yuan, but its proportion remained at 3% for most years.

2 Structure of R&D expenditure

Along with the rapid growth of R&D expenditure since 2005, research institutes have registered an average annual growth rate of 17.7%, 13.4% and 15.9% in funding to basic research, applied research and experimental development respectively. In terms of the proportion of funding to the three categories of research activities, experimental development snapped up the biggest share of 57.2%, versus 13.8% for basic research and 28.9% for applied research (Table 6-4).

Table 6-4 R&D expenditure of research institutes by type of activity (2005–2015)

	R&D expenditure (Billion yuan)	Basic research		Applied research		Experimental development	
		Billion yuan	%	Billion yuan	%	Billion yuan	%
2005	51.31	5.80	11.3	17.63	34.4	27.87	54.3
2006	56.73	6.79	12.0	19.62	34.6	30.32	53.4
2007	68.79	7.47	10.9	22.71	33.0	38.61	56.1
2008	81.13	9.27	11.4	27.13	33.4	44.72	55.1
2009	99.60	11.06	11.1	35.09	35.2	53.44	53.7
2010	118.64	12.99	11.0	38.76	32.7	66.89	56.4
2011	130.67	16.02	12.3	41.72	31.9	72.93	55.8
2012	154.89	19.79	12.8	46.93	30.3	88.17	56.9
2013	178.14	22.16	12.4	52.58	29.5	103.40	58.0
2014	192.62	25.89	13.4	55.29	28.7	111.44	57.9
2015	213.65	29.53	13.8	61.84	28.9	122.28	57.2

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* 2016.

China Science and Technology Indicators 2016

Engineering and technology sciences disciplines were the biggest recipients of R&D expenditure at research institutes, snapping up 71.0% of the total, followed by natural science with 15.6%. Agricultural science, medical science, humanities and social sciences received a smaller share of 7.0%, 4.4% and 2.0% respectively (Figure 6-8).

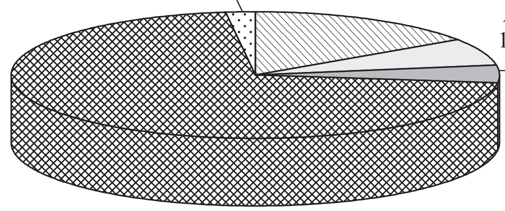

Figure 6-8 R&D expenditure of research institutes by discipline (2015)

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3 R&D projects

R&D projects are an important way of R&D activities. In 2015, research institutes conducted 100 thousand research projects with the commitment of 349 thousand person-years of R&D personnel and 151.38 billion yuan of project funding, with an increase of 8.8%, 2.6% and 18.9%, respectively, over the previous year, and representing an average annual growth of 9.8%, 7.1% and 15.7% respectively from 2005 (Table 6-5).

Table 6-5 R&D projects of research institutes (2005–2015)

	Number of R&D projects	R&D personnel in FTE of R&D projects (10 000 person-years)	Internal R&D expenditure of R&D projects (Billion yuan)
2005	39072	17.6	35.35
2006	42262	20.2	36.54
2007	49453	22.2	45.17
2008	54900	22.9	53.77
2009	61135	23.7	57.98
2010	67050	25.4	68.15
2011	70967	27.3	80.71
2012	79343	31.1	107.83
2013	85069	32.7	122.17
2014	91465	34.0	127.27
2015	99559	34.9	151.38

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In terms of affiliation, centrally administered research institutes played a dominant role in R&D

projects by representing 64.8% of R&D projects, 78.9% of R&D personnel, and up to 91.9% R&D expenditure.

Among the 62 first-level disciplines, the top ten in terms of R&D project-based funding were aeronautics and aerospace science and technology, electronics, communications and automatic control technology, nuclear science and technology, fundamental disciplines in engineering and technology sciences, earth science, agricultural science, physics, biology, materials science and computer science and technology (Figure 6-9).

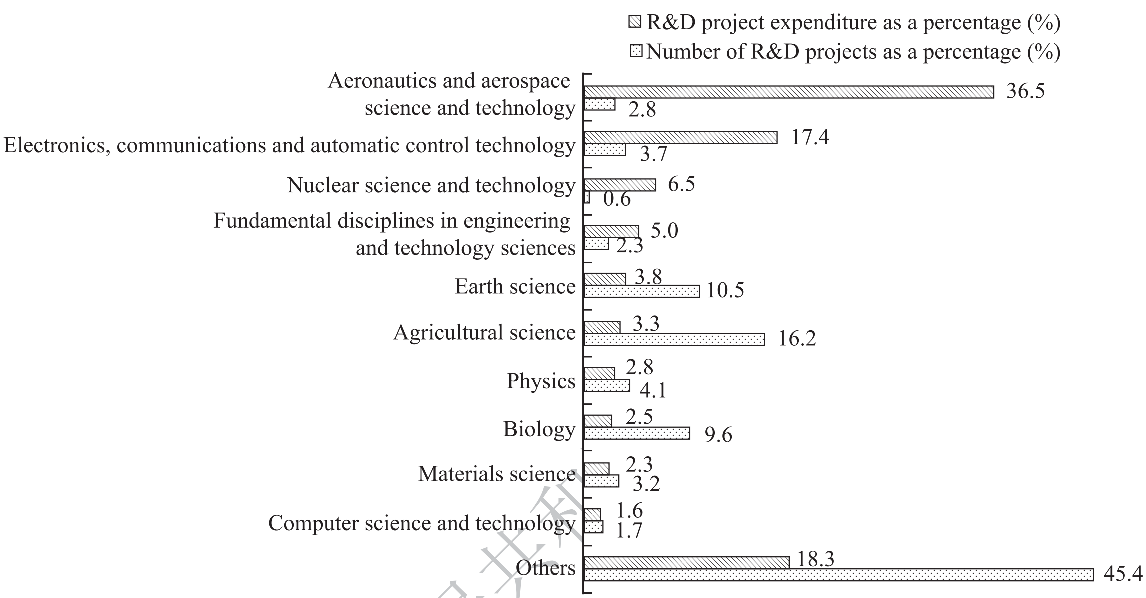

Figure 6-9 Expenditure of R&D projects of research institutes by discipline

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

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In terms of funding, the expenditure of R&D projects of research institutes in 2015 was 74.9% funded by national S&T programs, 5.9% by local government S&T programs, 2.7% by enterprises as in the case of enterprise-commissioned R&D projects, 2.6% internally funded, and 0.6% by foreign S&T programs (Figure 6-10).

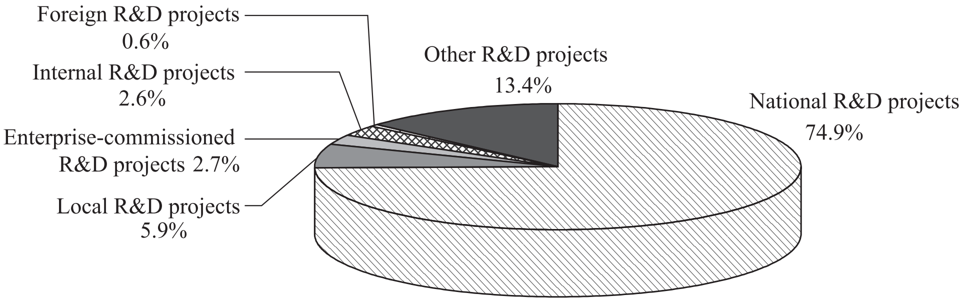

Figure 6-10 R&D projects of research institutes by funding source (2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

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4 Methods of collaboration in R&D projects

In terms of the method of collaboration, most R&D projects were independently conducted by research institutes. In 2015, there were 82 thousand R&D projects independently conducted by research institutes, or 82.3% of all R&D projects; 7918 conducted in collaboration with domestic independent research institutes, or 8.0%; 2919 conducted in collaboration with domestic enterprises, or 2.9%; and 3430 conducted in collaboration with domestic higher education institutions, or 3.4%, with only 1.0% being conducted in collaboration with foreign organizations (including overseas organizations and wholly foreign-owned enterprises registered in China) (Table 6-6).

Table 6-6 R&D projects of research institutes by method of collaboration (2015)

	Number of R&D projects		Personnel		Expenditure	
	Number	%	Person-years	%	10 000 yuan	%
Method of collaboration	99559		348699		15137870	
Collaboration with overseas organizations	1018	1.0	1969	0.6	60947	0.4
Collaboration with domestic higher education institutions	3430	3.4	12562	3.6	364968	2.4
Collaboration with domestic independent research institutes	7918	8.0	32879	9.4	1893839	12.5
Collaboration with wholly foreign-owned enterprises registered in China	36	0.0	83	0.0	2289	0.0
Collaboration with other enterprises registered in China	2919	2.9	7667	2.2	279637	1.8
Independent implementation	81899	82.3	281527	80.7	12148197	80.3
Others	2339	2.3	12013	3.4	387993	2.6

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

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Section 4 Output and Achievement Transformation of S&T Activity

Scientific papers and patents are important output of research institutes in knowledge innovation and original innovation. With China's increasing investment in science and technology, Chinese research institutes achieved a varying degree of progress in publication of scientific papers, patent applications and grants, and the value of technology transactions①.

1 S&T papers

In 2015, Chinese research institutes published 57 thousand domestic S&T papers, basically on par with that in 2010, representing 11.5% of all domestic S&T papers, up 0.8 percentage point from 2010, and 29.7 thousand SCI papers, basically on par with that in the previous year (Figure 6-11).

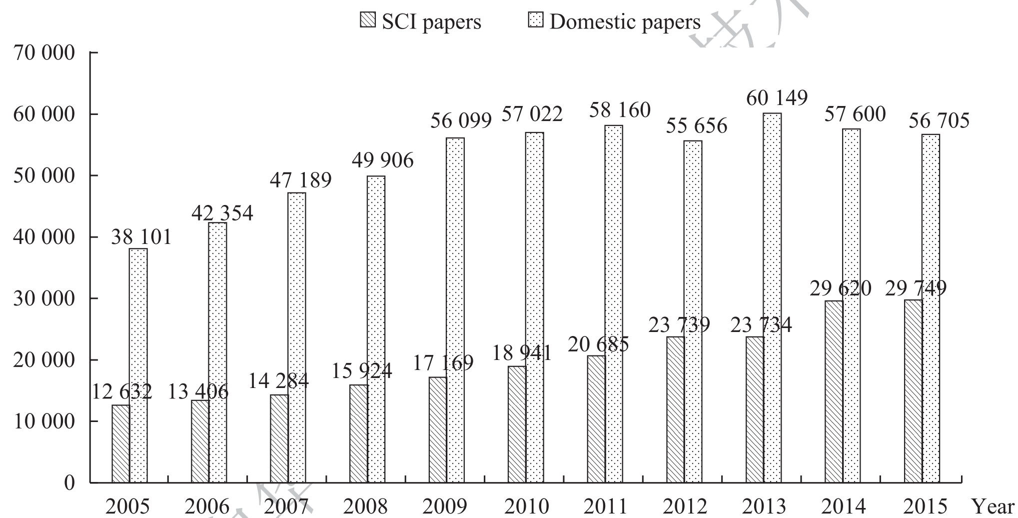

Figure 6-11 SCI papers and domestic papers published by research institutes (2000–2015)

See Annexed Table 6-3

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In terms of discipline, engineering and technology science had the greatest number of papers published, accounting for 33.6%, followed by natural science with 21.6%, agricultural science with 19.1%, humanities and social sciences with 13.7% and medical science with 12.0%. For the papers published overseas, natural science represented the highest proportion with 46.5%,

① In this section, data about papers are from *China S&T Papers Statistics and Analysis* released by the Institute of Scientific and Technical Information of China, data about patents from *China Patent Statistical Yearbook* released by the State Intellectual Property Office of China, and structural data from *China Statistical Yearbook on Science and Technology* jointly released by National Bureau of Statistics and Ministry of Science and Technology.

followed by engineering and technology sciences (29.4%), medical science (11.8%), agricultural science (11.2%), and humanities and social sciences (1.1%) (Table 6-7).

Table 6-7 S&T papers published by research institutes by discipline in 2015

Unit: %

Discipline	S&T Papers	Papers published overseas
Natural science	21.6	46.5
Agricultural science	19.1	11.2
Medical science	12.0	11.8
Engineering and technology sciences	33.6	29.4
Humanities and social sciences	13.7	1.1

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

China Science and Technology Indicators 2016

2 Patent

Chinese research institutes filed 64 thousand patent applications in 2015, representing an average annual growth of 20.8% from 2005. They included 45 thousand invention patent applications, or 69.1%, representing an average annual growth of 20.8%. The number of patents granted to research institutes also saw a swift growth, reaching 34 thousand in 2015, representing an average annual growth of 23.2% from 2005. They included 19 thousand invention patents, or 57.2%, representing an average annual growth of 23.0% (Figure 6-12).

By type of patents filed, invention patents had the greatest number, with its proportion in the total patents filed staying at more than 65% from 2005, followed by utility model patents, accounting for approximately 28% in recent years, and design patents coming last with less than 8%.

By type of patents granted, invention patents also had the greatest number, accounting for 46%~57% between 2005 and 2015; followed by utility model patents within the 38%~50% range, and design patents within the 2%~5% range. In terms of growth, the period between 2005 and 2015 saw an average annual growth of more than 23% for both invention patents and utility model patents, higher than design patents.

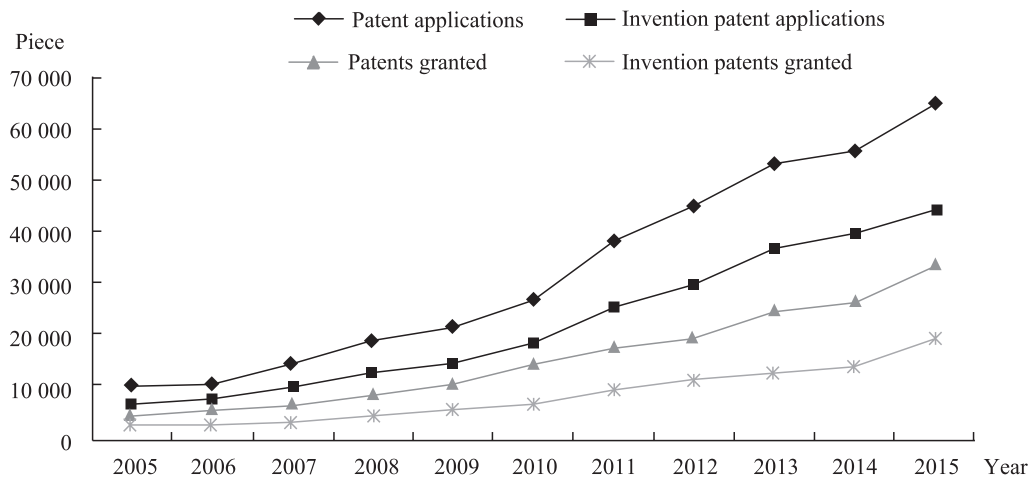

Figure 6-12 Patents filed and granted to research institutes (2005–2015)

See Annexed Table 6-3

China Science and Technology Indicators 2016

By discipline, engineering and technology sciences represented the highest proportion of patents granted to research institutes with 66.1%, followed by natural science with 16.4%, agricultural science with 14.8%, medical science with 2.4% and humanities and social sciences with 0.2% (Table 6-8).

Table 6-8 Patent applications of research institutes by discipline (2015)

Unit: %

Discipline	Patent applications	Invention patent applications
Natural science	16.4	18.9
Agricultural science	14.8	12.1
Medical science	2.4	2.5
Engineering and technology sciences	66.1	66.5
Humanities and social sciences	0.2	0.1

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

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3 Transformation of technological achievements

Transferring of patent ownership is an important way for research institutes to transform their R&D results. In 2015, research institutes transferred and licensed a total of 3567 patents for an income of 720 million yuan, including 959 transferred by centrally administered research institutes for an income of 660 million yuan.

By discipline, engineering and technology sciences had the most active transaction of patent ownership transfer and licensing by research institutes by representing 84.6% of patents transferred, followed by natural science with 7.8%. These two areas also had the greatest amount of revenue from patent ownership transfer and licensing, accounting for 45.1% and 29.1%, respectively. Medical science had the highest amount of revenue per patent transferred and licensed at 2.4 million yuan (Table 6-9).

Table 6-9 Patents transferred and licensed by research institutes by discipline (2015)

Discipline	Number of patents transferred and licensed (Piece)	Revenue from patents transferred and licensed (10 000 yuan)	Average revenue per patent licensed (10 000 yuan)
Natural science	280	21057	75.2
Agricultural science	218	5718	26.2
Medical science	53	12962	244.6
Engineering and technology sciences	3016	32698	10.8
Humanities and social sciences	0	0	0

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In terms of the turnover of the technology market, there was a steady growth of turnover of technology contracts with research institutes as seller. The turnover reached 56.04 billion yuan in 2015, up 22.1% from the previous year; the proportion in the turnover of the national technology market remained stable at 5%~7%, which was 5.7% in 2015 (Figure 6-13).

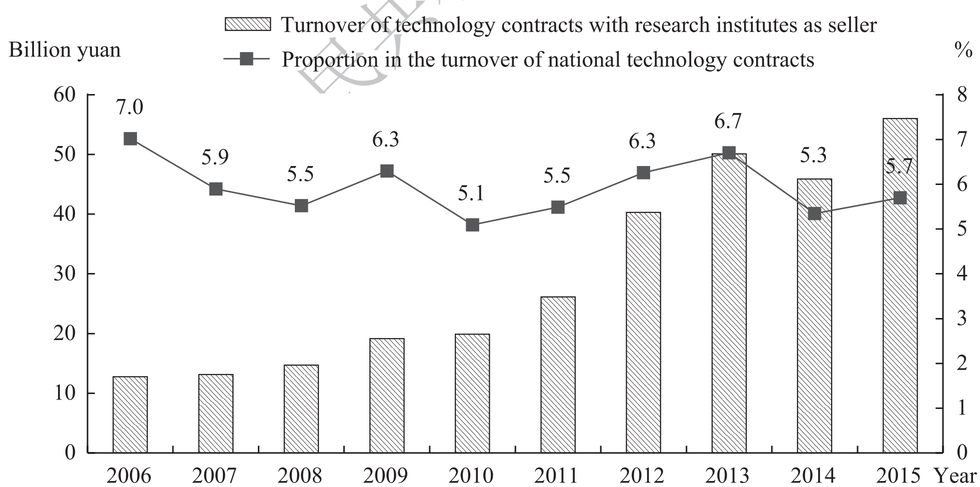

Figure 6-13 Turnover of technology contracts with research institutes as seller and proportion in national total (2006–2015)

See Annexed Table 6-3

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In 2015, research institutes created a total of 3813 national and industry standards, including 2685 by centrally administered research institutes (70.4%) and 1128 by locally administered research institutes (29.6%). By discipline, engineering and technology sciences outperformed other disciplines with 2607 or 68.4%, followed by agricultural science with 735 or 19.3%, medical science with 8.2%, natural science with 3.5% and humanities and social sciences with 0.6% (Figure 6-14).

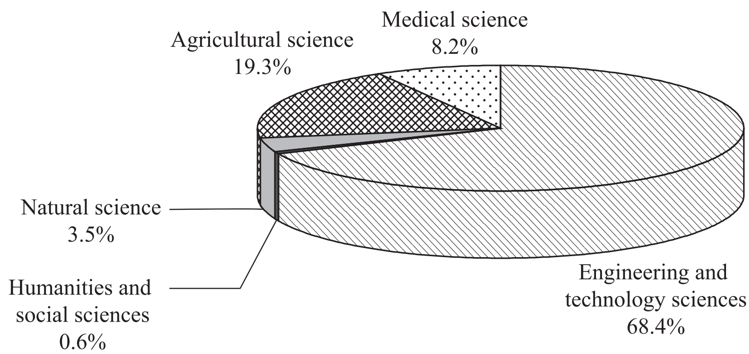

Figure 6-14 National or industry standards created by research institutes (2015)

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

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Chapter 7 Development of High-technology Industry

The high-technology industry is essential for international economic and technological competition. The development of the high-technology industry is of great significance for promoting the adjustment of industrial structure, transforming the mode of economic development and strengthening the role of science and technology in supporting economic development. This chapter analyzes the development and characteristics of China's high-technology industry in four aspects: high-technology industry, high-technology products' import and export, national high-technology industrial development zones, and venture capital.

Section 1 High-technology Industry

Based on *Industrial Classification for National Economic Activities* (GB/T4754—2011) with reference to OECD classification of the high-technology industry, six industries — manufacture of aircrafts and spacecrafts, manufacture of electronic equipment and communication equipment, manufacture of computers and office equipment, manufacture of medicines, manufacture of medical equipment and measuring instrument and meters, and manufacture of electronic chemicals — are included in the statistical scope of China's high-technology industry. This section analyzes the scale and technological innovation capacity of China's high-technology industry and the position and performance of China's high-technology industry in the global context.

1 Scale of high-technology industry

The recent years saw a steady expansion of China's high-technology industry. In 2015, revenue from principal business of China's high-technology industry amounted to 14 trillion yuan, up 9.8% year on year[1]. From 2005 to 2015, China's high-technology industry experienced an overall slowdown of growth, with the growth rate reaching the highest point of 18.0% in 2006 and then falling to the lowest point of 4.0% in 2008 before gradual recoveries (Figure 7-1).

[1] All growth figures in this section are based on constant prices in 2000 and other data based on current prices.

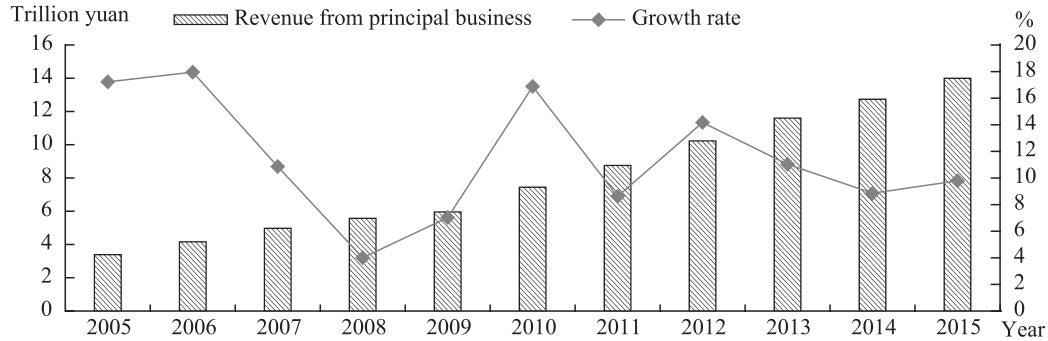

Figure 7-1 Revenue from principal business of the high-technology industry and annual growth (2005–2015)

See Annexed Table 7-1

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In recent five years, the manufacture of medicines industry saw the highest growth of revenue by posting an average annual growth of 14.6%, followed by manufacture of electronic equipment and communication equipment in the second place with a growth of 13.8%. The manufacture of computers and office equipment industry experienced a negative growth with a fall of 2.9%.

Because of the differences in revenue growth of different industries, the structure of the high-technology industry has been changing continuously. In terms of revenue as a percentage of the total revenue of the high-technology industry, manufacture of electronic equipment and communication equipment came the first with 57.0% in 2015, up 8.7 percentage points from 2010, representing the highest growth among the five industries between 2010 and 2015, followed by manufacture of medicines with 18.7%, up 3.4 percentage points, manufacture of computers and office equipment with 14%, down 12.7 percentage points; manufacture of medical equipment and measuring instrument and meters with 7.6%, up 0.2 percentage point, and manufacture of aircrafts and spacecrafts with 2.5%, up 0.4 percentage point (Figure 7-2).

China's expanding high-technology industry has held a steadily rising position in the world as well. According to the *Science and Engineering Indicators 2016* of the US National Science Foundation, the value added of China's high-technology industry as a percentage of the global total stood at only 9.8% in 2005, surpassed Japan in 2007, and reached 27.3% in 2014, ranking the second in the world, next only to the United States (Figure 7-3). The scale of China's high-technology exports was steadily increasing as well. According to the *World Development Indicators 2016* of the World Bank, China's high-technology exports as a percentage of the world rose to 25.9% in 2014, ranking the first in the world.

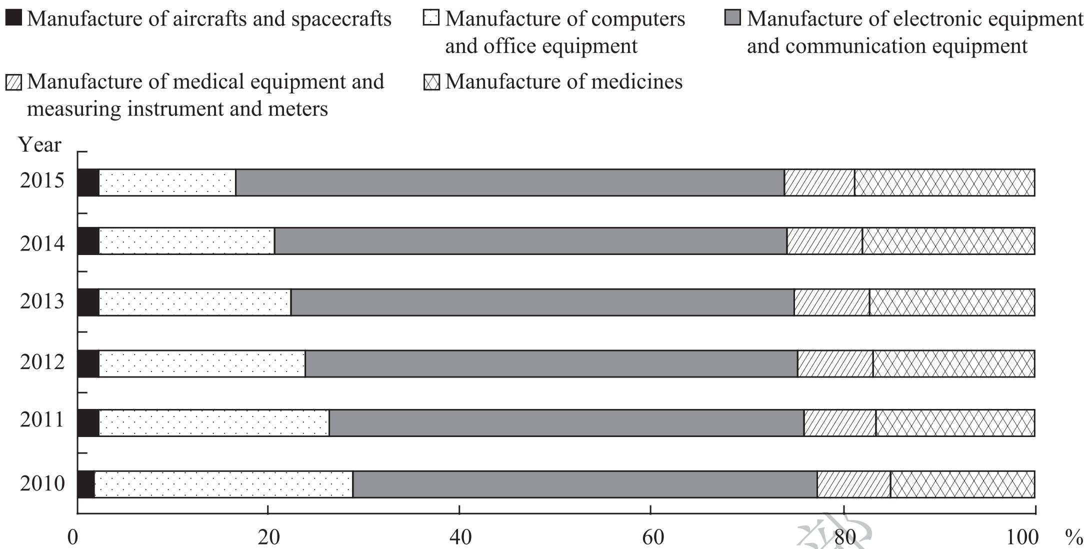

Figure 7-2　Revenue from principal business of the high-technology industry by industry (2010–2015)

See Annexed Table 7-1

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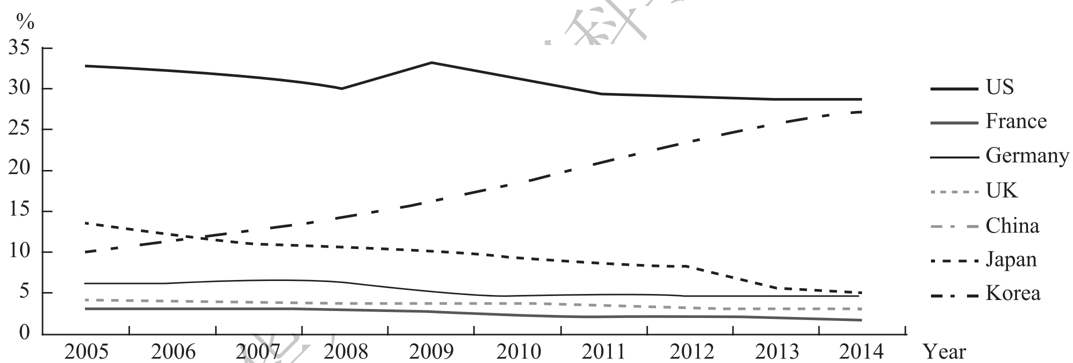

Figure 7-3　Value added of the high-technology industry of select countries as a percentage of global total (2005–2014)

Source: National Science Board, *Science and Engineering Indicators 2016*.

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2　The high-technology industry and manufacturing

As an important part of manufacturing, the high-technology industry not only offers new growth points to manufacturing and creates jobs but also upgrades manufacturing. Since the reform and opening up, China's high-technology industry has developed into an indispensable major force of Chinese manufacturing and an important player in the international high-technology market. In 2015, the high-technology industry contributed 14.1% of revenue from principal business of manufacturing.

China's high-technology industry development has greatly improved China's export structure by steadily increasing the proportion of high-technology exports in manufacturing exports. Compared to major developed countries, China's high-technology exports as a percentage of its manufacturing exports is at a high level. According to World Bank statistics, the percentage was 25.8% in 2015, which not only was 7.5 percentage points higher than the world average but also compared favorably with that of developed countries such as the United States, the United Kingdom, Norway, Japan and Germany (Figure 7-4).

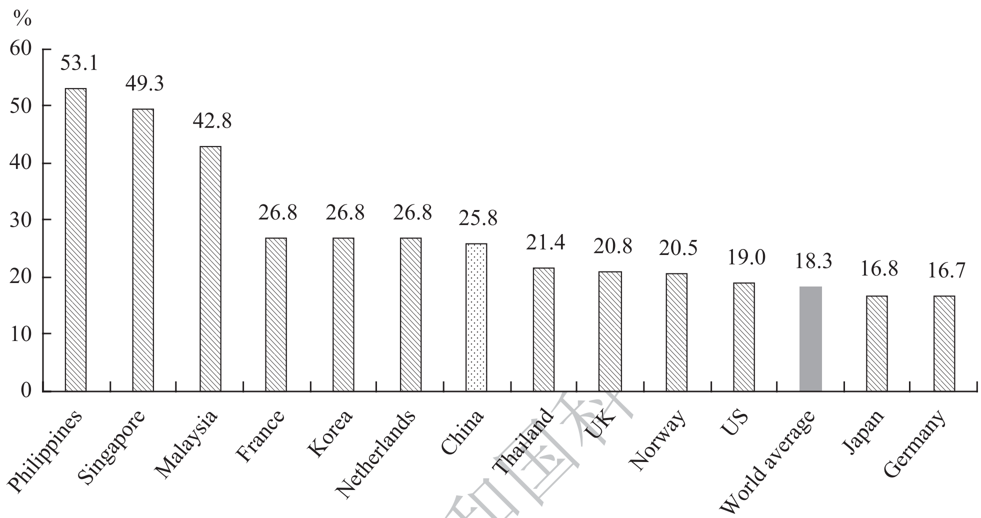

Figure 7-4 High-technology exports as a percentage of manufacturing of select countries (2015)

Source: World Bank, *World Development Indicators 2017.*

China Science and Technology Indicators 2016

3 Technological innovation in the high-technology industry

The high-technology industry is an active, highly innovation-driven force of manufacturing. As the underlying driver of a sustainable high-technology industry, technological innovation mainly takes the forms of enterprise R&D, technology import and technology absorption, and its achievements are embodied by new products and patents.

3.1 R&D activity

R&D intensity (ratio of R&D expenditure to revenue from principal business) is an important indicator of an industry's ability of independent R&D. The recent years saw a steady increase of the R&D expenditure and R&D intensity of the high-technology industry. In 2015, the R&D expenditure of large and medium-sized enterprises reached 222.0 billion yuan, accounting for 29.7% of the R&D expenditure of all large and medium-sized manufacturing enterprises, up 2.2 percentage points over the previous year. At the same time, the R&D intensity of the high-technology industry[①] reached 1.98%. Among the industries, manufacture of aircrafts and spacecrafts registered the highest R&D intensity of 5.46%, and electronic manufacture of computers and office equipment which had the highest R&D expenditure had a low R&D intensity of only 0.88%. Overall, the R&D intensity of China's high-technology industry was rather low and wide-varying among individual industries (Figure 7-5).

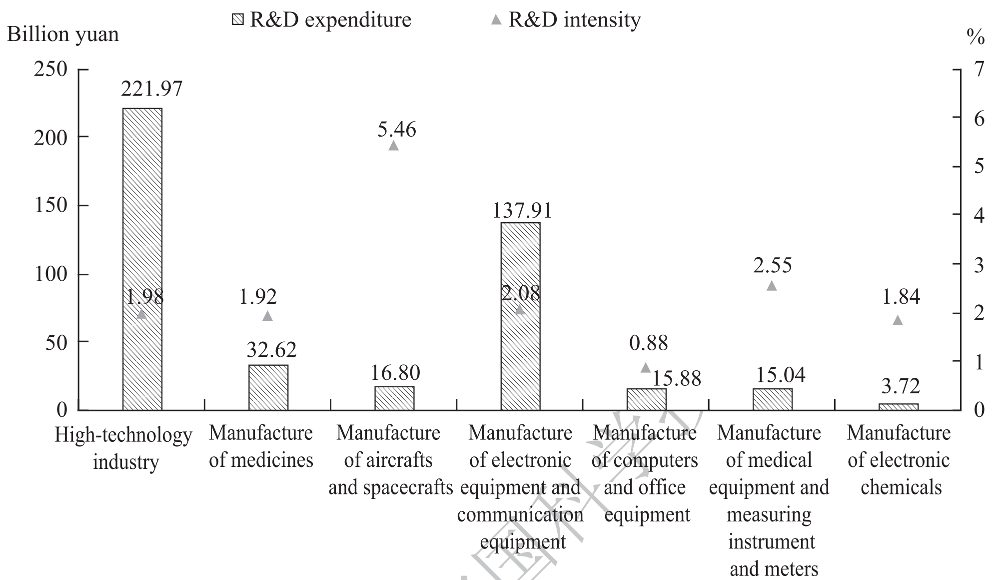

Figure 7-5　R&D expenditure and intensity of the high-technology industry (2015)

See Annexed Table 7-2

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3.2　Technology import and absorption

Technology import and technology absorption are important ways for enterprises in developing countries to progress technologically. China's high-technology industry has experienced a massive import of foreign technologies. Many high-technology enterprises have gradually built an independent R&D ability by importing and absorbing technology and continuously improving their technological strength. The expenditure on technology import of large and medium-sized enterprises in China's high-technology industry hit the historical high of 13.1 billion yuan in 2007 and then gradually decreased to 5.3 billion yuan in 2013, which slightly rebounded to 7.2 billion yuan in 2015 (Figure 7-6). On the other hand, with the increasing R&D strength of domestic research institutes, the number of enterprises that purchase technology domestically to advance their technological transformation has been steadily increasing, with their expenditure on domestic technology transfers increasing from 950 million yuan in 2005 to 6.3 billion yuan

① The above data are of large and medium-sized industrial enterprises.

in 2015.

Technology absorption is as important as technology import for improving enterprises' capacity of technological innovation. In recent years, China's high-technology industry has experienced fluctuations in expenditure on technology absorption. China's high-technology industry spent 2.75 billion yuan on absorption of imported technology in 2005, which dropped by 60% in 2006 and then gradually recovered in 2007 and 2008 before becoming stable after that. In 2015, China's high-technology industry spent 1.3 billion yuan on technology introduction and absorption.

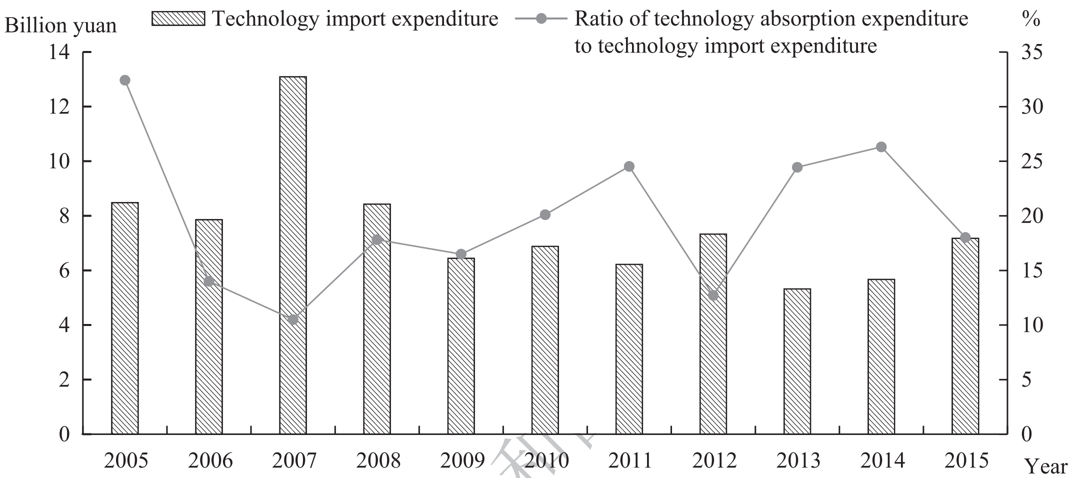

Figure 7-6 Technology import expenditure of the high-technology industry and ratio of technology absorption expenditure to technology import expenditure (2005–2015)

See Annexed Table 7-2

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3.3 Performance of technological innovation

Invention patents are an important indicator of innovation achievement and independent innovation capacity, and the number of invention patents in force held by an enterprise is the most important indicator of its technological output. With an increasing investment in R&D, the number of invention patents in force in China's high-technology industry has increased substantially. Compared to 2005 when China's large and medium-sized high-technology enterprises had only 6658 invention patents in force, the number rose to 199.7 thousand in 2015, representing an increase of nearly 30 times (Figure 7-7).

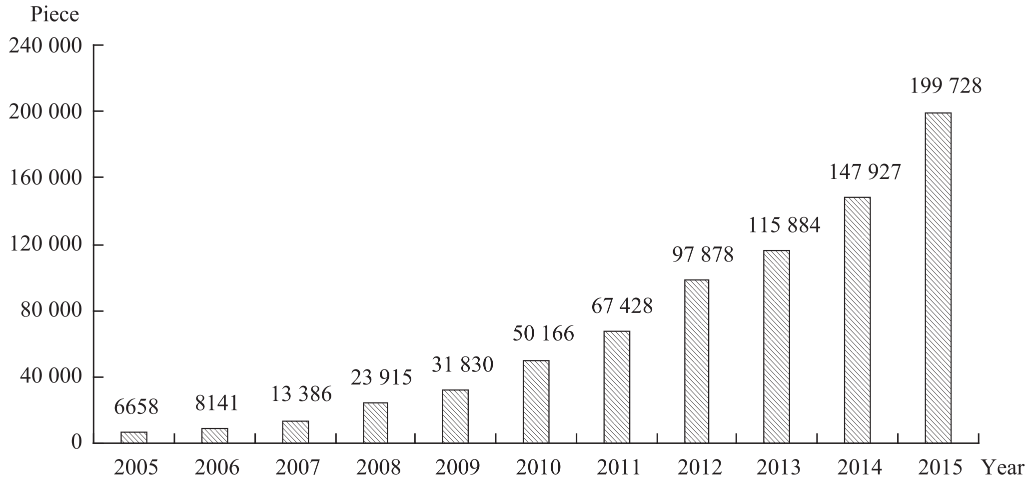

Figure 7-7 Number of invention patents in force of large and medium-sized high-technology enterprises (2005–2015)

See Annexed Table 7-2

China Science and Technology Indicators 2016

Section 2 High-technology Products

Compared to other industrial manufactured products, high-technology products have the characteristics of high R&D investment and high value added. The market share of a country's high-technology products in global markets thus to some extent represents its national technology strength and its high-technology industrialization capacity. China's high-technology products are grouped with reference to the US Import and Export Catalog of Advanced Technology Products (ATP). This section, based on import and export data of high-technology products, presents an analysis of China's trade in high-technology products in terms of the overall conditions, technology fields and trade partners.

1 Overview of China's import and export of high-technology products

Between 2005 and 2013, China's high-technology imports showed an overall upward trajectory, though the trend began reversing in recent two years. In 2015, China's high-technology imports and exports reached USD 1204.6 billion, including USD 655.3 billion in exports, down 0.8% year on year, and USD 549.3 billion in imports, down 0.4% year on year. Internationally, due to the sluggish investment demand in western developed countries as well as developing countries, China's high-technology imports and exports are expected to face a further downward pressure (Figure 7-8, Figure 7-9).

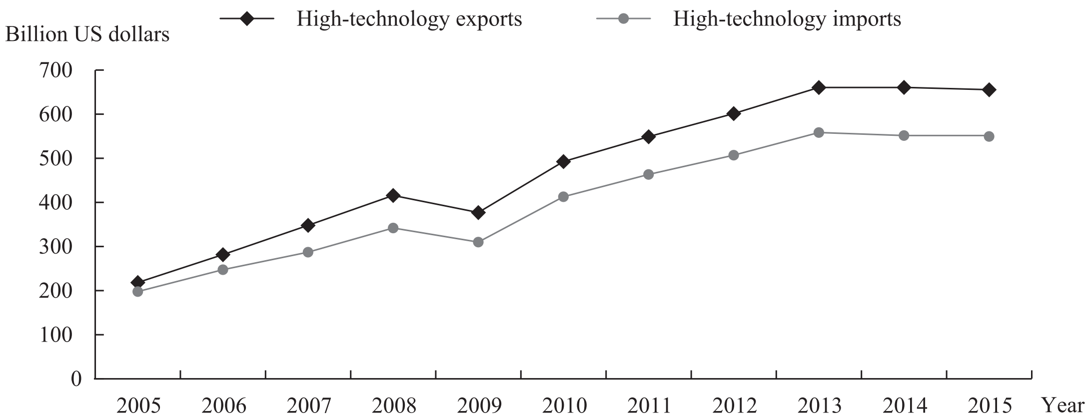

Figure 7-8　China's high-technology imports and exports (2005–2015)

See Annexed Table 7-3

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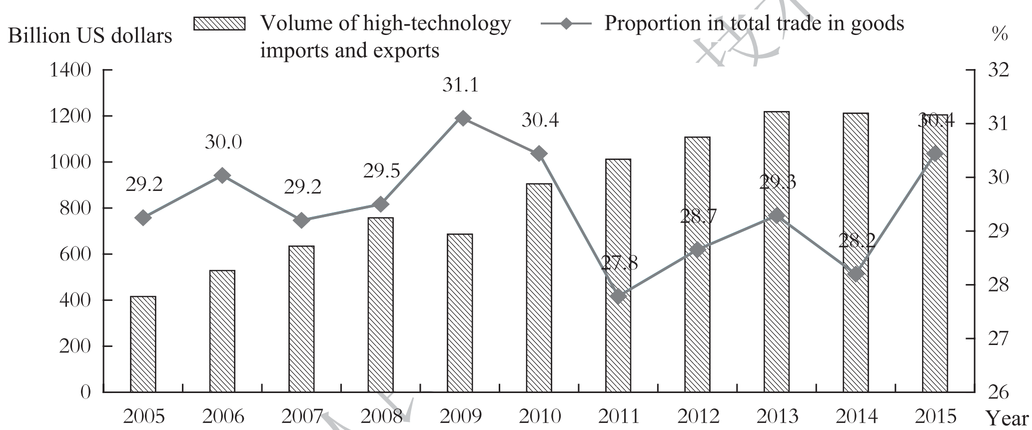

Figure 7-9　China's trade in high-technology products and as a percentage of its total trade in goods (2005–2015)

Source: General Administration of Customs, Import and export statistics.

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2　China's imports and exports of high-technology products by technology field

By technology field, China's high-technology exports in 2015 by and large continued to be focused on computer and communication technology and electronic technology as before. Among the technology fields of China's high-technology exports, computer and communication technology remained in a dominant position by exporting USD 441.9 billion worth of goods, accounting for 67.4% of the total export value of high-technology products, followed by electronic technology in the second place with USD 125.5 billion, or 19.2%.

In 2015, China's import of high-technology products continued to be led by electronic technology with USD 278.7 billion, or 50.7% of China's total import value of high-technology products. Computer and communication technology came the second with USD 116.9 billion, or 21.3%. Overall, trade in electronic technology had a growth significantly higher than trade in other high-technology products (Table 7-1).

Table 7-1 China's import and export of high-technology products by technology field (2015)

Technology field	Export			Import		
	Export value (Billion US dollars)	Proportion (%)	Year on year growth (%)	Import value (Billion US dollars)	Proportion (%)	Year on year growth (%)
Total	655.30	100	−0.8	549.29	100	−0.4
Computer and communication technology	441.89	67.4	−3.7	116.92	21.3	−3.5
Life science and technology	24.59	3.8	2.7	26.71	4.9	6.5
Electronic technology	125.54	19.2	9.6	278.66	50.7	3.5
Computer-integrated manufacturing technology	12.51	1.9	−3.3	35.85	6.5	−7.1
Aerospace technology	7.33	1.1	12.0	34.97	6.4	−2.2
Photoelectric technology	35.73	5.5	−1.6	49.37	9.0	−9.0
Biotechnology	0.69	0.1	5.7	1.13	0.2	8.8
Materials technology	6.23	1.0	2.1	4.81	0.9	−12.2
Others	0.80	0.1	6.0	0.88	0.2	41.0

See Annexed Table 7-4

China Science and Technology Indicators 2016

3 China's major trade partners in high-technology products

In export of high-technology products, Hong Kong of China and the United States were the top two destinations, accounting for 28.9% and 18.4%, respectively. Hong Kong of China, the United States and Korea combined to account for 55.3% of China's total export of high-technology products in computer and communication technology, the largest field of export of high-technology products. Hong Kong of China was also the top destination of China's export of high-technology products in electronic technology, accounting for 43.7%.

In import of high-technology products, Korea was China's top exporter, accounting for 18.9%, followed by Taiwan of China with 18.2%, the United States with 9.3%, and Japan with 8.4%, with import from Japan seeing a significant decline in recent years. In import of high-technology products in electronic technology, the largest segment of China's high-technology import, Taiwan of China, Korea and Malaysia were the top exporters, accounting for 27.9%, 22.4% and 10.4%, respectively. In aerospace technology, a smaller segment, the United States and France were the top two exporters, accounting for 60.2% and 20.5%, respectively (Figure 7-10).

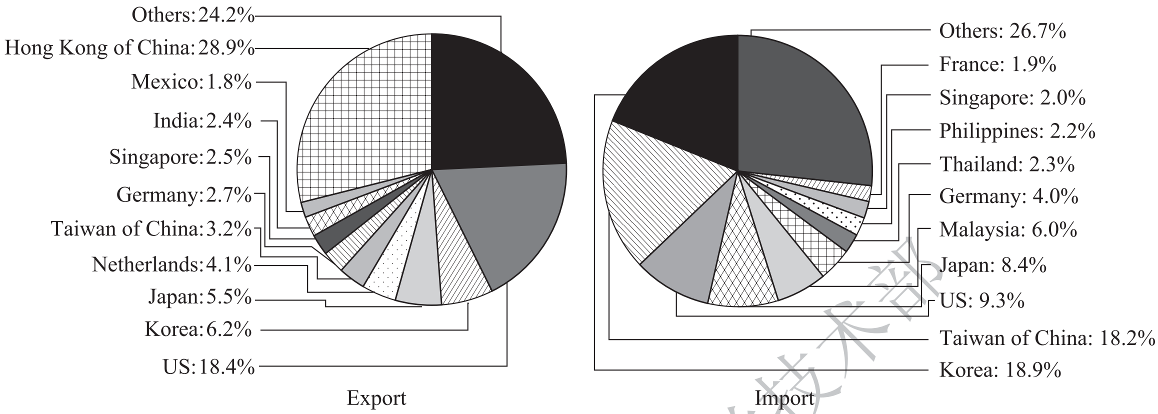

Figure 7-10 Major countries and regions of China's trade in high-technology products (2015)

Source: General Administration of Customs, Import and export statistics.

China Science and Technology Indicators 2016

4 Modes of export of high-technology products

The modes of export of high-technology products mainly include processing with imported materials[①], processing with supplied materials[②] and general trade[③]. For a long time, processing trade with imported materials accounted for 70% of China's trade in high-technology products, but its proportion began falling from 2010 and dropping to 59.1% in 2015. The proportion of processing trade with supplied materials decreased as well to 4.0% in 2015 from 14.2% in 2005. On the other hand, the proportion of general trade saw a substantial increase, rising to 19.8% in 2014 and 22.8% in 2015 (Figure 7-11).

① Processing with imported material refers to a business mode whereby a domestic entity with the power to engage in foreign trade uses foreign exchange to purchase imported raw materials, sources, supplementary materials, accessories, parts and components, and wrapping materials so as to process these into finished products for re-export.

② Processing with supplied materials refers to a business mode whereby all or part of the raw materials, auxiliary materials, spare parts, components, accessories and packaging materials are supplied by the overseas enterprise, and the operating Chinese enterprise just carries out processing or assembling in accordance with the requirements of the overseas enterprise, and charges for the processing, with the finished products being marketed by the overseas enterprise.

③ General trade refers to the import or export of goods by enterprises in China with import-export rights.

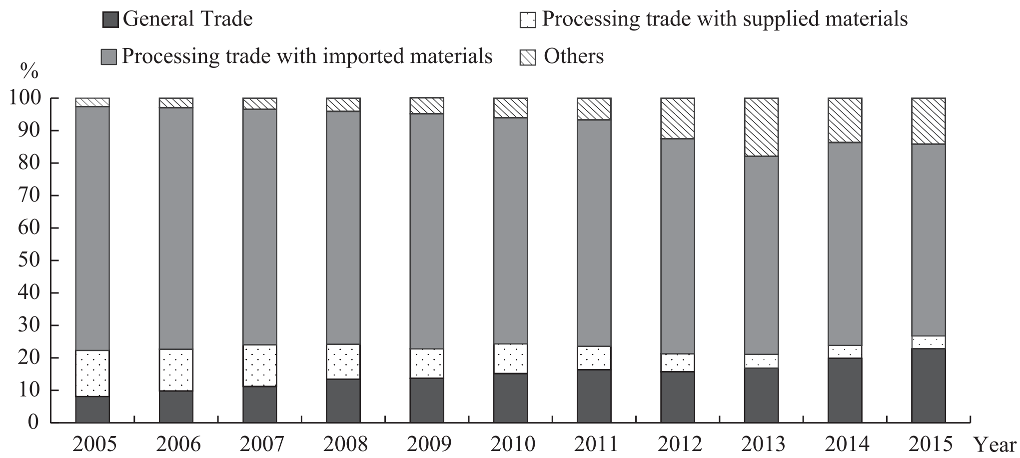

Figure 7-11 China's export of high-technology products by mode of export (2005–2015)

Source: General Administration of Customs, Import and export statistics.

Section 3 National High-technology Industrial Development Zones

Establishing national high-technology industrial development zones ("national high-technology zones") was a strategic move of China to develop the high-technology industry. This section introduces the development of China's national high-technology zones and high-technology enterprises.

1 National high-technology zones

1.1 Economic development in national high-technology zones

In 2015, a total of 31 provincial-level high-technology zones were approved by the State Council as national high-technology zones, bringing the total number of national high-technology zones to 146. In 2015, there were more than 965 thousand registered industrial and commercial enterprises in national high-technology zones. Among the 82 712 enterprises surveyed, there were 1170 listed companies and 2110 enterprises listed on the New Third Board; 31 160 high-technology enterprises; 10 enterprises with an annual revenue of more than 100 billion yuan, an increase of 3 over the previous year; 362 enterprises with an annual revenue of more than 10 billion yuan, an increase of 13 over the previous year; 3532 enterprises with an annual revenue of more than 1 billion yuan, accounting for 4.3%; and 20 633 enterprises with an annual revenue of more than 100 million yuan, accounting for 24.9%.

(1) Economic development

In 2015, the national high-technology zones achieved 25.4 trillion yuan in total revenue, 18.6 trillion yuan in total industrial output value, 1.6 trillion in net profit, 1.4 trillion yuan in tax payments, USD 473.3 billion in foreign exchange from export, and 8.1 trillion yuan in total product, accounting for 11.9% of the gross domestic product.

(2) Industrial structure

Among the enterprises in national high-technology zones, there were 36 827 in high-technology manufacturing and high-technology services, accounting for 44.5%. More specifically, these included 12 364 in high-technology manufacturing, or 14.9%, and 24 463 in high-technology industry services, or 29.6%. The number of high-technology industry services enterprises is twice as many as the number of high-technology manufacturing ones. The high-technology industry composed by high-technology manufacturing and high-technology services has become the mainstay of industries represented by enterprises in the national high-technology zones. The high-technology industry had a workforce of 6.9 million, accounting for 40.3% of all employees in national high-technology zones. In 2015, high-technology manufacturing and services achieved 8.1 trillion yuan in business revenue, 5.6 trillion yuan in aggregate industrial output value, 579.35 billion yuan of net profit, 389.1 billion yuan of tax payments, and US$289.8 billion of export value, each accounting for about 30% of national high-technology zones.

1.2 Innovation performance of national high-technology zones

(1) Innovation environment

As of the end of 2015, there were a large number of R&D institutions in China's national high-technology zones, including 753 higher education institutions, 2415 research institutes, and 1455 post-doctoral research centers. There were a total of 318 state key laboratories, 803 industry technology research institutes, 107 national engineering laboratories, 114 national engineering research centers, and 217 national engineering technology research centers. Moreover, all types of industry promotion organizations has been established, including 1354 technology startup incubators, 371 technology startup accelerators, 1021 makerspaces, and 311 productivity promotion centers; 788 technology transfer centers, 961 industry technology and innovation alliances, and 542 nationally accredited product testing centers.

(2) Innovation resources

In 2015, China's 146 national high-technology zones had a total of 3438 persons supported by the national Recruitment Program of Global Experts, including 1558 approved with recommendation by high-technology zones; 3.1 million enterprise personnel engaged in S&T activity, accounting for 18.1% of all employees in the high-technology zones; 1.8 million R&D personnel, equivalent to 1.1 million person-years in FTE; and 657.6 person-years of R&D personnel per 10 thousand employees, 13.6 times the national average (48.5 person-years). The national high-technology zones had 5.5 million employees with a bachelor's degree or higher and 1.9 million with an intermediate or senior professional title, accounting for 32.0% and 11.1%, respectively, of the total workforce in the national high-technology zones.

In 2015, the national high-technology zones received a total of 56.5 billion yuan of government budget appropriation, accounting for 12.7% of the budget outlays of the national high-technology zones. The enterprise R&D expenditure of the national high-technology zones amounted to 452.2 billion yuan, accounting for 41.6% of the national enterprise R&D expenditure. The R&D intensity of the national high-technology zones reached 5.6%, 2.7 times the national average.

(3) Innovation achievements

In 2015, enterprises in the national high-technology zones participated in a total of 346 thousand S&T projects. In 2015, enterprises in national high-technology zones filed 353 thousand patent applications, including 187 thousand invention patents which accounted for 17.0% of the national invention patent applications, and were granted 215 thousand patents, including 71 thousand invention patents, which accounted for 19.8% of the national invention patents granted in the year. In 2015, enterprises in the national high-technology zones had 926 thousand patents in force, including 279 thousand invention patents, representing 162.3 patents per 10 thousand employees, 8.5 times the national average (19.0).

2 High-technology enterprises

High-technology enterprises, as a solid foundation for developing high-technology industry, have been the robust driving force for industrial restructuring and upgrading national competitiveness. In recent years, high-technology enterprises have made constant efforts to seek development through technological innovation. As a result, the enterprises as a whole have steadily improved their innovation capability and competitive edges as well as played a positive role in promoting the growth of China's strategic emerging industry and shifting of economic growth mode.

2.1 Numbers of high-technology enterprises

As of the end of 2015, there were 76 141 high-technology enterprises nationwide, up by 21.7% compared with the previous year. 63.3% of them were concentrated in six provinces and municipalities including Beijing, Guangdong, Jiangsu, Shanghai, Zhejiang and Shandong.

In 2015, a total of 31 160 high-technology enterprises were in national high-technology zones, accounting for 40.9% of all high-technology enterprises in the country and 37.7% of all enterprises in national high-technology zones; and a total of 44 981 high-technology enterprises were located outside national high-technology zones, accounting for 59.1% of all high-technology enterprises.

2.2 Economic scale

In 2015, high-technology enterprises achieved nearly 22 trillion yuan of total revenue from principal business, up 2.3% year on year; approximately 19 trillion yuan of aggregate industrial output value, down 10.2% year on year; 1.5 trillion yuan of net profit, up 3.4% year on year; 1.1 trillion yuan of tax payments, up 3.5% year on year; and USD 476.9 billion of foreign exchange from export, down 5.9% year on year, contributing 18.6% of China's total foreign exchange from export in the year. In 2015, high-technology enterprises posted an average operating margin of 6.7% and a return on net assets of 10.2%, both improving over the previous year (Table 7-2).

Table 7-2 High-technology enterprises on major economic indicators (2014, 2015)

Indicator	2014	2015	Annual growth in 2015 (%)
Number of high-technology enterprises	62556	76141	21.7
Total revenue (Billion yuan)	21730.48	22223.41	2.3
Gross industrial output value (Billion yuan)	21133.59	18975.75	−10.2
Net profit (Billion yuan)	1439.92	1489.48	3.4
Actual tax payments (Billion yuan)	1067.48	1105.21	3.5
Total foreign exchange from export (Billion US dollars)	506.86	476.87	−5.9

Source: Torch High Technology Industry Development Center, Ministry of Science and Technology, *China Torch Statistical Yearbook 2016*.

China Science and Technology Indicators 2016

2.3 Human resources

In 2015, high-technology enterprises had 20.5 million employees, including 10.5 million with a bachelor's degree or higher, or 51.2%. They included 80 thousand PhDs, 883 thousand master's degree holders and 90 thousand overseas returnees, 2.1 million with an intermediate or senior professional title, or 10.5%, and 5.3 million engaged in S&T activity, or 25.7%. Those engaged in S&T activity included 3.0 million R&D personnel, or 1.8 million person-years in FTE, representing 897.7 person-years per 10 000 employees, 18.5 times the national average (48.5).

2.4 Technology investment

In 2015, high-technology enterprises spent 1048.1 billion yuan on S&T activity, including 630.4 billion yuan of R&D expenditure, up 7.9% year on year, accounting for 57.3% of national enterprise R&D expenditure.

2.5 Technology output

In 2015, high-technology enterprises filed a total of 576 thousand patent applications, including

275 thousand invention patent applications, or 25.0% of all invention patents filed nationwide; were granted 374 thousand patents, including 115 thousand invention patents, or 32.0% of the national total of invention patents granted; and had 1.7 million patents in force, including 445 thousand invention patents in force, representing 217.6 invention patents per 10 000 employees, 11.5 times the national average. In 2015, high-technology enterprises achieved 8.2 trillion yuan in new product sales revenue, accounting for 44.0% of their total product sales revenue.

Section 4 Venture Capital Investment

Venture capital (VC) investment provides critical financial support to high-technology enterprises, especially for the establishment and the growth of high-technology SMEs. Based on the statistics gained from joint annual survey on VC investment by the Ministry of Science and Technology, the Ministry of Commerce and the National Development Bank, this section analyzed the status quo of VC investment and its operational features.

1 Overview of venture capital development

In 2015, China had 1775 venture capital institutions[①], representing an increase of 224 or 14.4% over the previous year. They included 1311 venture capital enterprises (funds), up 144 or 12.3% year on year, and 464 venture capital management enterprises, up 80 or 20.8% over the previous year (Figure 7-12).

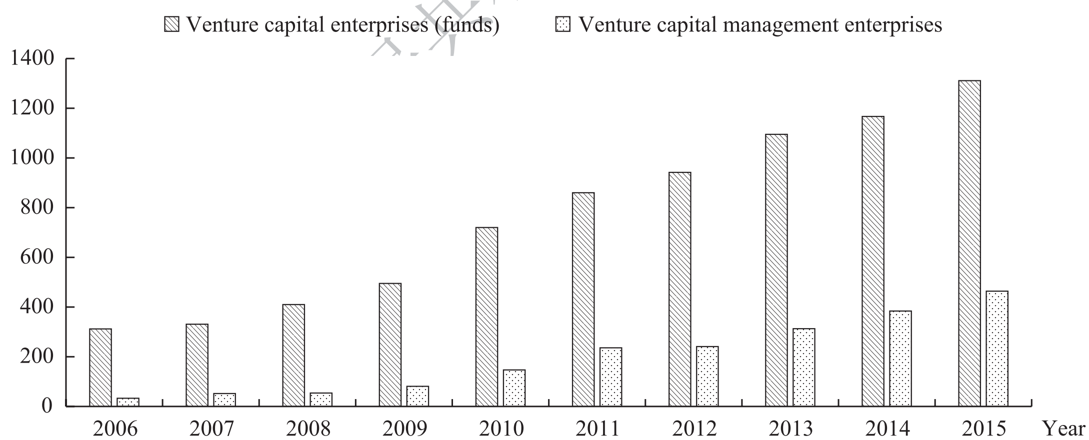

Figure 7-12 Number of venture capital institutions in China (2006–2015)

Source: Chinese Academy of Science and Technology for Development, *Venture Capital Development in China 2016.*

① The number represents all existing institutions, mainly including venture capital enterprises (funds), venture capital management enterprises and a few public institutions engaged in government venture capital business. The figure excludes all institutions which were no longer engaged in venture capital business or no longer existed.

In 2015, venture capital managed by venture capital institutions in China amounted to 665.3 billion yuan, or 0.96% of China's GDP, up 142.1 billion yuan or 31.7% over the previous year, representing 466 million yuan per venture capital fund. The largest fund managed 35 sub-funds with a total of 40 billion yuan under management.

2 Investment of venture capital institutions

According to disclosed data, venture capital institutions in China invested in a total of 3423 projects in 2015, up 39.2% year on year, and the total investment amounted to 46.6 billion yuan, representing an increase of 24.4% year on year and 13.6 million yuan per project.

As of the end of 2015, China's venture capital institutions had cumulatively invested in approximately 17 thousand projects, representing an increase of 3258 or up 23.1% from 2014, and their cumulative investment amounted to 336.1 billion yuan, up 14.6% from 2014 (Table 7-3).

Table 7-3 Cumulative venture capital investment in China (2011–2015)

Indicator	2011	2012	2013	2014	2015
Cumulative number of venture capital projects	9978	11112	12149	14118	17376
Cumulative amount of venture capital investment (Billion yuan)	203.66	235.51	263.41	293.36	336.12

Source: Chinese Academy of Science and Technology for Development, *Venture Capital Development in China 2016*.

3 Venture capital investment and high-technology enterprises

Venture capital investment is a powerful booster of high-technology enterprise development. To a great extent, the development of venture capital will promote the high-technology enterprise. In 2015, there was a comparative increase of venture capital investment in high-technology enterprise projects, though at a lower investment intensity, with investment trending to smaller early-stage enterprises. In 2015, there were a total of 820 venture capital investments in high-technology enterprise projects, up 19.0% year on year; the total investment amounted to 11.7 billion yuan, slightly down from a year earlier, with the average investment amount per project standing at 14.3 million yuan.

As of the end of 2015, venture capital institutions in China had cumulatively invested in a total of 8047 high-technology enterprise projects, accounting for 46.3% of all projects they had invested in, and they had cumulatively invested a total of 149.3 billion yuan in high-technology enterprises, accounting for 44.4% of their all-time venture capital investment (Table 7-4).

Table 7-4 Cumulative venture capital investment in high-technology enterprises/projects in China (2011–2015)

Category	2011	2012	2013	2014	2015
Number of high-technology enterprises/projects invested in	5940	6404	6779	7330	8047
Amount of investment in high-technology enterprises/projects (Billion yuan)	103.86	119.31	130.21	140.19	149.31

Source: Chinese Academy of Science and Technology for Development, *Venture Capital Development in China 2016*.

China Science and Technology Indicators 2016

In 2015, the top five industries in terms of the amount of venture capital investment received in China were computer, communications and other electronic equipment manufacturing, information transmission, software and information technology services, new energy and environmental protection industry, medicine and health care, and financial and insurance industry, which combined to account for 62.1% of the total venture capital investment; and the top five industries in terms of the number of projects receiving venture capital investment are information transmission, software and information technology services, new energy and environmental protection industry, computer, communications and other electronic equipment manufacturing, medicine and health care, and financial and insurance industry, which combined to represent 61.1% of all venture capital investment projects. As far as the trend is concerned, the new energy and environmental protection industry and the financial and insurance industry were increasingly favored by venture capital in terms of both the number of projects and the amount of investment (Table 7-5).

Table 7-5 Top ten industries of venture capital investment in China (2014, 2015)

Unit: %

Industry		2015		2014	
		Investment Amount	Investment Project	Investment Amount	Investment Project
Computer, communications and other electronic equipment manufacturing	Communication equipment Computer hardware industry semiconductor Optoelectronics and opto-mechatronics	21.7	10.8	17.3	14.6

Continued

Industry		2015		2014	
		Investment Amount	Investment Project	Investment Amount	Investment Project
Information transmission, software and information technology services	Network industry IT service industry Software industry Other IT industries	16.1	24.8	12.6	25.5
New energy and environmental protection industry	New energy and energy efficiency technology New materials industry Environmental engineering Applied nuclear technology	11.0	12.8	7.8	13.2
Pharmaceutical and biological industry Medicine and health care		7.5	7.5	9.0	9.4
Financial and insurance industry		5.7	5.2	2.3	3.6
Culture, sports and entertainment industry (communications and cultural entertainment industry)		5.5	4.3	4.5	3.8
Traditional manufacturing industry		3.8	4.4	6.2	5.0
Social services		3.4	3.1	1.9	1.7
Consumer goods and services		2.1	2.7	1.6	2.6
Other industries		10.4	10.9	6.9	8.1

Source: Chinese Academy of Science and Technology for Development, *Venture Capital Development in China 2016*.

See Annexed Table 7-8

China Science and Technology Indicators 2016

Chapter 8 Regional Science and Technology Indicators

Regional S&T progress is important to the implementation of innovation-driven development strategy and the construction of national innovation system. Due to uneven economic and social development, regional S&T development in China has great disparities and the major regional S&T indicators also show different features. This chapter analyzes the S&T activities of 31 Chinese provinces (autonomous regions, municipalities directly under the Central Government) in 2015 based on the regional distribution of major S&T indicators and regional S&T distribution features.

Section 1 Regional Distribution of Major S&T Indicators

The analysis of regional major S&T indicators is helpful for us to understand the development and the changing trend of regional S&T. This section analyzes, based on the regional level, the distribution features of S&T indexes of China in 2015, such as S&T expenditure, S&T activity output and innovation capability of high-technology industry, and the regional structural features of some important indicators.

1 General features

From the aspects of R&D personnel, R&D expenditure, patents output and high-technology industry, the most prominent feature of China's S&T resources is unbalanced regional distribution.

1.1 R&D personnel

(1) R&D personnel in FTE

In 2015, China had 3.8 million person-years of R&D personnel in FTE. China's 31 regions could be divided into four categories by the number of their R&D personnel in FTE, and they included in the descending order 14 economically developed regions such as Jiangsu, Guangdong and Zhejiang in Category 1 which had more than 100 thousand person-years of R&D personnel, or 83.0% of national total; three regions, i.e. Shaanxi, Liaoning and Chongqing, in Category 2 which had 60~100 thousand person-years, or 6.4%; seven regions including Heilongjiang in Category 3 which had 30~60 thousand person-years; and seven regions including Gansu in

Category 4 which had less than 30 thousand person-years (Figure 8-1).

(2) R&D personnel in FTE per 10 000 employees

In 2015, China had 48.5 person-years of R&D personnel in FTE per 10 000 employees. China's 31 regions could be divided into four categories by their R&D personnel intensity, and they included in the descending order three municipalities (Tianjin, Beijing and Shanghai) and Jiangsu, in Category 1 which had more than 100 person-years per 10 000 employees; four provinces including Zhejiang, Guangdong, Fujian and Shandong in Category 2 which had 50~100; 13 regions including Shaanxi in Category 3 which had 25~50; and 10 regions including Sichuan in Category 4 which had less than 25 (Figure 8-1).

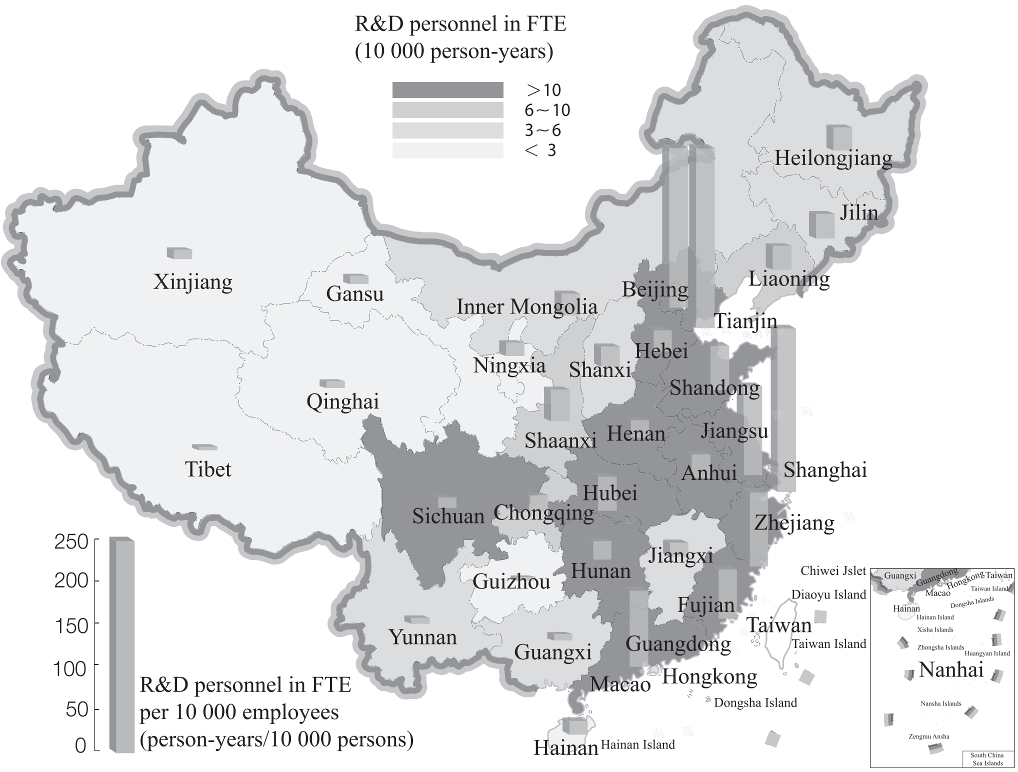

Figure 8-1 R&D personnel by region (2015)

See Annexed Table 8-1 and Annexed Table 8-10

China Science and Technology Indicators 2016

1.2 R&D expenditure

(1) Total R&D expenditure

In 2015, China's R&D expenditure amounted to 1.42 trillion yuan. China's 31 regions, again, could be divided into four categories by their R&D intensity in the descending order. Category

1 included 12 regions such as Jiangsu, Guangdong and Shandong, whose R&D expenditure exceeded 40 billion yuan. Category 2 included five regions such as Shaanxi, Fujian and Liaoning whose R&D expenditure was between 20 billion yuan and 40 billion yuan. The above 17 regions combined to have 1.30 trillion yuan, accounting for 91.5% of national total. Category 3 included seven regions including Jiangxi whose R&D expenditure was between 10 billion yuan and 20 billion yuan. Category 4 included seven regions including Gansu whose R&D expenditure was less than 10 billion yuan (Figure 8-2).

(2) R&D expenditure to regional GDP

In 2015, China's ratio of R&D expenditure to GDP reached 2.06%. China's 31 regions could be divided into four categories by their ratio of R&D expenditure to regional GDP and they included in the descending order eight regions including Beijing, Shanghai and Tianjin in Category 1 whose ratio was above 2.0%; five regions including Anhui, Hubei and Sichuan in Category 2 whose ratio was between 1.5% and 2.0%; nine regions including Hunan in Category 3 whose ratio was between 1.0% and 1.5%; and nine regions including Ningxia in Category 4 whose ratio was below 1.0% (Figure 8-2).

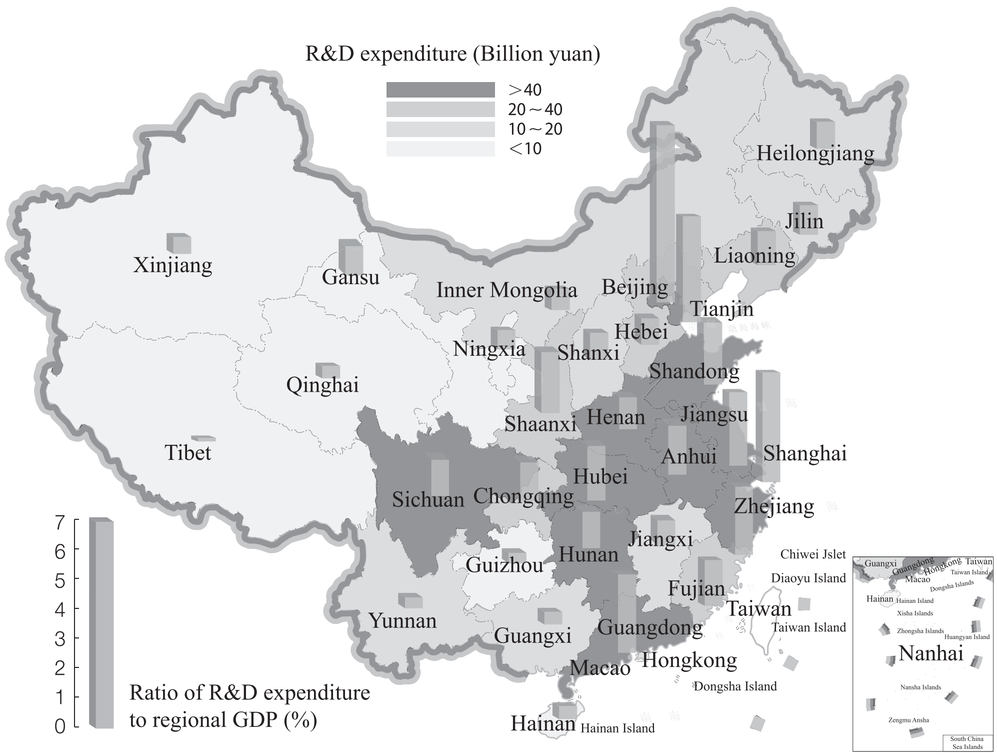

Figure 8-2 R&D expenditure by region (2015)

See Annexed Table 8-1 and Annexed Table 8-10

1.3 Invention patents

(1) Invention patents filed

In 2015, China (including Hong Kong, Macao and Taiwan) had 968 thousand domestic invention patents filed. China's 31 regions could be divided into four categories by the number of their invention patents filed. Category 1 included 13 regions including Jiangsu, Guangdong and Shandong with more than 20 thousand invention patents filed, which combined to have 810 thousand, or 83.7% of national total. Category 2 included six regions including Hunan, Liaoning, Fujian, Shaanxi, Heilongjiang and Hebei with 10~20 thousand. Category 3 included seven regions including Guizhou with 3~10 thousand. And Category 4 included five regions including Ningxia with less than 3 thousand (Figure 8-3).

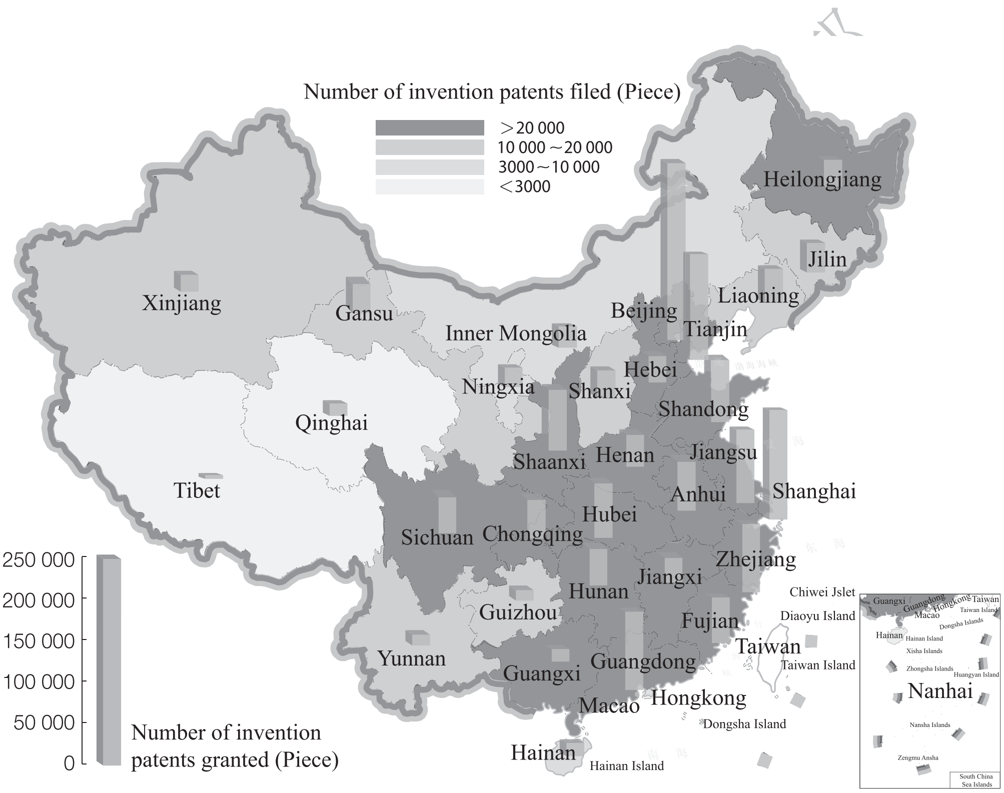

Figure 8-3 Invention patents filed and granted by region (2015)

See Annexed Table 8-2 and Annexed Table 8-3

China Science and Technology Indicators 2016

(2) Invention patents granted

In 2015, China (including Hong Kong, Macao and Taiwan) had 263 thousand invention patents granted. China's 31 regions could be divided into four categories by the number of their invention patents granted. Category 1 included 14 regions including Jiangsu, Beijing, Guangdong, Zhejiang and Shanghai with more than 5 thousand. Category 2 included eight regions including Tianjin, Heilongjiang and Guangxi with 2~5 thousand. The invention patents granted of the above 22 regions combined to account for 97.3% of national total. Category 3 included three regions including Jiangxi with 1~2 thousand. And Category 4 included six regions including Xinjiang with less than 1 thousand (Figure 8-3).

1.4 High-technology industry

(1) Revenue from principal business of high-technology industry

In 2015, the revenue from principal business of China's high-technology industry amounted to 14.0 trillion yuan. China's 31 regions could be divided into four categories in the descending order by the revenue from principal business of their high-technology industry. Category 1 included three regions including Guangdong, Jiangsu and Shandong with more than 1.0 trillion yuan. Category 2 included 12 regions including Shanghai, Henan and Zhejiang with 200~1.0 trillion yuan. The above 15 regions accounted for 90.9% of national total. Category 3 included eight regions including Shaanxi with 50~200 billion yuan. Category 4 included eight regions including Inner Mongolia with less than 50 billion yuan (Figure 8-4).

(2) Export of high-technology products

In 2015, the export value of China's high-technology products amounted to USD 655.3 billion. China's 31 regions could be divided into four categories in the descending order by their export value of high-technology products. Category 1 included two regions, i.e. Guangdong and Jiangsu, with more than USD 100 billion. Category 2 included one region, i.e. Shanghai, with USD 50~100 billion. These three regions accounted for 68.5% of national total. Category 3 included eight regions including Chongqing, Henan and Tianjin with USD 10~50 billion. Category 4 included 20 regions including Shaanxi with less than USD 10 billion (Figure 8-4).

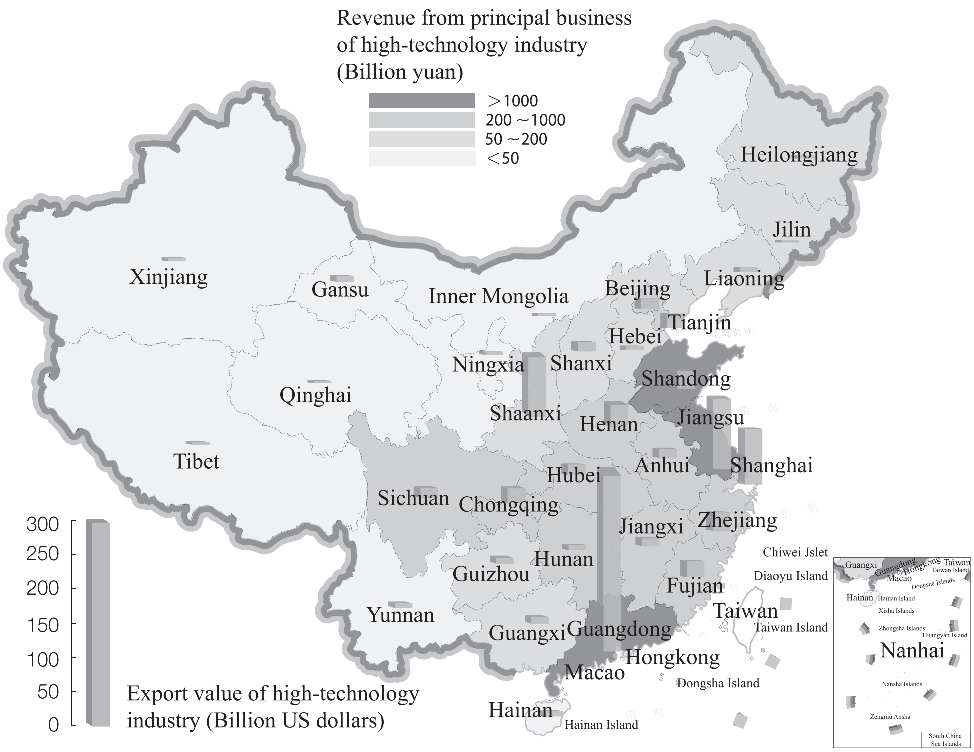

Figure 8-4　High-technology industry by region (2015)

See Annexed Table 8-4 and Annexed Table 8-5

China Science and Technology Indicators 2016

2　Structural characteristics

2.1　R&D resources by sector of performance

(1) R&D personnel

In 2015, China's R&D personnel in FTE were 10.2% represented by research institutes, 9.4% by higher education institutions and 80.4% by enterprises and other organizations. There were six regions where R&D personnel of research institutes accounted for more than 20%, with the ratio for the top three being 45.5% for Tibet, 39.9% for Beijing and 31.9% for Shaanxi. In most regions, higher education R&D personnel in FTE as a percentage of regional total stood between 10% and 20%. There were five regions whose percentage was higher than 20%, including Jilin with 30.2%, Tibet with 27.3%, Heilongjiang with 26.1%, Guangxi with 25.6% and Xinjiang with 22.5%. The R&D personnel of enterprises and other organizations in FTE as a percentage of regional total stood at a high level in all regions, with 13 posting a percentage of more than 80%, with Zhejiang, Guangdong and Jiangsu in the top three posting 93.6%, 92.6% and 90.9%, respectively (Figure 8-5).

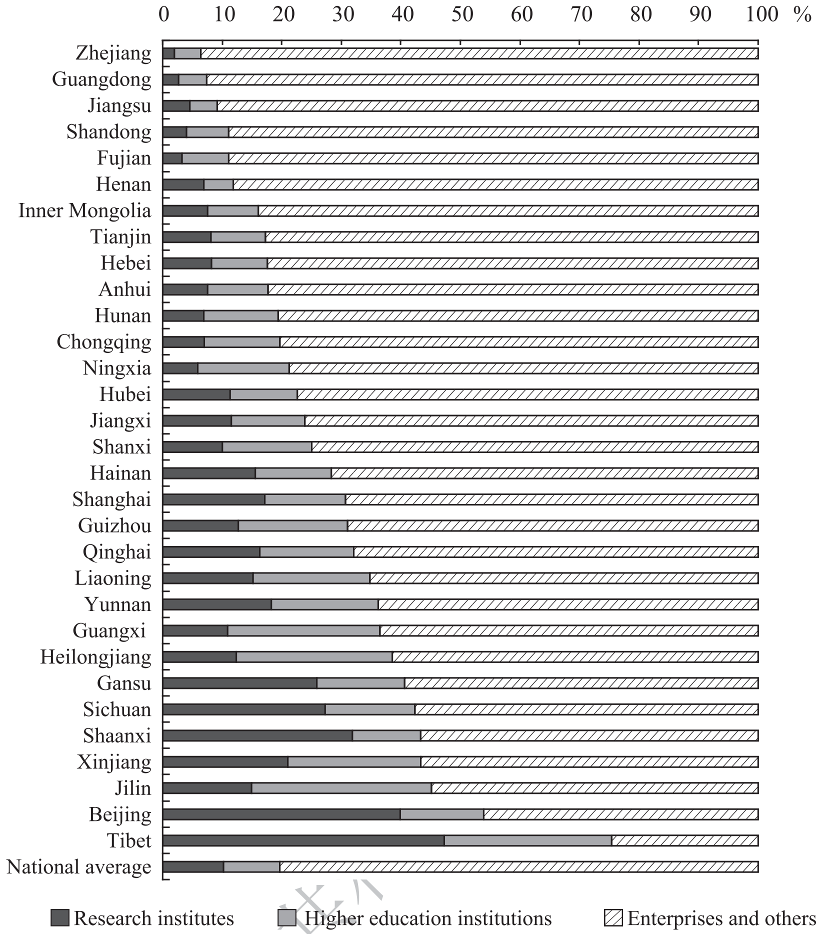

Figure 8-5 R&D personnel of regions by sector of performance (2015)

See Annexed Table 8-6

China Science and Technology Indicators 2016

(2) R&D expenditure

In 2015, China's total R&D expenditure amounted to 1.42 trillion yuan, including 15.1% for research institutes, 7.0% for higher education institutions, and 77.9% for enterprises and other organizations. By region, there were four regions where the R&D expenditure of research institutes accounted for more than one third of regional total, including Beijing (50.8%), Tibet (44.9%), Sichuan (42.1%) and Shaanxi (41.6%). Regions where higher education R&D expenditure accounted for a high percentage in regional total included Tibet (36.2%) and Heilongjiang (26.0%). In most regions, the R&D expenditure of enterprises and other organizations accounted for more than 50% of regional total, with Shandong on the top even posting 94.0% (Figure 8-6).

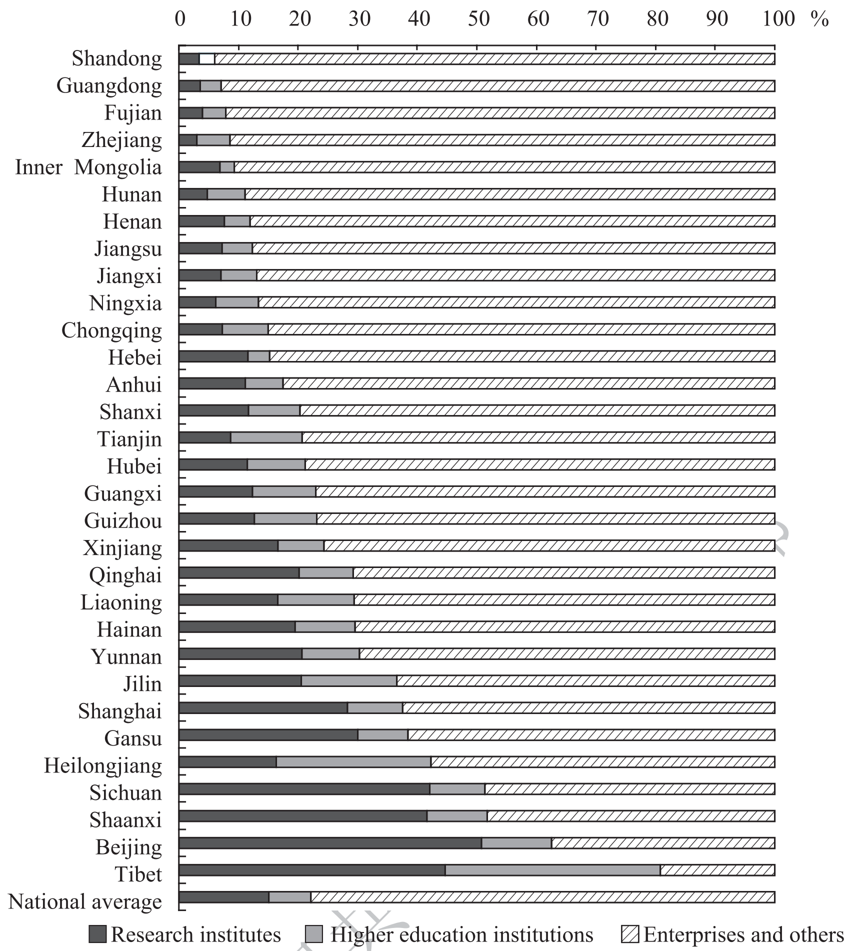

Figure 8-6 R&D expenditure of regions by sector of performance (2015)

See Annexed Table 8-7

China Science and Technology Indicators 2016

2.2 SCI papers by discipline

In 2015, China published a total of 297 thousand SCI papers. By discipline, industrial technology and basic disciplines had the highest number of SCI papers published, accounting for 47.3% and 27.2%, respectively. By region, SCI papers in basic disciplines accounted for more than 40% in all regions, with four posting more than 60%; and regions where SCI papers in industrial technology took the lead were mostly traditional industrial regions (Figure 8-7).

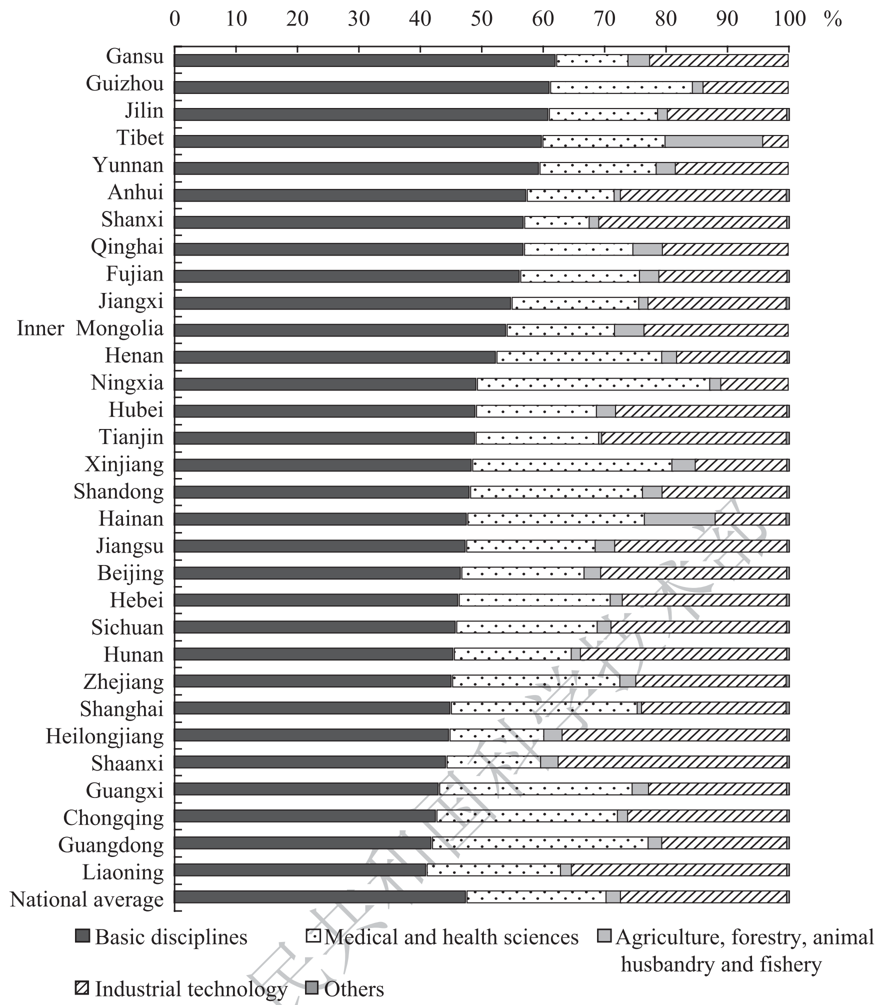

Figure 8-7 SCI papers by discipline (2015)

See Annexed Table 8-8

China Science and Technology Indicators 2016

2.3 Domestic patents granted by type

In 2015, China had a total of 1.6 million domestic patents granted, including 16.5% of invention patents, 54.4% of utility model patents and 29.1% of design patents. By region, invention patents accounted for less than 30% of all patents granted in most regions; and there were 25 regions such as Tianjin, Shandong and Anhui where utility model patents accounted for more than 50% (Figure 8-8).

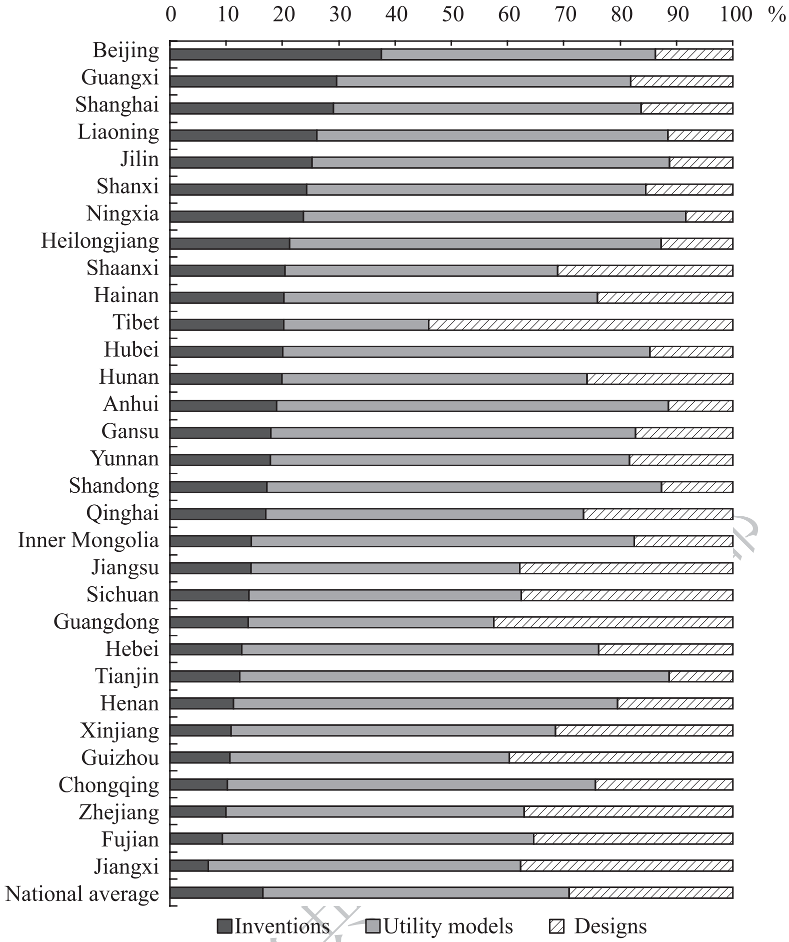

Figure 8-8 Domestic invention patents granted by type (2015)

See Annexed Table 8-3

China Science and Technology Indicators 2016

2.4 Revenue from principal business of high-technology industry by sector

In 2015, the revenue from principal business of China's high-technology industry amounted to 13 996.9 billion yuan, with manufacture of electronic equipment and communication equipment having the highest proportion at 55.9%. By region, there were ten regions where manufacture of electronic equipment and communication equipment accounted for more than 50%, with Guangdong, Shanxi and Fujian in the top three posting 80.7%, 76.1% and 63.2%, respectively (Figure 8-9).

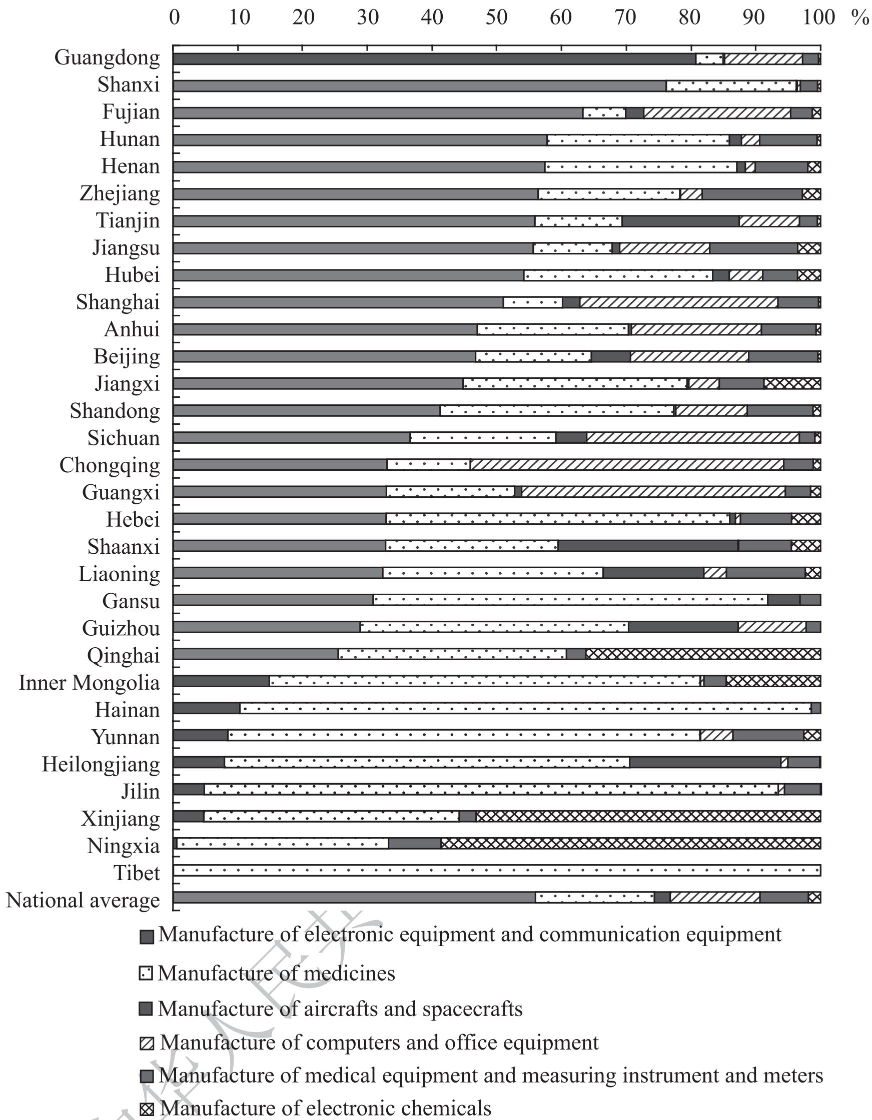

Figure 8-9　Revenue from principal business of high-technology industry by sector (2015)

See Annexed Table 8-9

China Science and Technology Indicators 2016

Section 2　Features of Regional Distribution of S&T

In recent years, the overall strategy for regional development of China has been operated smoothly and boosted China's S&T and economic growth. To better observe the regional distribution of S&T in China, this section divides the 31 provinces (autonomous regions, municipalities directly under the Central Government) into four regions, i.e. Coastal East China, Northeast China, Central China and Western China [1]. This section selects 8 indicators [2] and applies the method of location quotient and radar chart to compare and analyze the four regions.

Column 8-1 The concept of location quotient and its application in this section

Location quotient (also referred to as regional specialization ratio) is an analytical method frequently applied in regional science research. It was initially used to reflect the specialization level of a certain industrial sector in a region compared with the national level of this industry, so the industrial sectors with comparative advantages in the region could be discovered. According to the calculation of the location quotient of an industry in every region, the concentration feature of spatial distribution of an industry can also be found. This section uses the location quotient to analyze the comparative advantages of different regions in S&T development. Let T_{ij} be the value of S&T indicator j in region i, T_{0j} be the national average value of S&T indicator j, and then the location quotient (C_{ij}) of S&T indicator j in region i can be expressed as: $C_{ij}=T_{ij}/T_{0j}\times 100$. If $C_{ij} \leqslant 100$, it means that the value of S&T indicator j in region i is lower than or equal to the national average level; if $C_{ij}>100$, it means that the value of S&T indicator j in region i is higher than the national average level, with a certain comparative advantage.

1 S&T distribution of Coastal East China

The S&T development level in the ten provinces and municipalities of Coastal East China differs greatly and can be divided into 3 groups. Group 1 includes Beijing, Tianjin and Shanghai; Group 2 includes Jiangsu, Zhejiang, Guangdong and Shandong; Group 3 includes Fujian, Hebei and Hainan.

All location quotients of Beijing were higher than the region's average level; two indicators,

① Coastal East China includes Beijing, Tianjin, Hebei, Shandong, Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong and Hainan; Northeast China includes Liaoning, Jilin and Heilongjiang; Central China includes Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan; Western China includes Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang.

② The 8 indicators include "R&D personnel in FTE per 10 000 employees", "R&D expenditure as a percentage of regional GDP", "S&T expenditure as a percentage of local fiscal expenditure", "number of invention patents per 10 000 persons", "number of SCI papers per hundred thousand people", "revenue from principal business of high-technology industry as a percentage of revenue from principal business of industrial enterprises above designated size", "export value of high-technology products as a percentage of export value of goods", and "technology market contract turnover as a percentage of regional GDP". For the convenience of expression, they are abbreviated as "R&D personnel", "R&D expenditure", "fiscal S&T expenditure", "invention patents", "SCI papers", "high-technology industry", "high-technology products" and "technology contracts", respectively.

technology contracts and SCI papers, were as high as 883 and 771 respectively. In Tianjin, seven indicators were higher than the average; R&D personnel was 284, the highest; high-technology industry was 97, below the average. All eight indicators of Shanghai were above the average level, in which the location quotients of SCI papers and R&D personnel were 318 and 221 respectively (Figure 8-10).

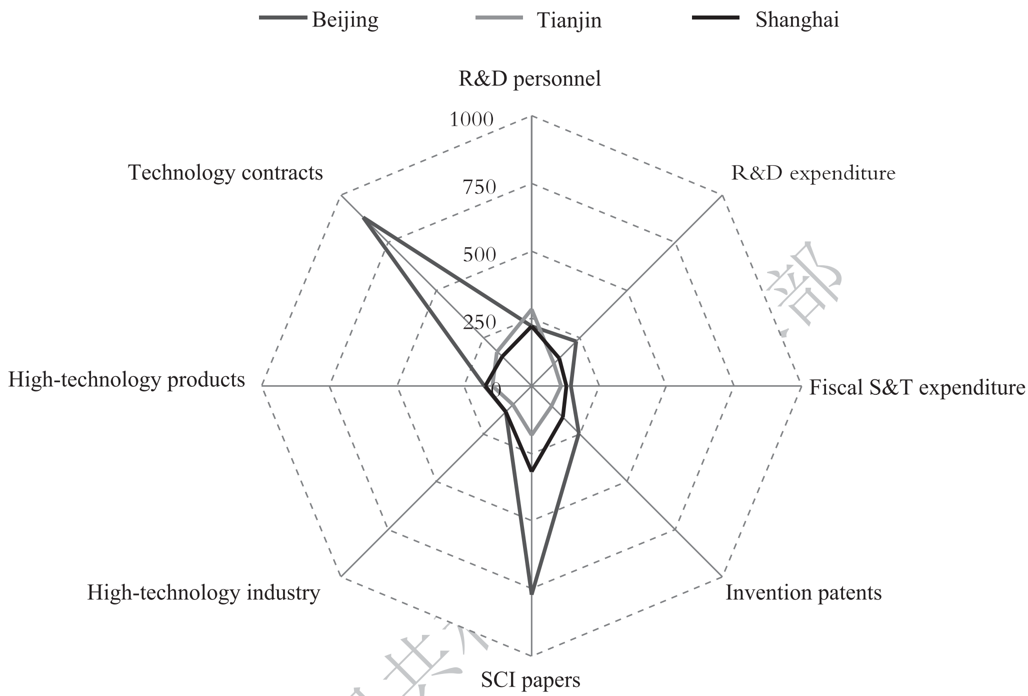

Figure 8-10 S&T distribution of Beijing, Tianjin and Shanghai (2015)

China Science and Technology Indicators 2016

In Jiangsu, seven indicators were higher than the region's average level, but the location quotient of technology contracts was only 48% of the average. In Zhejiang, the location quotients of R&D personnel, fiscal S&T expenditure and invention patents were 109, 111 and 188 respectively, all higher than or equal to the average level; other five indicators were below the average level. In Guangdong, five indicators, R&D personnel, fiscal S&T expenditure, invention patents, high-technology industry and high-technology products were 103, 130, 115, 180 and 114 respectively, all higher than the average level; the remaining three were below the average. In Shandong, all eight indicators were below the average level; the location quotient of technology contracts was only 29% of the average (Figure 8-11).

The eight indicators of Fujian, Hebei and Hainan were all below the region's average level. Fujian performed better in R&D personnel, invention patents and high-technology industry, which were 69%, 66% and 64% of the average level respectively. Hebei and Hainan lagged far behind in technology contracts, only 8% and 4% of the average level respectively (Figure 8-12).

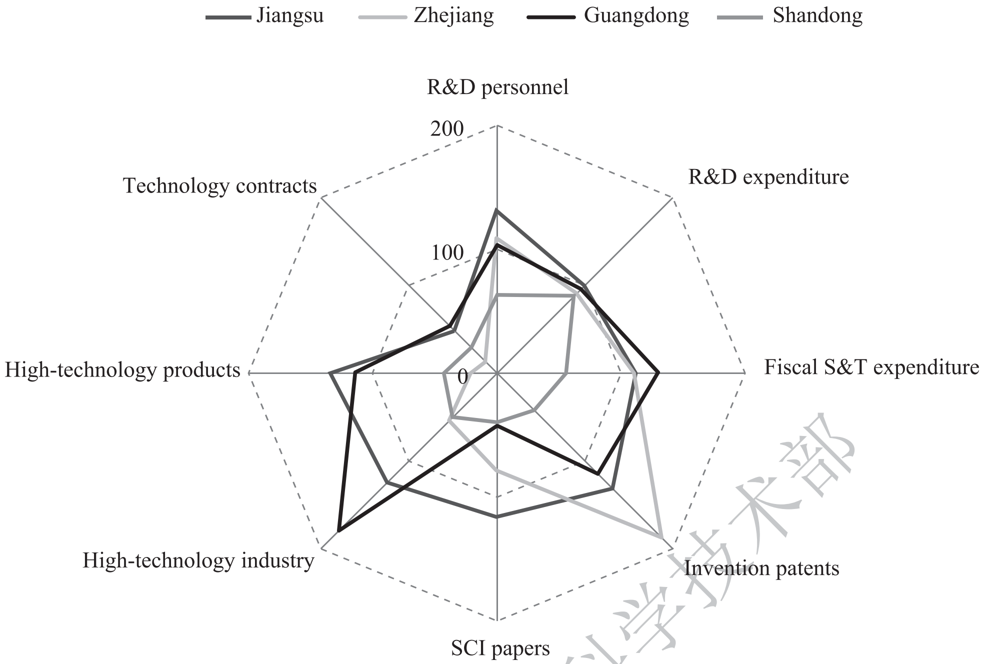

Figure 8-11　S&T distribution of Jiangsu, Zhejiang, Guangdong and Shandong (2015)

China Science and Technology Indicators 2016

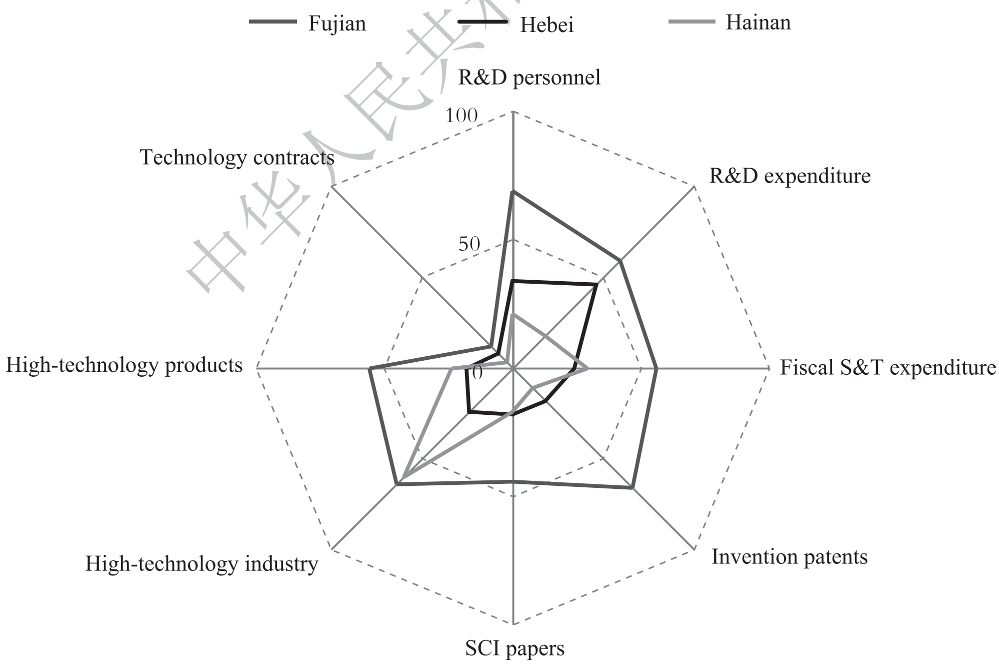

Figure 8-12　S&T distribution of Fujian, Hebei and Hainan (2015)

China Science and Technology Indicators 2016

2 S&T distribution of Northeast China

The analysis of the northeastern region in the eight regional S&T distribution indicators shows that S&T development in the three regions in Northeast China was balanced overall. Liaoning outperformed Northeast China average in seven indicators, with its location quotient reaching 127 for invention patents and 128 for technology contracts. Its location quotient was slightly lower than the average only in high-technology industry. Jilin outperformed Northeast China average in three indicators, with its location quotient in high-technology industry scoring the highest with 130, and its location quotient was below the average in five indicators, i.e. R&D expenditure, fiscal S&T expenditure, invention patents, high-technology products, and technology contracts. Heilongjiang had only one indicator where its location quotient was higher than Northeast China average, i.e. technology contracts with 115, and its location quotient was lower than the average in the other seven indicators of R&D personnel, R&D expenditure, fiscal S&T expenditure, invention patents, SCI papers, high-technology industry, and high-technology products (Figure 8-13).

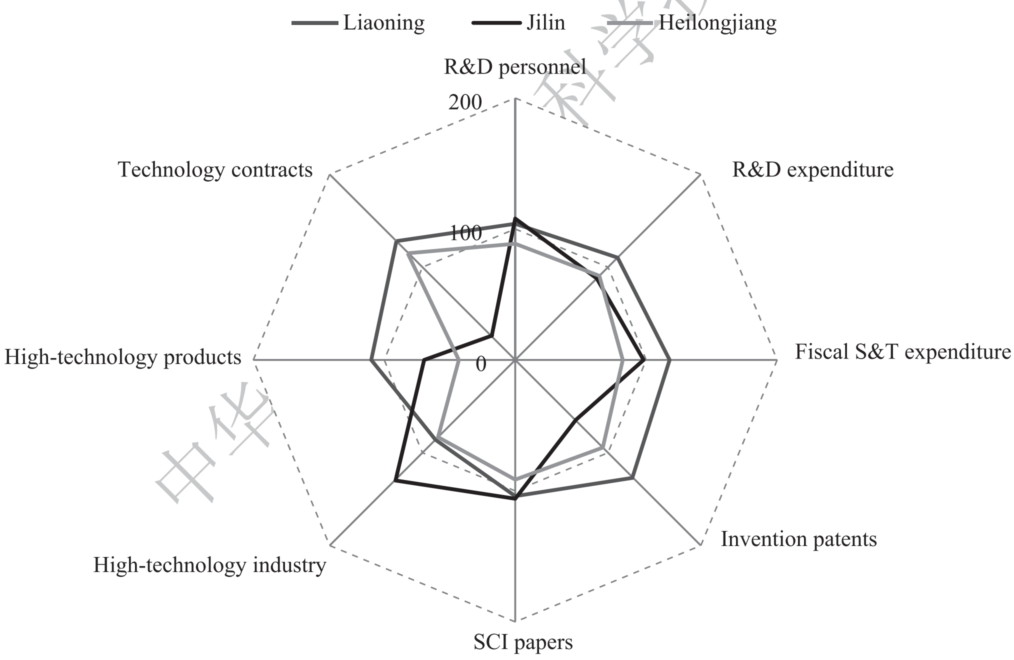

Figure 8-13 S&T distribution of Northeast China (2015)

China Science and Technology Indicators 2016

3 S&T distribution of Central China

The six regions in Central China had some differences in their S&T development and can be divided into two groups, with Shanxi, Henan and Hebei in Group 1 and Hunan, Anhui and

Jiangxi in Group 2.

Shanxi's location quotient was higher than Central China average in high-technology products with 101 and was lower than the average in the other seven indicators. Henan's location quotient was higher than Central China average in high-technology industry (104) and high-technology products (177) and was lower than the average in the other six indicators. Hubei's location quotient was lower than Central China average in high-technology industry and high-technology products and higher than the average in the other six indicators, reaching 208% and 314% of the average in SCI papers and technology contracts, respectively, in particular (Figure 8-14).

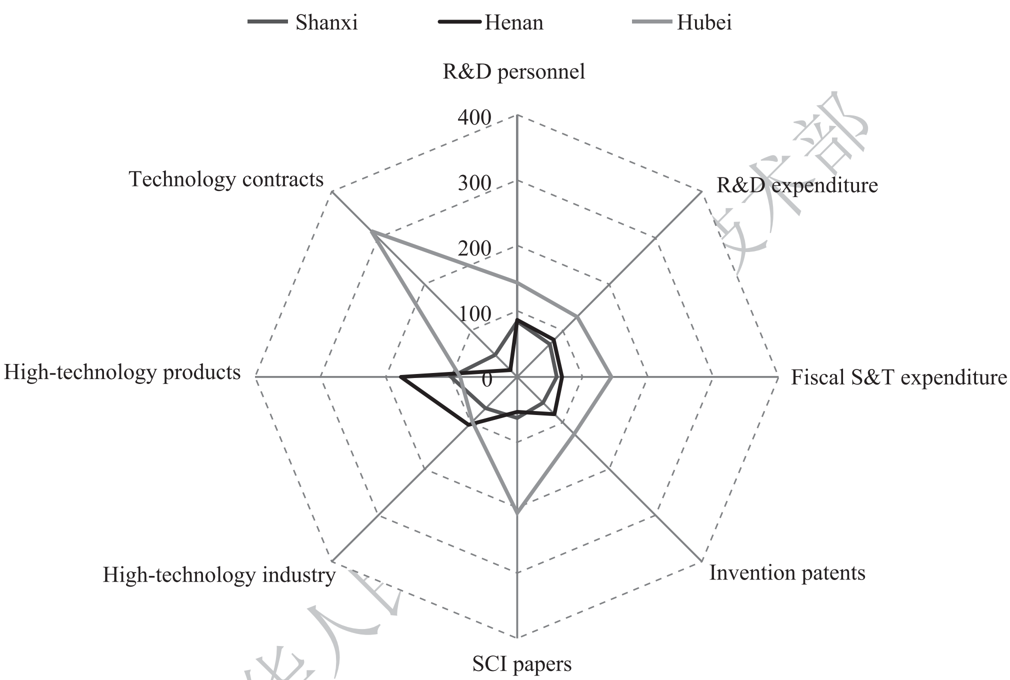

Figure 8-14　S&T distribution of Shanxi, Henan and Hubei (2015)

China Science and Technology Indicators 2016

Hunan was above Central China average in SCI papers, close to the average in R&D personnel, R&D expenditure, invention patents and high-technology industry, and below the average in fiscal S&T expenditure, technology contracts and high-technology products. Anhui was above Central China average in seven indicators including R&D personnel, R&D expenditure, fiscal S&T expenditure, invention patents, SCI papers, high-technology industry and technology contracts, posting a location quotient of 160 in invention patents in particular, and was below the average only in high-technology products. Jiangxi was above Central China average in high-technology industry with a location quotient of 115 and below the average in the rest seven indicators (Figure 8-15).

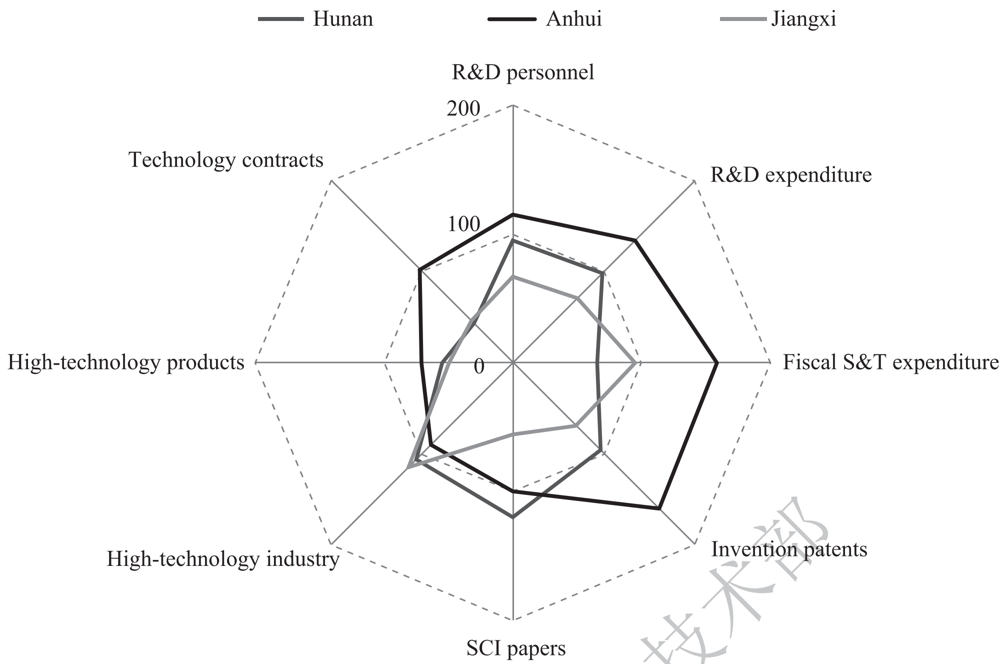

Figure 8-15 S&T distribution of Hunan, Anhui and Jiangxi (2015)

China Science and Technology Indicators 2016

4 S&T distribution of Western China

To clearly show differences, the regions of Western China can be divided into 4 groups: Group 1 includes Inner Mongolia, Shaanxi and Ningxia. Group 2 includes Gansu, Qinghai and Xinjiang. Group 3 includes Chongqing, Sichuan and Guizhou. And the fourth group includes Guangxi, Yunnan and Tibet.

Inner Mongolia was above Western China average in R&D personnel with a location quotient of 147 and was below the average in the rest seven indicators. Shaanxi was above Western China average in all the eight indicators with 338 in SCI papers, 431 in technology contracts, 216 in R&D personnel, 183 in R&D expenditure and 161 in invention patents, among others. Ningxia was above Western China average in R&D personnel with 129 and fiscal S&T expenditure with 132 and below the average in other six indicators (Figure 8-16).

Gansu outperformed Western China average in R&D expenditure (103), SCI papers (120) and technology contracts (205) and was below the average in other five indicators. Qinghai was above Western China average in technology contracts with a location quotient of 209 and was below the average in all the rest seven indicators. Xinjiang was close to the Western China average in R&D personnel (90) and fiscal S&T expenditure (95) and was below the average in other six indicators (Figure 8-17).

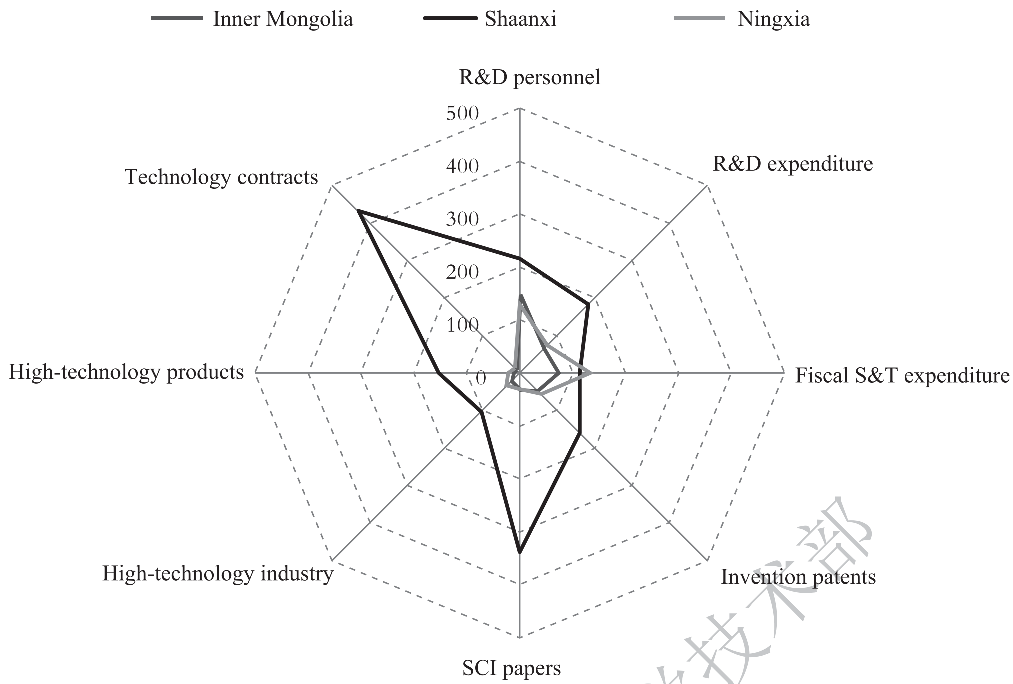

Figure 8-16 S&T distribution of Inner Mongolia, Shaanxi and Ningxia (2015)

China Science and Technology Indicators 2016

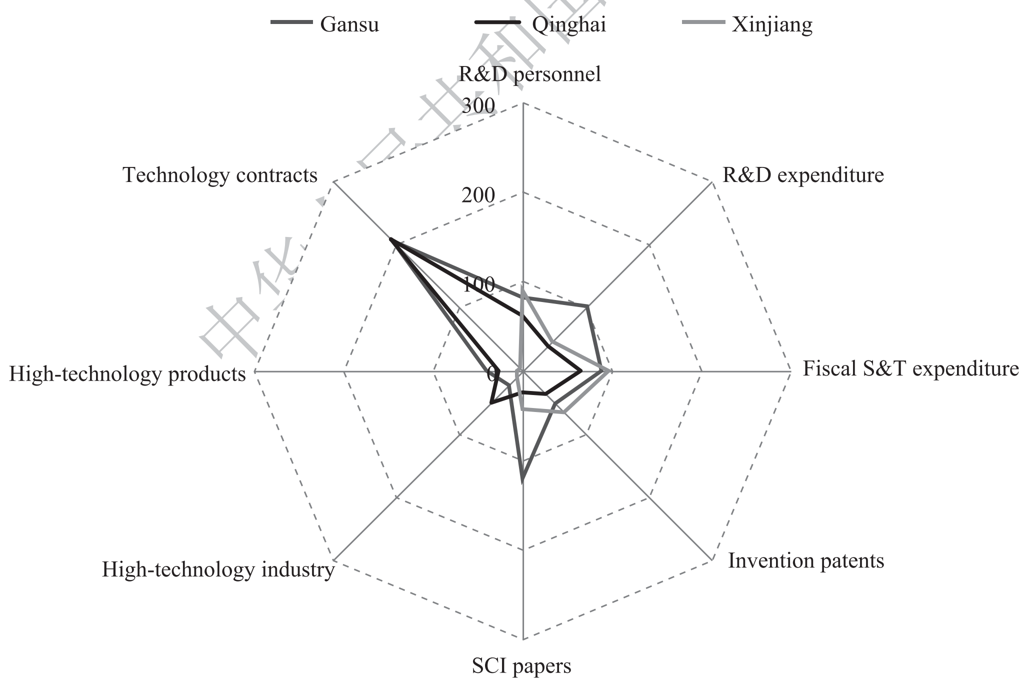

Figure 8-17 S&T distribution of Gansu, Qinghai and Xinjiang (2015)

China Science and Technology Indicators 2016

With the exception of technology contracts, Chongqing was above Western China average in all the rest seven indicators and outperformed the average by more than 1.5 times in invention patents (224), SCI papers (165), high-technology industry (208) and high-technology products (159) in particular. Sichuan outperformed Western China average in all the eight indicators, posting 147 in invention patents and 144 in high-technology industry in particular. Guizhou was above Western China average in fiscal S&T expenditure with a location quotient of 130 and below the average in all the rest seven indicators (Figure 8-18).

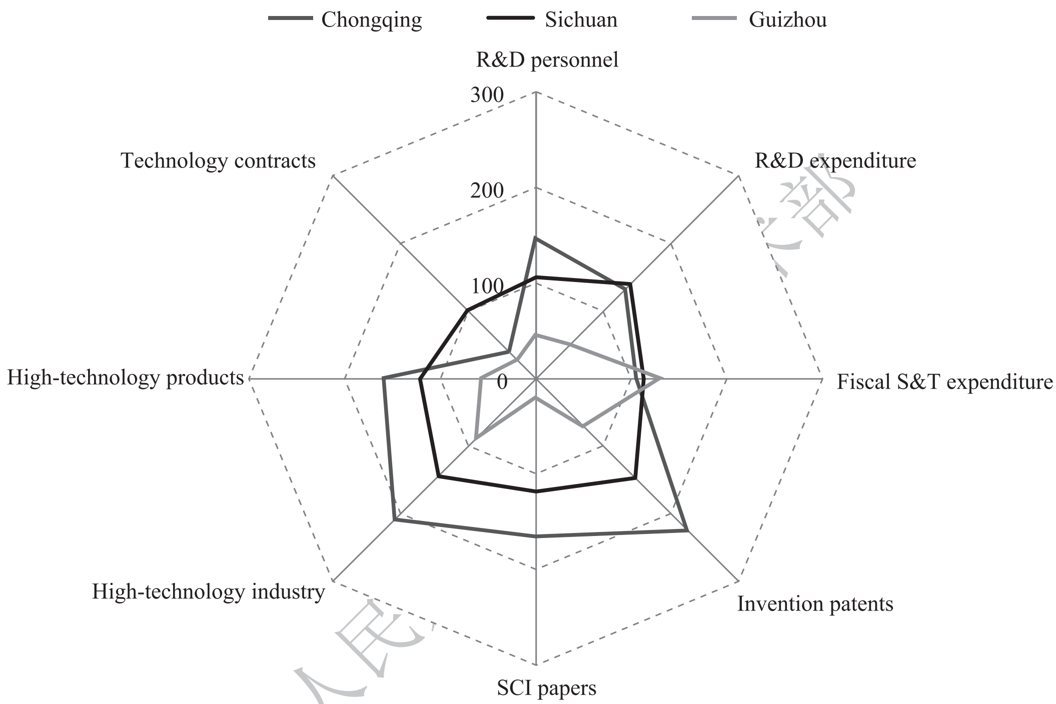

Figure 8-18 S&T distribution of Chongqing, Sichuan and Guizhou (2015)

China Science and Technology Indicators 2016

In Guangxi, the location quotient of fiscal S&T expenditure was 106, higher than Western China average, while other seven were lower. In Yunnan, the location quotient of fiscal S&T expenditure was 90, close to the average; the other seven were all lower. In Tibet, all indicators were lower than the average except for technology contracts whose data was missing (Figure 8-19).

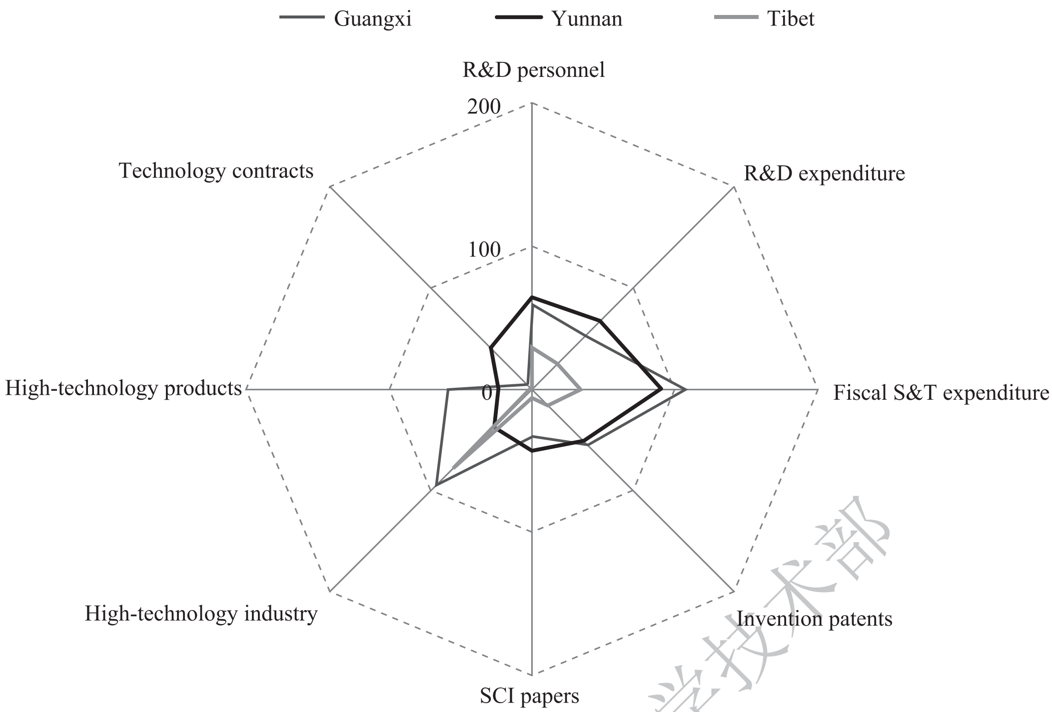

Figure 8-19　S&T distribution of Guangxi, Yunnan and Tibet (2015)

China Science and Technology Indicators 2016

Annexed Tables

Annexed Table 1-1 Overview of human resources in science and technology (2006–2015)

Category	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total population at year-end (10 000 persons)	131448	132129	132802	133450	134091	134735	135404	136072	136782	137462
Employees (10 000 persons)	74978	75321	75564	75828	76105	76420	76704	79300	77253	77451
Stock of graduates holding a junior college or above diploma (10 000 persons)[a]	6000	6780	7650	8570	9510	10510	11540	12610	13730	14900
HRST stock (10 000 persons)[a]	3840	4200	4700	5190	5700	6300	6743	7105	7512	7915
#Number of persons holding a bachelor's degree or above (10 000 persons)	1620	1810	2020	2161	2353	2556	2745	2943	3170	3421
R&D personnel (10 000 person-years)	150.25	173.62	196.54	229.13	255.38	288.29	324.68	353.28	371.06	375.88
#Basic research	13.13	13.81	15.4	16.46	17.37	19.32	21.22	22.32	23.54	25.32
#Research institutes	3.20	3.59	3.82	4.08	4.20	5.03	5.66	6.09	6.56	7.12
Higher education institutions	8.97	9.45	10.90	11.27	12.00	12.93	14.01	14.66	15.47	16.42
Enterprises	0.68	0.50	0.36	0.17	0.16	0.22	0.23	0.29	0.23	0.40
Others	0.29	0.27	0.31	0.94	1.00	1.14	1.32	1.28	1.27	1.39
Applied research	29.97	28.60	28.94	31.53	33.56	35.28	38.38	39.56	40.70	43.04
#Research institutes	8.98	9.33	9.74	10.29	10.91	11.33	12.14	12.97	12.84	13.14
Higher education institutions	11.35	11.98	13.68	14.12	14.83	15.03	15.43	15.91	16.08	17.21
Enterprises	8.12	5.81	3.99	2.50	2.72	4.00	5.80	5.56	6.58	7.33
Others	1.53	1.47	1.53	4.62	5.10	4.91	5.01	5.12	5.20	5.37
Experimental development	107.14	131.21	152.20	181.14	204.46	233.73	265.09	291.40	306.82	307.53
#Research institutes	11.02	12.63	12.45	13.35	14.24	15.20	16.55	17.32	17.98	18.11
Higher education institutions	3.94	3.95	2.10	2.12	2.14	1.96	1.92	1.92	1.93	1.86
Enterprises	89.98	112.37	135.24	162.08	184.51	212.75	242.61	268.21	282.82	283.36
Others	2.20	2.26	2.40	3.59	3.57	3.81	4.02	3.96	4.09	4.21

Continued

Category	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
#Research institutes	23.19	25.55	26.01	27.72	29.35	31.57	34.35	36.37	37.38	38.36
Higher education institutions	24.25	25.39	26.68	27.52	28.97	29.93	31.35	32.49	33.48	35.49
Enterprises	98.78	118.68	139.59	164.75	187.39	216.93	248.64	274.06	289.64	291.08
Others [b]	4.02	4	4.25	9.14	9.68	9.86	10.34	10.36	10.56	10.96
# R&D researchers				115.23	121.08	131.81	140.40	148.40	152.43	161.90
#Research institutes				17.25	18.21	19.99	21.78	23.59	24.27	25.07
Higher education institutions				22.50	23.92	24.90	26.21	27.27	28.23	29.87
Enterprises				70.78	73.99	81.88	87.24	92.27	94.61	101.46
Others				4.70	4.96	5.04	10.34	10.36	5.32	5.50

a: Estimated based on education statistics.

b: Others refer to government-affiliated public institutions that are engaged in S&T activities yet cannot be defined as research institutes.

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2005–2016); National Bureau of Statistics, *China Statistical Yearbook* (2005–2016); Department of Development Planning of the Ministry of Education, *China Statistical Yearbook on Education* (2005–2015).

Annexed Table 1-2 R&D personnel of selected countries/regions

Country/region	Year	R&D personnel (10 000 person-years)	R&D personnel per 10 000 employees (10 000 person-years)	R&D researchers (10 000 person-years)	R&D researchers per 10 000 employees (10 000 person-years)
China	2015	375.88	48.5	161.90	20.9
Argentina	2014	7.69	42.9	5.17	28.8
Australia	2010	14.78	132.2	10.04	89.8
Austria	2015	6.93	161.6	4.23	98.7
Belgium	2015	7.79	169.2	5.51	119.7
Canada	2013	22.66	125.6	15.92	88.2
Taiwan of China	2015	24.59	219.6	14.54	129.8
Czech	2015	6.64	128.3	3.81	73.5
Denmark	2015	5.95	210.4	4.24	150.0
Finland	2015	5.04	201.7	3.75	150.2
France	2014	41.71	152.3	26.73	97.6
Germany	2015	61.37	142.5	35.75	83.0
Greece	2015	5.05	125.7	3.51	87.2
Hungary	2015	3.68	85.5	2.53	58.8
Iceland	2015	0.29	160.1	0.19	105.8
Ireland	2015	2.94	148.0	2.15	107.8
Israel	2012	7.71	211.1	6.35	173.8
Italy	2015	24.81	101.4	12.07	49.3
Japan	2015	87.50	133.6	66.21	101.1
Korea	2015	44.20	170.4	35.64	137.4
Luxembourg	2015	0.56	137.6	0.29	70.6
Mexico	2013	5.91	12.0	2.99	6.1
Netherlands	2015	12.83	146.0	7.70	87.6
New Zealand	2013	2.49	109.5	1.79	78.7
Norway	2015	4.27	154.6	3.08	111.6
Poland	2015	10.92	68.4	8.26	51.7
Portugal	2015	4.85	106.1	3.96	86.6
Romania	2015	3.13	36.6	1.75	20.4
Russia	2015	83.37	115.3	44.92	62.1
Singapore	2014	4.25	117.4	3.67	101.2
Slovakia	2015	1.76	106.1	3.96	86.6
Slovenia	2015	1.42	77.6	1.44	63.5
South Africa	2013	3.80	25.5	2.33	15.7
Spain	2015	20.09	108.4	12.24	66.1
Sweden	2015	8.45	175.8	6.87	142.8
Switzerland	2012	7.55	159.5	3.59	76.0
Turkey	2014	11.54	44.5	8.97	34.6
UK	2015	41.65	133.1	28.93	92.5
US	2014			135.19	91.0

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*; OECD, Main Science and Technology Indicators 2016-2.

Annexed Table 1-3　R&D personnel of selected countries/regions by sector of performance

Unit: 10 000 person-years

Country/region	Year	Total	Enterprises	Higher education institutions	Government research institutes	Others
China	2015	375.88	291.08	35.49	49.32	
Argentina	2014	7.69	1.00	2.79	3.78	0.13
Austria	2015	6.93	4.86	1.76	0.27	0.04
Belgium	2015	7.79	4.34	2.75	0.66	0.03
Canada	2013	22.66	13.23	7.47	1.81	0.15
Taiwan of China	2015	24.59	18.68	3.32	2.49	0.10
Czech	2015	6.64	3.64	1.69	1.30	0.02
Denmark	2015	5.95	3.62	2.13	0.18	0.03
Finland	2015	5.04	2.98	1.55	0.45	0.06
France	2014	41.71	24.80	11.17	4.98	0.76
Germany	2015	61.37	37.91	13.44	10.02	
Greece	2015	5.05	0.81	2.85	1.35	0.04
Hungary	2015	3.68	2.10	0.77	0.81	
Iceland	2015	0.29	0.16	0.11	0.03	
Ireland	2015	2.94	1.83	1.02	0.10	
Italy	2015	24.81	12.86	7.49	3.82	0.65
Japan	2015	87.50	59.22	20.86	6.03	1.40
Korea	2015	44.20	32.37	7.27	3.82	0.75
Luxembourg	2015	0.56	0.31	0.11	0.13	
Mexico	2013	5.91	1.92	2.11	1.69	0.18
Netherlands	2015	12.83	8.01	3.36	1.47	
New Zealand	2013	2.49	1.00	1.16	0.33	
Norway	2015	4.27	2.20	1.37	0.69	
Poland	2015	10.92	4.21	4.50	2.21	0.02
Portugal	2015	4.85	1.81	2.78	0.19	0.06
Romania	2015	3.13	1.01	0.90	1.21	0.01
Russia	2015	83.37	42.64	12.17	28.40	0.16
Singapore	2014	4.25	2.16	1.74	0.35	
Slovakia	2015	1.76	0.44	0.88	0.43	
Slovenia	2015	1.42	0.92	0.26	0.24	
South Africa	2013	3.80	1.19	1.78	0.74	0.09
Spain	2015	20.09	8.74	7.33	3.97	0.04
Sweden	2015	8.45	5.87	2.14	0.42	0.02
Turkey	2014	11.54	6.19	4.13	1.22	
UK	2015	41.65	20.76	18.84	1.59	0.46

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*; OECD, Main Science and Technology Indicators 2016-2.

Annexed Table 1-4 Number of bachelor's students and master's students (2003–2015)

Type	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Undergraduates													
Total number of graduates	929598	1196290	1465786	1726674	1995944	2256783	2455359	2587737	2796229	3038473	3199716	3413787	3585940
#Science	103409	134164	163076	194807	228090	251610	264494	268658	279101	294060	248790	255304	255632
Engineering science	351537	442463	517225	575634	633744	704604	763635	813012	884542	964583	1058768	1132226	1180508
Agricultural science	29758	34078	35419	36740	43270	45649	46847	48442	51148	53789	58752	59796	60908
Medical science	55927	81098	96011	107210	122815	139105	152392	162401	168582	178085	192344	209748	223917
Sub-total	540631	691803	811731	914391	1027919	1140968	1227368	1292513	1383373	1490517	1558654	1657074	1720965
Total number of enrollment	1825262	2099151	2363647	2530854	2820971	2970601	3261081	3512563	3566411	3740574	3814331	3834152	3894184
#Science	220157	247995	268061	279708	1462	312069	332874	344921	341487	344671	277254	273910	273744
Engineering science	595398	669745	739668	798106	1194782	943738	1023678	1108832	1134270	1195234	1274915	1299865	1324652
Agricultural science	41637	44379	45674	47312	49802	53332	58940	62322	60835	63974	68658	70675	70091
Medical science	119270	131218	147726	155242	192273	175221	202892	219549	217290	228294	238919	240758	247158
Sub-total	976462	1093337	1201129	1280368	1438319	1484360	1618384	1735624	1753882	1832173	1859746	1885208	1915645
Total number of students on campus	6292089	7378436	8488188	9433395	10243030	11042207	11798511	12656132	13496577	14270888	14944353	15410653	15766848
#Science	723579	845784	959757	1041387	1100855	1152206	1201046	1251280	1287275	1314644	1076027	1073015	1077234
Engineering science	2156584	2424903	2699776	2958802	3205516	3475740	3718959	3995779	4275808	4522917	4953334	5119977	5247875
Agricultural science	151756	164514	174783	188067	197269	204809	213986	226030	235342	244261	259837	269252	275293
Medical science	496136	558369	627249	688777	736800	778706	830050	883847	942912	1006410	1064363	1111699	1152058
Sub-total	3528055	3993570	4461565	4877033	5240440	5611461	5964041	6356936	6741337	7088232	7353561	7573943	7752460
Postgraduates													
Total number of graduates	111091	150777	189728	255902	311839	344825	371273	383600	429994	486455	513626	535863	551522
#Science	13220	17540	22028	29137	35266	39444	41822	43654	47731	50266	49992	49002	48856
Engineering science	41337	56074	72941	94516	114621	123226	130514	128678	145303	168434	176436	184647	194859
Agricultural science	3849	5165	6038	8853	11297	12879	13425	14079	12845	16313	17464	19443	20288
Medical science	12207	16128	19405	26415	32453	37402	34629	35582	49039	56001	58550	61192	62602
Sub-total	70613	94907	120412	158921	193637	212951	220390	221993	254918	291014	302442	314284	326605
Total number of enrollment	268925	326286	364831	397925	418612	446422	510953	538177	560168	589673	611381	621323	645055
#Science	33969	41067	45193	47749	51389	55526	59279	58388	57688	58124	60202	62014	63571
Engineering science	103212	120750	131345	144841	146318	155484	158703	153704	195082	209244	217338	217500	227167
Agricultural science	9693	12110	13864	14841	15733	13259	14800	14874	20063	21080	23388	23383	24147
Medical science	26501	33012	38340	42200	44161	47412	44713	40067	60831	64868	66525	70466	75325
Sub-total	173375	206939	228742	249631	257601	271681	277495	267033	333664	353316	367453	373363	390210
Total number of students on campus	651260	819896	978610	1104653	1195047	1283046	1404942	1538416	1645845	1719818	1793953	1847689	1911406
#Science	82125	102381	120510	134729	146146	157404	168908	177570	181072	180330	183997	189830	196859
Engineering science	255754	318063	369738	412273	436352	461951	474170	490374	587587	616173	648218	669703	689597
Agricultural science	22105	28930	36061	41442	45285	44914	45325	45273	56119	58893	63778	66068	68212
Medical science	63939	81859	100343	115901	128471	140030	128205	128916	181129	188666	196621	204148	215232
Sub-total	423923	531233	626652	704345	756254	804299	816608	842133	1005907	1044062	1092614	1129749	1169900

Source: The Department of Development Planning of the Ministry of Education, *China Statistical Yearbook on Education* (2003–2015) .

Annexed Table 1-5 Number of Chinese students studying abroad and returning home from overseas (1990–2015)

Unit: 10 000 persons

Year	Chinese students studying abroad	Returned overseas students
1990	0.30	0.16
1991	0.29	0.21
1992	0.65	0.36
1993	1.07	0.51
1994	1.91	0.42
1995	2.04	0.58
1996	2.09	0.66
1997	2.24	0.71
1998	1.76	0.74
1999	2.37	0.77
2000	3.90	0.91
2001	8.40	1.22
2002	12.52	1.79
2003	11.73	2.02
2004	11.47	2.47
2005	11.85	3.50
2006	13.40	4.20
2007	14.40	4.40
2008	17.98	6.93
2009	22.93	10.83
2010	28.47	13.48
2011	33.97	18.62
2012	39.96	27.29
2013	41.39	35.35
2014	45.98	36.48
2015	52.37	40.91

Source: National Bureau of Statistics, *China Statistical Yearbook* (1991–2016).

Annexed Table 2-1 R&D expenditure (2000–2015)

Year	R&D expenditure (100 million yuan)	GDP (100 million yuan)	R&D expenditure as a percentage of GDP (%)	R&D expenditure growth (%)
2000	895.7	100280.1	0.89	29.15
2001	1042.5	110863.1	0.94	14.02
2002	1287.6	121717.4	1.06	22.74
2003	1539.6	137422.0	1.12	16.50
2004	1966.3	161840.2	1.21	19.40
2005	2450.0	187318.9	1.31	19.81
2006	3003.1	219438.5	1.37	17.92
2007	3710.2	270232.3	1.37	14.57
2008	4616.0	319515.5	1.44	15.43
2009	5802.1	349081.4	1.66	25.86
2010	7062.6	413030.3	1.71	13.78
2011	8687.0	489300.6	1.78	13.69
2012	10298.4	540367.4	1.91	15.83
2013	11846.6	595244.4	1.99	12.57
2014	13015.6	643974.0	2.02	8.97
2015	14169.9	689052.1	2.06	9.33

Note: Calculated based on comparable price.
Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

Annexed Table 2-2 R&D expenditure by type of R&D activity and sector of performance (2000–2015)

Unit: 100 million yuan

Year	R&D expenditure	By type of R&D activity			By sector of performance			
		Basic research	Applied research	Experimental development	Research institutes	Enterprises	Higher education institutions	Others
2000	895.7	46.7	151.9	697.0	258.0	537.0	76.7.0	24.0
2001	1042.5	55.6	184.9	802.0	288.5	630.0	102.4	21.6
2002	1287.6	73.8	246.7	967.2	351.3	787.8	130.5	18.0
2003	1539.6	87.7	311.4	1140.5	399.0	960.2	162.3	18.1
2004	1966.3	117.2	400.5	1448.7	431.7	1314.0	200.9	19.7
2005	2450.0	131.2	433.5	1885.2	513.1	1673.8	242.3	20.8
2006	3003.1	155.8	489.0	2358.4	567.3	2134.5	276.8	24.5
2007	3710.2	174.5	492.9	3042.8	687.9	2681.9	314.7	25.7
2008	4616.0	220.8	574.8	3820.4	811.3	3381.7	390.2	32.9
2009	5802.1	270.3	730.8	4801.0	995.9	4248.6	468.2	89.4
2010	7062.6	324.5	893.8	5844.3	1186.4	5185.5	597.3	93.4
2011	8687.0	411.8	1028.4	7246.8	1306.7	6579.3	688.9	112.1
2012	10298.4	498.8	1162.0	8637.6	1548.9	7842.2	780.6	126.7
2013	11846.6	555.0	1269.1	10022.5	1781.4	9075.8	856.7	132.6
2014	13015.6	613.5	1398.5	11003.6	1926.2	10060.6	898.2	130.7
2015	14169.9	716.1	1528.6	11925.1	2136.5	10881.3	998.6	153.5

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

Annexed Table 2-3 R&D expenditure by sector of performance (2015)

Unit: 100 million yuan

Internal R&D expenditure		Total	Enterprises	Research institutes	Higher education institutions	Others
		14169.9	10881.3	2136.5	998.6	153.5
By type of activity	Basic research	716.1	11.4	295.3	391.0	18.4
	Applied research	1528.6	329.3	618.4	516.3	64.7
	Experimental development	11925.1	10540.7	1222.8	91.3	70.4
By type of expenditure	Labor costs	3988.4	3343.9	425.7	153.8	65.0
	Other current expenses	8323.3	6345.4	1265.2	653.0	59.7
	Instrument and equipment purchase	1601.2	1153.3	279.3	146.8	21.9
	Other capital expenses	257.0	38.7	166.3	45.1	6.9
By source of funding	Government funding	3013.2	463.4	1802.7	637.3	109.8
	Enterprise funding	10588.6	10197.8	65.4	301.5	24.0
	Foreign funding	105.2	94.6	5.0	5.2	0.3
	Other funding	462.9	125.6	263.4	54.6	19.3

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

Annexed Table 2-4 Ratio of R&D expenditure to GDP of selected countries (2004–2015)

Unit: %

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
China	1.22	1.32	1.38	1.38	1.46	1.68	1.73	1.79	1.93	2.01	2.02	2.06
Australia	1.73		2.00		2.25		2.20	2.13			2.11	2.11
Austria	2.17	2.38	2.37	2.43	2.59	2.61	2.74	2.68	2.81	2.81	3.06	3.07
Belgium	1.81	1.78	1.81	1.84	1.92	1.97	2.05	2.15	2.24	2.28	2.46	2.45
Canada	2.01	1.99	1.96	1.92	1.87	1.92	1.84	1.78	1.71	1.62	1.60	1.60
Czech	1.15	1.17	1.23	1.31	1.24	1.30	1.34	1.56	1.79	1.91	1.97	1.95
Denmark	2.42	2.39	2.40	2.51	2.78	3.07	2.94	2.97	3.02	3.06	2.92	2.96
Finland	3.31	3.33	3.34	3.35	3.55	3.75	3.73	3.64	3.43	3.32	3.17	2.90
France	2.09	2.04	2.05	2.02	2.06	2.21	2.18	2.19	2.23	2.23	2.24	2.23
Germany	2.42	2.43	2.46	2.45	2.60	2.73	2.72	2.80	2.88	2.94	2.89	2.87
Greece	0.53	0.58	0.56	0.58	0.66	0.63	0.60	0.67	0.69	0.78	0.84	0.96
Hungary	0.87	0.93	0.99	0.97	0.99	1.14	1.15	1.20	1.27	1.41	1.36	1.38
Iceland		2.69	2.91	2.56	2.53	2.66		2.49		1.99	2.01	2.19
Ireland	1.18	1.20	1.21	1.24	1.39	1.63	1.62	1.53	1.58		1.51	1.51
Israel	3.92	4.09	4.19	4.48	4.39	4.15	3.96	4.10	4.25	4.21	4.27	4.25
Italy	1.05	1.05	1.09	1.13	1.16	1.22	1.22	1.21	1.26	1.25	1.38	1.33
Japan	3.13	3.31	3.41	3.46	3.47	3.36	3.25	3.38	3.35	3.49	3.59	3.49
Korea	2.53	2.63	2.83	3.00	3.12	3.29	3.47	3.74	4.03	4.15	4.29	4.23
Luxembourg	1.62	1.59	1.69	1.65	1.65	1.72	1.5	1.41	1.16	1.16	1.28	1.31
Mexico	0.39	0.40	0.37	0.37	0.40	0.43	0.45	0.43		0.50	0.54	0.55
Netherlands	1.82	1.81	1.77	1.70	1.65	1.69	1.72	1.89	1.97	1.98	2.00	2.01
New Zealand		1.13		1.17		1.28		1.27		1.17	1.15	1.15
Norway	1.55	1.48	1.46	1.56	1.56	1.72	1.65	1.63	1.62	1.66	1.72	1.93
Poland	0.56	0.57	0.55	0.56	0.60	0.67	0.72	0.75	0.89	0.87	0.94	1.00
Portugal	0.73	0.76	0.95	1.12	1.45	1.58	1.53	1.46	1.37	1.36	1.29	1.28
Slovakia	0.50	0.49	0.48	0.45	0.46	0.47	0.62	0.67	0.81	0.83	0.88	1.18
Slovenia	1.37	1.41	1.53	1.42	1.63	1.82	2.06	2.43	2.58	2.59	2.38	2.21
Spain	1.04	1.10	1.17	1.23	1.32	1.35	1.35	1.32	1.27	1.24	1.24	1.22
Sweden	3.39	3.39	3.50	3.26	3.50	3.42	3.22	3.22	3.28	3.30	3.15	3.26
Switzerland	2.68				2.73				2.96			
Turkey	0.52	0.59	0.58	0.72	0.73	0.85	0.84	0.86	0.92	0.95	1.01	1.01
UK	1.61	1.63	1.65	1.69	1.69	1.75	1.69	1.69	1.63	1.63	1.68	1.70
US	2.49	2.51	2.55	2.63	2.77	2.82	2.74	2.77	2.81	2.73	2.76	2.79
Argentina	0.37	0.38	0.40	0.40	0.42	0.48	0.49	0.52	0.58	0.58	0.59	0.59
Romania	0.38	0.41	0.45	0.52	0.57	0.46	0.45	0.49	0.48	0.39	0.38	0.49
Russia	1.15	1.07	1.07	1.12	1.04	1.25	1.13	1.09	1.12	1.12	1.09	1.13
Singapore	2.10	2.16	2.13	2.34	2.62	2.16	2.01	2.16	2.02		2.20	2.20
South Africa	0.85	0.90	0.93	0.92	0.93	0.87	0.76	0.76	0.76		0.73	0.73

Source: OECD, Main Science and Technology Indicators 2016-2.

Annexed Table 2-5 R&D expenditure of selected countries by source of funding and sector of performance (2015)

Country	R&D funds (100 million dollars)	Source of funding (%)				Sector of performance (%)			
		Enterprises	Governments	Overseas	Others	Enterprises	Higher education institutions	Research institutes	Others
China	2275.4	74.73	21.26	0.74	3.27	76.79	7.05	15.1	
Austria	115.8	47.05	36.59	15.90	0.46	70.82	24.32	4.44	0.42
Belgium	111.7					71.95	19.94	7.77	0.34
Canada	287.7								
Czech	36.0	34.53	32.21	32.50	0.76	54.30	24.91	20.40	0.39
Denmark	89.1	59.37	29.40	6.52	4.70	63.96	33.36	2.31	0.37
Finland	67.3	54.76	28.89	14.52	1.83	66.67	24.39	8.17	0.77
France	539.5					65.10	20.28	13.07	1.55
Germany	967.0					67.74	17.35	14.91	
Greece	18.7	31.76	52.70	12.85	2.70	33.34	38.23	27.64	0.78
Hungary	16.8	49.72	34.62	14.95	0.71	73.44	12.11	13.29	
Iceland	3.7	33.25	32.01	26.35	8.38	64.66	30.51	4.83	
Israel	127.3					85.36	11.72	1.69	1.23
Italy	242.8					55.30	28.57	13.25	2.88
Japan	1440.5	77.97	15.41	0.48	6.14	78.49	12.28	7.90	1.33
Korea	583.1	74.55	23.66	0.75	1.04	77.53	9.09	11.74	1.64
Luxembourg	7.4					51.02	17.84	31.14	
Mexico	63.1	20.59	71.21	0.38	7.82	30.94	26.22	38.22	4.62
Netherlands	151.2	48.70	33.36	15.13	2.81	55.57	32.10	12.33	
New Zealand	22.0								
Norway	74.8					54.25	30.67	15.07	
Poland	47.9	39.00	41.82	16.74	2.43	46.57	28.88	24.39	0.16
Portugal	25.4					47.12	45.50	5.91	1.47
Slovakia	10.3	25.06	31.94	39.43	3.57	27.95	43.79	27.86	0.40
Slovenia	9.5	69.21	19.89	10.56	0.35	76.26	10.19	13.51	0.04
Spain	146.1					52.54	28.12	19.13	0.21
Sweden	161.7					69.52	26.86	3.44	0.19
Turkey	80.4								
UK	486.5	48.39	27.98	17.59	6.04	65.73	25.62	6.80	1.86
US	5028.9	64.15	24.04	4.67	7.14	71.52	13.23	11.18	4.08
Argentina	33.6								
Romania	8.7	37.29	41.69	19.23	1.79	44.00	17.44	38.26	0.30
Russia	150.1	26.47	69.52	2.65	1.36	59.21	9.59	31.07	0.14
India	147.3								
Brazil	230.0								

Source: OECD, Main Science and Technology Indicators 2016-2; Department of Science and Technology, India; Ministry of Science, Technology, Innovation and Communication, Brazil.

Annexed Table 2-6 R&D expenditure of selected countries by type of R&D activity

Unit: %

Country	Year	Basic research	Applied research	Experimental development
China	2015	5.1	10.8	84.2
Australia	2008	20.1	38.7	41.2
Austria	2013	18.9	35.6	43.9
Czech	2014	31.0	35.0	34.0
Denmark	2014	19.2	37.6	43.2
France	2014	24.4	37.6	34.7
Italy	2014	24.9	47.0	28.1
Japan	2015	12.5	20.8	66.7
Korea	2015	17.2	20.8	61.9
UK	2014	16.9	43.3	39.8
US	2015	17.2	19.4	63.4
Russia	2015	15.5	19.9	64.7

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*; OECD, R&D Statistics 2017.

Annexed Table 2-7 R&D expenditure of selected countries by type of expenditure

Unit: %

Country	Year	Labor costs	Other current expenses	Instrument and equipment purchases	Land and construction expenses
China	2015	28.15	58.74	11.30	1.81
Japan	2015	38.37	51.89	2.32	7.41
Germany	2013	60.34	30.91		
France	2014	61.16	27.80	4.47	6.56
Spain	2014	63.98	28.40	1.52	6.10
Italy	2014	63.32	27.59		
Russia	2015	54.92	38.48	1.10	5.50
Korea	2015	42.49	47.73	2.28	7.51
Australia	2008	39.06	53.84		

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016;* OECD, R&D Statistics 2017.

Annexed Table 2-8 R&D expenditure of selected countries/regions by source of funding and sector of performance (2015)

Country/ region	R&D funds (100 million US dollars)	Source of funding (%)				Sector of performance (%)			
		Enterprises	Governments	Others	Overseas	Enterprises	Higher education institutions	Research institutes	Others
China	2275.4	74.73	21.26	3.27	0.74	76.79	7.05	15.1	
Austria	115.8	47.05	36.59	0.46	15.90	70.82	24.32	4.44	0.42
Belgium	111.7					71.95	19.94	7.77	0.34
Canada	287.7								
Czech	36.0	34.53	32.21	0.76	32.50	54.30	24.91	20.40	0.39
Denmark	89.1	59.37	29.40	4.70	6.52	63.96	33.36	2.31	0.37
Finland	67.3	54.76	28.89	1.83	14.52	66.67	24.39	8.17	0.77
France	539.5					65.10	20.28	13.07	1.55
Germany	967.0					67.74	17.35	14.91	
Greece	18.7	31.76	52.70	2.70	12.85	33.34	38.23	27.64	0.78
Hungary	16.8	49.72	34.62	0.71	14.95	73.44	12.11	13.29	
Iceland	3.7	33.25	32.01	8.38	26.35	64.66	30.51	4.83	
Israel	127.3					85.36	11.72	1.69	1.23
Italy	242.8					55.30	28.57	13.25	2.88
Japan	1440.5	77.97	15.41	6.14	0.48	78.49	12.28	7.90	1.33
Korea	583.1	74.55	23.66	1.04	0.75	77.53	9.09	11.74	1.64
Luxembourg	7.4					51.02	17.84	31.14	
Mexico	63.1	20.59	71.21	7.82	0.38	30.94	26.22	38.22	4.62
Netherlands	151.2	48.70	33.36	2.81	15.13	55.57	32.10	12.33	
New Zealand	22.0								
Norway	74.8					54.25	30.67	15.07	
Poland	47.9	39.00	41.82	2.43	16.74	46.57	28.88	24.39	0.16
Portugal	25.4					47.12	45.50	5.91	1.47
Slovakia	10.3	25.06	31.94	3.57	39.43	27.95	43.79	27.86	0.40
Slovenia	9.5	69.21	19.89	0.35	10.56	76.26	10.19	13.51	0.04
Spain	146.1					52.54	28.12	19.13	0.21
Sweden	161.7					69.52	26.86	3.44	0.19
Turkey	80.4								
UK	486.5	48.39	27.98	6.04	17.59	65.73	25.62	6.80	1.86
US	5028.9	64.15	24.04	7.14	4.67	71.52	13.23	11.18	4.08
Argentina	33.6								
Romania	8.7	37.29	41.69	1.79	19.23	44.00	17.44	38.26	0.30
Russia	150.1	26.47	69.52	1.36	2.65	59.21	9.59	31.07	0.14
Taiwan of China	160.0	77.94	21.07	0.91	0.08	77.81	9.42	12.46	0.31

Source: OECD, Main Science and Technology Indicators 2016-2.

Annexed Table 3-1 Chinese SCI papers (2005–2015)

Year	Number of papers	Share in the world total (%)	Ranking
2005	68226	5.25	5
2006	71184	5.87	5
2007	89147	7.03	3
2008	116677	8.12	2
2009	127532	8.84	2
2010	143769	10.12	2
2011	165818	11.08	2
2012	192761	12.08	2
2013	232070	13.47	2
2014	264522	14.98	2
2015	296847	16.34	2

Note: SCI is the abbreviation for Science Citation Index. The statistics of Chinese SCI papers for the period between 2005 and 2007 only included Chinese mainland authors, i.e. excluding SCI papers published by Hong Kong, Macao and Taiwan authors. The statistics for other years included papers published by Hong Kong and Macao authors.

Source: Institute of Scientific and Technical Information of China, *China S&T Papers Statistics and Analysis* (2005–2015).

Annexed Table 3-2 Number of Chinese SCI papers by discipline and organization type (2005–2015)

Category	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	63150	71351	79669	95506	108806	121530	136445	158615	192697	235139	265469
By discipline											
Fundamental disciplines	39022	44198	50829	57325	66760	74111	71061	85084	101516	114672	125530
Medical and health sciences	5515	5641	8472	13055	13960	15501	22102	27987	34823	52042	60449
Agriculture, forestry, animal husbandry and fishery	1109	1408	1396	2221	2175	3040	4111	4047	4612	4780	6282
Industrial technology	17425	19675	18743	22533	25541	28600	38699	41450	51525	62674	72249
Others	79	429	229	372	370	278	472	47	221	971	959
By organization type											
Higher education institutions	49438	57286	64381	78079	89780	100772	113481	131356	161344	195093	219957
Research institutes	12632	13406	14284	15924	17169	18941	20685	23739	23734	29620	29749
Enterprises	203	134	208	359	359	342	433	633	692	665	744
Medical institutions	458	406	702	1046	1373	1340	1687	2707	3588	8020	8973
Others	419	119	94	98	125	135	159	180	3339	1741	6046

Note: When analyzing the distribution of mainland China's S&T papers included in SCI by discipline and type of organizations, we only count SCI papers with the first authors coming from mainland China.

Source: Institute of Scientific and Technical Information of China, *China S&T Papers Statistics and Analysis* (2005–2015).

Annexed Table 3-3　Number of Chinese SCI papers by discipline (2005–2015)

Discipline	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Mathematics	3063	3670	4565	5281	5620	6211	6583	7190	8934	9410	8693
Mechanics	369	224	270	473	514	444	1170	1650	1819	2154	2394
Information systems science	292	6	355	312	447	642	1039	1228	701	906	634
Physics	9351	10239	10966	13426	13927	14707	16677	18822	24453	26520	27490
Chemistry	18656	20317	23356	23734	28799	30898	26628	33384	36201	41378	44723
Astronomy	339	622	611	667	822	836	1003	1092	1201	1324	1447
Earth science	1989	2044	3039	3351	3509	4084	3641	4987	6689	8095	9633
Biology	4963	7076	7667	10081	13122	16289	14320	16731	21518	24885	30516
Preventive medicine and hygiene	300	156	361	454	573	718	925	1094	1444	2441	2608
Basic medical sciences	1698	1692	2077	4220	4880	5269	5947	7478	9411	11589	18283
Pharmacy	864	505	1102	1788	1312	1134	4167	3739	4149	5949	7509
Clinical medicine	2393	3196	4831	6068	7015	7767	10591	14757	18632	31014	30696
Traditional Chinese medicine	7	0	63	57	155	281	355	813	1014	930	1108
Military medicine and special medicine	253	92	38	468	25	332	117	106	173	119	245
Agronomy	678	1166	993	1707	1273	1996	2819	2280	2561	2732	3316
Forestry	46	33	64	92	93	126	188	279	368	435	617
Animal and veterinary sciences	193	38	63	104	544	573	384	989	895	848	1305
Aquatic science	192	171	276	318	265	345	720	499	788	765	1044
Surveying and mapping science and technology	2	0	1	0	2	0	3	13	9	0	2
Materials science	6657	5929	7501	7516	6860	8653	12512	13242	16272	17879	20060
Fundamental disciplines in engineering and technology	160	651	65	411	1478	1311	2141	541	725	1854	1959
Mining engineering technology	14	12	22	28	72	77	99	85	131	408	539
Energy science and technology	119	333	398	778	759	941	2079	2275	3013	4486	5094
Metallurgy and metallography	1132	1218	1137	1143	1226	1516	3665	1698	1840	1966	1949
Machinery and instrumentation	968	763	1210	1472	1504	1652	1668	1656	2761	3038	3443

Continued

Discipline	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Power and electrics	1502	11	38	25	13	8	343	809	728	260	382
Nuclear science and technology	58	87	188	198	372	172	238	333	450	710	1220
Electronics, communication and automation	444	2468	2847	3302	4324	5070	3383	5447	6584	9781	10460
Computing technology	3844	5157	1770	2040	2736	2241	3236	5051	6665	7490	9782
Chemical engineering	1006	936	951	1617	1426	1413	2292	2366	2637	3329	4081
Light and textile industry	1	0	1	6	3	0	2	20	4	0	4
Foods	89	122	203	649	391	611	1306	1556	1857	2427	1738
Civil engineering	352	351	428	484	727	791	500	793	1060	1462	1831
Hydraulics	3	11	53	40	65	73	588	841	864	1092	1205
Transportation	4	2	7	13	9	20	206	65	376	512	537
Aeronautics/aviation/aerospace	65	101	108	371	283	318	226	299	451	654	731
Safety science and technology	24	7	18	1	3	4	34	361	22	91	89
Environmental science	981	1516	1797	2439	3288	3729	4178	3842	4820	5235	7143
Management	64	155	190	243	191	185	431	157	256	697	727
Others	15	274	39	129	179	93	41	47	221	274	232

Source: Institute of Scientific and Technical Information of China, *China S&T Papers Statistics and Analysis* (2005–2015).

Annexed Table 3-4 Number of Chinese SCI papers by region (2005–2015)

Region	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Beijing	14738	15546	16665	18945	20868	23307	25630	29455	35284	42777	46179
Tianjin	2195	2506	2497	2880	3006	3428	3634	4520	5646	6745	8107
Hebei	626	757	841	1046	1207	1387	1541	1850	2122	2993	3374
Shanxi	624	645	627	795	978	983	1146	1297	1699	2086	2596
Inner mongolia	80	107	131	188	207	274	295	410	539	766	870
Liaoning	2662	3010	3554	4145	4612	5034	5320	6207	7626	9011	9987
Jilin	2165	2290	2562	2952	3180	3443	4026	4454	5209	6180	6852
Heilongjiang	1372	1460	1842	2330	2844	3203	3648	4292	5320	6361	7184
Shanghai	7662	8361	9023	10782	12322	13300	14350	16105	18967	22210	24818
Jiangsu	4680	5485	6377	8019	9891	11243	12913	15177	19471	24329	27483
Zhejiang	3879	4459	4835	5733	6146	6854	7713	9092	10576	12599	13674
Anhui	2387	2606	2697	2888	3077	3242	3731	4313	5254	6693	7155
Fujian	1274	1332	1570	1911	2174	2330	2682	3156	3816	4686	5383
Jiangxi	263	401	572	668	851	929	1058	1355	1772	2219	2624
Shandong	2797	3283	3750	4523	5062	5793	6493	7435	9045	10308	13250
Henan	641	896	1078	1498	1807	2106	2567	2707	3909	4791	5903
Hubei	3306	3982	4583	5306	5684	6034	6779	7936	9455	12267	13335
Hunan	1702	2370	2618	3147	3534	3818	4405	5340	6548	7769	8813
Guangdong	2510	3133	3694	4575	5611	6631	7743	9223	10667	13566	16127
Guangxi	248	319	420	566	681	735	870	1052	1399	1745	1973
Hainan	27	44	64	68	107	139	199	249	334	475	543
Chongqing	709	823	865	1353	1842	2408	2688	3566	4076	5136	5913
Sichuan	1848	2251	2836	3629	4252	4843	5517	6495	7887	9793	10846
Guizhou	130	143	196	287	288	306	405	428	611	684	857
Yunnan	560	618	690	913	1108	1354	1344	1579	1944	2349	2643
Tibet	0	0	7	2	4	6	3	3	7	16	25
Shaanxi	2274	2861	3201	4047	4955	5690	6584	7416	9358	11392	13195
Gansu	1281	1365	1589	1942	2076	2192	2440	2619	3006	3695	3836
Qinghai	54	50	61	67	71	90	77	114	114	147	186
Ningxia	16	30	28	42	44	55	81	109	152	189	276
Xinjiang	138	145	196	252	317	373	509	647	869	1162	1462
Unknown	302	73	0	7	0	0	54	14	15	0	0

Source: Institute of Scientific and Technical Information of China, *China S&T Papers Statistics and Analysis* (2005–2015).

Annexed Table 3-5 China's efficiency of R&D expenditure and personnel (2000–2013)

Year	Efficiency of R&D personnel (papers per 10 000 person-years)	Efficiency of R&D expenditure (papers per 100 million yuan)
2000	1362.23	205.20
2001	1633.46	211.37
2002	1731.87	183.96
2003	1949.47	180.23
2004	1828.25	155.10
2005	2161.14	184.99
2006	2215.70	180.48
2007	2565.57	214.24
2008	2741.37	216.27
2009	2843.17	192.81
2010	3114.55	197.03
2011	3529.30	219.06
2012	3945.29	237.26
2013	4290.06	249.21

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2001–2014); Institute of Scientific and Technical Information of China, *China S&T Papers Statistics and Analysis* (2005–2013).

Annexed Table 3-6 Resident and non-resident invention patent applications and invention patents granted (2006–2015)

Unit: Piece

Category	Year	Applications	Grants
Total	2006	210490	57786
	2007	245161	67948
	2008	289838	93706
	2009	314573	128489
	2010	391177	135110
	2011	526412	172113
	2012	652777	217105
	2013	825136	207688
	2014	928177	233228
	2015	1101864	359316
Resident	2006	122318	25077
	2007	153060	31945
	2008	194579	46590
	2009	229096	65391
	2010	293066	79767
	2011	415829	112347
	2012	535313	143847
	2013	704936	143535
	2014	801135	162680
	2015	968251	263436
Non-resident	2006	88172	32709
	2007	92101	36003
	2008	95259	47116
	2009	85477	63098
	2010	98111	55343
	2011	110583	59766
	2012	117464	73258
	2013	120200	64153
	2014	127042	70548
	2015	133613	95880

Source: State Intellectual Property Office, *Patent Statistics Annual Report* (2006–2015).

Annexed Table 3-7 Non-resident invention patent applications in China by country (2006–2015)

Unit: Piece

Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	88172	92101	95259	85477	98111	110583	117464	120200	127042	133613
Austria	263	346	379	357	475	598	664	811	944	982
Australia	562	617	609	525	608	621	657	641	664	635
Belgium	413	525	535	486	563	592	595	642	657	638
Brazil	69	80	74	73	117	130	107	115	137	134
Canada	756	817	896	807	940	1033	1111	1037	1009	1025
Switzerland	1932	2366	2337	2362	2644	2665	2924	3212	3338	3432
Germany	7502	8066	8686	8264	9867	11422	12659	13712	13597	13851
Denmark	438	520	631	584	734	781	732	840	847	845
Finland	898	973	979	902	1089	964	1069	1039	1165	1041
France	2954	2991	3170	3011	3506	3973	4315	4143	4575	4702
UK	1478	1628	1795	1624	1737	1876	1874	1849	2050	2221
Israel	307	379	440	330	450	532	532	530	656	700
India	172	146	184	122	168	202	248	279	267	235
Italy	1163	1228	1194	998	1184	1245	1288	1318	1361	1430
Japan	32801	32870	33264	30293	33882	39231	42278	41193	40460	40078
Korea	9187	8467	8022	5907	7178	8129	8985	10866	11528	12907
Netherlands	3503	3481	3261	3089	2998	2999	2629	2546	2924	3032
Norway	163	218	187	192	235	234	234	237	223	224
Russia	72	66	85	91	111	120	139	152	130	148
Sweden	1318	1527	1766	1653	1780	1730	1663	1795	2020	1948
US	20536	22887	24527	21799	25380	28457	29510	29992	33963	37216
Others	1685	1903	2238	2008	2465	3049	3251	3251	4527	6189

Source: State Intellectual Property Office, *Patent Statistics Annual Report* (2006–2015).

Annexed Table 3-8 Non-resident invention patents granted in China by country (2006–2015)

Unit: Piece

Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	32709	36003	47116	63098	55343	59766	73258	64153	70548	95880
Austria	122	125	155	215	205	239	308	302	431	690
Australia	210	264	272	322	314	280	353	366	311	458
Belgium	126	142	184	229	249	328	461	410	388	499
Brazil	25	28	31	37	37	34	55	54	60	88
Canada	194	253	350	461	440	490	605	570	576	731
Switzerland	820	871	941	1245	1317	1471	1898	1745	1950	2580
Germany	2628	2913	3598	5054	4609	5442	7058	6589	7250	10533
Denmark	160	190	206	280	257	334	449	431	512	636
Finland	317	338	472	674	539	545	783	606	645	852
France	1181	1171	1388	2200	1926	2006	2632	2602	2678	3503
UK	600	599	698	825	734	857	1226	1047	1018	1414
Israel	60	105	143	161	125	151	197	243	244	365
India	49	62	82	81	51	58	95	99	128	198
Italy	389	458	512	757	719	793	898	830	879	1156
Japan	15099	16174	21999	27897	23890	25387	28847	22609	26501	36418
Korea	2752	3127	4675	6476	5168	4882	5320	4271	4627	6262
Netherlands	1129	1214	1449	2128	1712	1817	2091	1862	1919	2284
Norway	67	77	80	139	97	109	151	153	142	202
Russia	31	24	35	49	46	49	59	41	23	89
Sweden	454	498	582	895	902	1020	1397	1158	1155	1495
US	5870	6891	8661	12158	10985	12334	16776	16674	17401	23157
Others	426	479	603	815	1021	1140	1599	1491	1710	2270

Source: State Intellectual Property Office, *Patent Statistics Annual Report* (2006–2015).

Annexed Table 3-9　Resident service and non-service invention patents granted (2006–2015)

Unit: Piece

Year	Service inventions	Colleges and universities	Research institutes	Enterprises	Government agencies and organizations	Non-service inventions
2006	18400	6198	2553	9433	216	6677
2007	24488	8214	3173	12851	250	7457
2008	36956	10266	3945	22493	252	9634
2009	52265	14391	5299	32160	415	13126
2010	66149	19036	6557	40049	507	13618
2011	95069	26616	9238	58364	851	17278
2012	125954	33821	11248	78651	2234	17893
2013	126860	33309	12284	79439	1828	16675
2014	146172	38317	13573	91874	2408	16508
2015	238818	57196	19243	158620	3759	24618

Source: State Intellectual Property Office, *Patent Statistics Annual Report* (2006–2015).

Annexed Table 3-10 PCT patent applications of selected countries (2006–2015)

Unit: Piece

Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Global total	149647	159935	163242	155408	164354	182442	195344	205305	214333	217235
US	51302	54062	51668	45659	45093	49210	51861	57459	61483	57123
Japan	27024	27743	28763	29810	32216	38864	43523	43771	42381	44053
China	3930	5455	6119	7900	12301	16398	18620	21515	25548	29839
Germany	16733	17825	18857	16793	17560	18846	18750	17920	17983	18004
Korea	5946	7064	7902	8040	9604	10357	11787	12381	13119	14564
France	6263	6566	7076	7217	7231	7406	7802	7905	8261	8421
UK	5096	5540	5479	5039	4892	4876	4917	4848	5268	5290
Netherlands	4545	4421	4361	4420	4011	3511	4078	4188	4206	4334
Switzerland	3614	3816	3778	3677	3762	4045	4222	4372	4100	4265
Sweden	3333	3654	4135	3567	3303	3476	3600	3946	3913	3842
Italy	2701	2949	2884	2653	2657	2686	2845	2868	3059	3072
Canada	2573	2844	2907	2509	2689	2914	2738	2846	3072	2821
Australia	2001	2050	1938	1736	1770	1748	1710	1604	1723	1741
Israel	1593	1743	1902	1555	1475	1449	1374	1607	1581	1685
Finland	1845	1994	2212	2123	2136	2075	2312	2095	1811	1584
Spain	1202	1295	1391	1563	1769	1732	1705	1705	1705	1530
India	833	904	1073	960	1276	1324	1310	1321	1429	1412
Austria	914	1009	951	1029	1144	1343	1319	1262	1387	1399
Denmark	1158	1153	1357	1339	1156	1288	1408	1264	1299	1327
Belgium	1030	1123	1135	1005	1066	1188	1212	1103	1196	1180

Source: WIPO Statistics Database, February 2017.

Annexed Table 3-11 Triadic patent applications of selected countries (2006–2015)

Unit: Piece

Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Japan	18006	17785	16027	16535	18463	18565	18637	17542	17484	17361
US	15461	13885	13815	13501	12744	13193	13712	14601	14688	14886
Germany	6532	5807	5473	5552	5058	4809	4586	4584	4520	4455
China	562	689	827	1299	1425	1501	1946	2169	2477	2889
Korea	2347	1977	1827	2108	2461	2368	2493	2679	2684	2703
France	2886	2783	2886	2723	2459	2597	2434	2461	2528	2578
UK	2091	1801	1697	1721	1656	1727	1699	1777	1793	1811
Switzerland	1150	1008	992	972	1065	1054	1140	1180	1192	1207
Netherlands	1477	1063	1128	1047	825	968	1038	1094	1161	1167
Italy	821	730	760	737	683	721	724	741	762	781
Sweden	885	961	836	791	644	614	662	632	648	658
Canada	667	683	684	673	552	578	526	561	553	537
Israel	420	352	369	375	348	366	402	426	443	463
Austria	355	377	340	369	389	362	379	412	438	462
Belgium	476	430	458	479	461	460	430	442	447	448
Australia	363	346	317	350	308	321	335	333	336	338
Denmark	318	315	343	258	301	259	283	294	297	297
Finland	295	259	253	223	228	227	288	289	291	291
Spain	268	257	267	254	238	220	230	228	229	229
Singapore	145	111	112	102	104	120	106	116	131	144

Source: OECD, Main Science and Technology Indicators 2017-1.

Annexed Table 3-12 Turnover of national technology market contracts (2005–2015)

Unit: 100 million yuan

Item	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	1551.4	1818.2	2226.5	2665.2	3039.0	3906.6	4763.6	6437.1	7469.1	8577.2	9835.8
By contract type											
Technology development	569.7	717.1	875.5	1075.5	1264.2	1634.2	2169.8	2635.9	2773.4	2949.0	3047.2
Technology transfer	360.0	321.3	420.4	532.6	538.5	610.1	523.4	1020.8	1083.8	1137.2	1466.5
Technical consulting	95.0	84.7	90.2	101.6	94.1	116.6	166.2	150.2	195.1	244.3	263.1
Technology-related services	526.6	695.1	840.4	955.6	1142.2	1545.6	1904.1	2630.1	3416.9	4246.7	5059.0
By seller type											
Government agency legal persons		14.1	19.4	20.4	17.4	35.4	40.2	76.0	74.5	110.9	114.1
Public institution legal persons		226.3	260.0	285.4	347.4	420.6	532.6	730.9	900.7	879.0	958.2
Social organization legal persons		7.1	4.5	3.6	10.3	13.7	7.9	7.6	4.9	4.5	13.1
Enterprise legal persons		1553.3	1919.8	2332.1	2626.2	3341.7	4119.3	5570.6	6436.2	7516.3	8476.9
Natural persons		4.7	9.4	6.7	7.2	5.0	15.5	31.7	11.4	13.9	8.7
Other organizations		12.6	13.4	17.1	30.4	90.1	48.0	20.3	41.3	52.6	264.8
By seller enterprise type											
Domestic-invested enterprises		1198.4	1425.0	1678.4	1910.8	2522.7	3230.5	4199.1	5170.9	6117.0	6853.1
Hong Kong, Macao and Taiwan-invested enterprises		17.9	32.4	41.7	91.9	95.2	71.2	113.9	138.0	179.5	146.3
Foreign-invested enterprises		266.7	360.6	444.7	486.6	512.1	568.5	835.1	818.0	793.3	1011.3
Individual businesses		3.8	4.3	3.2	6.7	5.4	4.1	9.7	10.2	17.8	19.3
Overseas enterprises		66.4	97.6	164.1	130.2	206.3	245.0	412.7	299.1	408.6	446.9

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

Annexed Table 3-13 National technology market contracts (2015)

Region	Technology outflow contracts		Technology absorption contracts	
	Number of contracts signed	Turnover (100 million yuan)	Number of contracts signed	Turnover (100 million yuan)
Total	307132	9835.8	307132	9835.8
Beijing	72306	3453.9	50140	1147.5
Tianjin	12456	503.4	9439	330.7
Hebei	3298	39.5	5989	145.3
Shanxi	698	51.2	2999	97.2
Inner mongolia	498	15.4	2609	188.6
Liaoning	11878	267.5	10883	231.3
Jilin	2420	26.5	3446	54.5
Heilongjiang	1857	127.3	3161	107.7
Shanghai	22119	663.8	22689	510.1
Jiangsu	32508	572.9	36607	1016.3
Zhejiang	11273	98.1	14999	201.9
Anhui	12488	190.5	12687	169.7
Fujian	4132	52.1	5629	367.6
Jiangxi	1137	64.8	2356	107.7
Shandong	20422	307.6	21874	386.6
Henan	3482	45.0	5082	127.6
Hubei	22532	789.3	14831	494.9
Hunan	3704	105.1	4291	151.6
Guangdong	17316	662.6	22396	652.1
Guangxi	1577	7.3	3299	57.7
Hainan	257	2.2	1404	28.2
Chongqing	2638	57.2	3340	184.3
Sichuan	11228	282.3	11195	293.3
Guizhou	650	26.0	2346	176.1
Yunnan	2666	51.8	4278	173.6
Tibet	—	—	382	17.0
Shaanxi	22508	721.8	12657	298.5
Gansu	4712	129.7	4869	118.1
Qinghai	952	46.9	1997	47.1
Ningxia	661	3.5	1451	28.6
Xinjiang	658	3.0	2673	121.3
Hong Kong, Macao and Taiwan	100	15.9	1017	103.9
Others	2001	451.6	4117	1699.2

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

Annexed Table 4-1 Enterprise R&D personnel and expenditure and as a percentage of national total (2000–2015)

Year	Enterprise R&D personnel (10 000 person-years)	Enterprise R&D personnel as a percentage of the national total (%)	Enterprise R&D expenditure (100 million yuan)	Enterprise R&D expenditure as a percentage of the national total (%)
2000	48.1	52.1	537.0	60.0
2001	53.2	55.6	630.0	60.4
2002	60.1	58.1	787.8	61.2
2003	65.6	59.9	960.2	62.4
2004	69.7	60.5	1314.0	66.8
2005	88.3	64.7	1673.8	68.3
2006	98.8	65.7	2134.5	71.1
2007	118.7	68.4	2681.9	72.3
2008	139.6	71.0	3381.7	73.3
2009	164.8	71.9	4248.6	73.2
2010	187.4	73.4	5185.5	73.4
2011	216.9	75.2	6579.3	75.7
2012	248.6	76.6	7842.2	76.2
2013	274.1	77.6	9075.8	76.6
2014	289.6	78.1	10060.6	77.3
2015	291.1	77.4	10881.3	76.8

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2001–2016).

Annexed Table 4-2 Sources and composition of enterprise R&D expenditure (2000–2015)

Category	Source of R&D Expenditure	Year					
		2010	2011	2012	2013	2014	2015
R&D expenditure by source (100 million yuan)	Government funding	236.8	288.5	363.1	409.0	422.3	463.4
	Enterprise funding	4809.0	6118.0	7295.2	8461.0	9429.2	10197.8
	Foreign funding	82.8	104.7	88.7	94.3	92.6	94.6
	Other funding	56.9	68.1	95.2	111.5	116.6	125.6
R&D expenditure by Composition (%)	Government funding	4.6	4.4	4.6	4.5	4.2	4.3
	Enterprise funding	92.7	93.0	93.0	93.2	93.7	93.7
	Foreign funding	1.6	1.6	1.1	1.0	0.9	0.9
	Other funding	1.1	1.0	1.2	1.2	1.2	1.2

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2011–2016).

Annexed Table 5-1 Higher education S&T activity (2005–2015)

Indicator	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of higher education institutions	1792	1867	1908	2263	2305	2358	2409	2442	2491	2529	2560
Number of R&D institutions	3936	4154	4502	5159	6082	7833	8630	9225	9842	10632	11732
R&D personnel (10 000 persons)	—	—	—	—	50.9	59.4	63.2	67.8	71.5	76.3	83.9
R&D personnel as a percentage of national total (%)	—	—	—	—	16.0	16.8	15.7	14.7	14.2	14.3	15.3
R&D personnel in FTE (10 000 person-years)	22.7	24.2	25.4	26.6	27.5	29.0	29.9	31.4	32.5	33.5	35.5
R&D personnel in FTE as a percentage of national total (%)	16.6	16.1	14.6	13.6	12.0	11.3	10.4	9.7	9.2	9.0	9.4
R&D expenditure (100 million yuan)	242.3	276.8	314.7	390.2	468.2	597.3	688.8	780.6	856.7	898.1	998.6
# Basic research (100 million yuan)	56.7	71.4	86.8	114.8	145.5	179.9	226.7	275.7	307.6	328.6	391.0
Applied research (100 million yuan)	125.0	137.3	161.8	208.9	250.0	337.0	372.4	402.7	441.3	476.4	516.3
Experimental development (100 million yuan)	60.6	68.2	66.1	66.5	72.6	80.3	89.8	102.2	107.8	93.1	91.3
# Government funding (100 million yuan)	133.1	151.5	177.7	225.5	262.2	358.8	405.1	474.1	516.9	536.5	637.3
Enterprise funding (100 million yuan)	88.9	101.2	110.3	134.9	171.7	198.5	242.9	260.5	289.3	302.7	301.5
Foreign funding (100 million yuan)	4.0	3.8	4.8	4.8	4.8	5.4	6.0	6.0	5.5	5.5	5.2
Other funding (100 million yuan)	16.3	20.3	21.9	24.9	29.5	34.5	34.8	40.0	45.1	53.5	54.6

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2006–2016).

Annexed Table 5-2 Higher education R&D expenditure of selected countries (2015)

Country	National R&D expenditure (Billion national currency)	Higher education R&D expenditure (Billion national currency)	Higher education R&D expenditure (Billion US dollars)	Higher education R&D expenditure as a percentage of national total (%)
China	14167.0	99.9	16.0	7.1
US	502.9	66.5	66.5	13.2
France	48.6	9.9	10.9	20.3
Germany	88.8	15.3	17.0	17.3
Japan	17436.1	2140.8	17.7	12.3
Korea	65959.4	5998.9	5.3	9.1
Italy	21.9	6.3	6.9	28.6
Sweden	137.1	36.6	4.3	26.7
UK	31.8	8.2	12.5	25.6

Continued

Country	National R&D expenditure (Billion national currency)	Higher education R&D expenditure (Billion national currency)	Higher education R&D expenditure (Billion US dollars)	Higher education R&D expenditure as a percentage of national total (%)
Canada	33.9	13.0	10.2	38.4
Netherlands	13.6	4.4	4.9	32.1
Denmark	60.0	20.0	3.0	33.4
Russia	914.7	87.7	1.4	9.6

Source: OECD, Main Science and Technology Indicators 2017-1.

Annexed Table 5-3 Ratio of higher education R&D expenditure to GDP (2005–2015)

Unit: %

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
UK	0.42	0.43	0.44	0.45	0.49	0.46	0.44	0.44	0.43	0.44	0.44
US	0.36	0.35	0.35	0.37	0.40	0.40	0.40	0.39	0.39	0.37	0.37
Netherlands	0.63	0.60	0.59	0.63	0.68	0.70	0.62	0.62	0.63	0.64	0.65
Finland	0.63	0.63	0.62	0.61	0.71	0.76	0.73	0.74	0.71	0.73	0.71
France	0.38	0.39	0.39	0.41	0.46	0.47	0.46	0.47	0.46	0.47	0.45
Germany	0.40	0.40	0.39	0.43	0.48	0.49	0.50	0.51	0.51	0.51	0.50
Japan	0.44	0.43	0.44	0.40	0.45	0.42	0.45	0.45	0.47	0.45	0.43
Korea	0.26	0.28	0.32	0.35	0.37	0.38	0.38	0.38	0.38	0.39	0.38
Argentina	0.10	0.11	0.12	0.12	0.15	0.15	0.16	0.18	0.18	0.18	—
Russia	0.06	0.07	0.07	0.07	0.09	0.09	0.10	0.10	0.10	0.12	0.11
China	0.13	0.12	0.12	0.12	0.13	0.15	0.15	0.15	0.15	0.14	0.15

Source: OECD, Main Science and Technology Indicators 2017-1.

Annexed Table 5-4 Higher education papers, patents and technology contracts (2005–2015)

Indicator	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
SCI papers (Piece)	49438	57286	64381	78079	89775	100772	113481	131356	161344	195093	219957
Domestic papers (Piece)	234609	243485	305787	317884	340630	343027	335907	337216	330605	320530	319447
# Fundamental disciplines	44916	47227	45410	47403	52398	45141	43732	38157	42033	36460	35802
Medical and health sciences	74066	58657	101680	106382	116361	123660	123988	121808	118826	114381	115467
Agriculture, forestry, animal husbandry and fishery	14218	17244	17692	33407	30232	26561	20352	20248	18927	19332	20804
Industrial technology	97351	113177	126283	129525	131832	135132	132250	141893	136353	131580	132531
Others	4058	7180	14722	1167	9807	12533	15585	15110	14466	18777	14843
Patent applications (Piece)	19921	22950	32680	45145	61579	79332	110136	132648	167656	183969	235162
# Invention patents	14643	17312	23001	30808	37965	48294	63028	75688	98509	111993	133645
Patents granted (Piece)	7399	10457	14773	19159	27947	43153	56484	77283	85038	92488	136334
# Invention patents	4453	6198	8214	10265	14391	19036	26616	33821	33309	38317	57196
Number of technology market contracts (10 000)	—	2.2	2.8	3.0	3.3	4.2	5.0	5.8	6.4	5.4	5.7
Turnover of technology market contracts (100 million yuan)	—	76.0	103.0	118.3	135.1	196.7	248.8	294.0	329.5	315.1	314.3

Source: Institute of Scientific and Technical Information of China, *China S&T Papers Statistics and Analysis (2005–2015)*; National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2006–2016).

Annexed Table 6-1 Personnel of research institutes (2005–2015)

Indicator	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
R&D personnel (10 000 persons)	24.1	25.7	29.0	30.4	32.3	34.2	36.2	38.8	40.9	42.3	43.6
R&D personnel in FTE (10 000 person-years)	21.5	23.1	25.5	26.0	27.7	29.3	31.6	34.4	36.4	37.4	38.4
# Basic research	2.8	3.2	3.6	3.8	4.1	4.2	5.0	5.7	6.1	6.6	7.1
Applied research	8.3	8.9	9.3	9.7	10.3	10.9	11.3	12.1	13.0	12.8	13.1
Experimental development	10.4	11.0	12.6	12.5	13.4	14.2	15.2	16.5	17.3	18.0	18.1

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2006–2016).

Annexed Table 6-2 Expenditure of research institutes (2005–2015)

Unit: 100 million yuan

Indicator	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Expenditure on R&D	513.1	567.3	687.9	811.3	996.0	1186.4	1306.7	1548.9	1781.4	1926.2	2136.5
# Basic research	58.0	67.9	74.7	92.7	110.6	129.9	160.2	197.9	221.6	258.9	295.3
Applied research	176.3	196.2	227.1	271.3	350.9	387.6	417.2	469.3	525.8	552.9	618.4
Experimental development	278.7	303.2	386.1	447.2	534.4	668.9	729.3	881.7	1034.0	1114.4	1222.8
# Government funding	424.7	481.2	592.9	699.7	849.5	1036.5	1106.1	1292.7	1481.2	1581.0	1802.7
Enterprise funding	17.6	17.3	26.2	28.2	29.8	34.2	39.9	47.4	60.9	62.1	65.4
Foreign funding	1.8	2.6	3.4	4.0	4.2	3.4	4.9	5.1	5.7	9.1	5.0
Other funding	69.0	66.1	65.3	79.3	112.4	112.2	155.8	203.8	233.5	273.9	263.4

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

Annexed Table 6-3 S&T output of research institutes

Indicator	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
SCI papers (Piece)	12632	13406	14284	15924	17169	18941	20685	23739	23734	29620	29749
Domestic papers (Piece)	38101	42354	47189	49906	56099	57022	58160	55656	60149	57600	56705
Patent applications (Piece)	9746	9878	14119	18612	21271	26962	37910	45119	53032	55861	64476
# Inventions	6726	6845	9748	12435	14332	18254	25222	29518	36582	39625	44545
Utility models	2661	2691	3598	4724	6022	7474	10512	12786	14360	15044	18830
Design patents	359	342	773	1453	917	1234	2176	2815	2090	1192	1101
Patents granted (Piece)	4192	5313	6558	8344	10269	14268	17777	19852	24878	26580	33651
# Inventions	2423	2553	3173	3945	5299	6557	9238	11248	12284	13573	19243
Utility models	1599	2484	3101	4161	4503	7074	8016	7754	11319	12238	13680
Design patents	170	276	284	238	467	637	523	850	1275	769	728
Number of technology market contracts as seller		39249	42695	44477	30858	29673	31833	36140	33118	29328	40663
Turnover of technology market contracts as seller (10 000 yuan)		1276619	1313030	1472110	1913980	1990272	2614299	4029582	5010078	4588179	5604063

Source: Institute of Scientific and Technical Information of China, *China S&T Papers Statistics and Analysis* (2006–2016); State Intellectual Property Office, *Patent Statistics Annual Report* (2005–2015); National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

Annexed Table 7-1　High-technology sector overview (2005–2015)

Industry	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total manufacturing											
Number of enterprises	251499	279282	313046	396950	405183	422532	301489	318772	343584	352365	358665
Average number of employees (10 000 persons)	5935	6347	6856	7732	7720	8391	8054	8395	8614	8647	8520
Revenue from principal business (100 million yuan)	213844	270478	347890	432760	471870	606300	729264	805662	909453	978230	992674
High-technology sector											
Number of enterprises	17527	19161	21517	25817	27218	28189	21682	24636	26894	27939	29631
Average number of employees (10 000 persons)	663	744	843	945	958	1092	1147	1269	1294	1325	1354
Revenue from principal business (100 million yuan)	33916	41585	49714	55729	59567	74483	87527	102284	116049	127368	139969
Aircraft and spacecraft and equipment manufacturing											
Number of enterprises	167	173	181	217	220	237	224	304	318	338	382
Average number of employees (10 00 persons)	30	30	30	31	33	34	35	36	34	37	39
Revenue from principal business (100 million yuan)	781	799	1006	1162	1323	1592	1934	2330	2853	3028	3413
Computer and office equipment manufacturing											
Number of enterprises	1267	1293	1450	1695	1676	1642	1313	1387	1565	1629	1695
Average number of employees (10 000 persons)	101	122	143	165	163	181	195	198	191	184	147
Revenue from principal business (100 million yuan)	10722	12634	14887	16499	16432	19958	21164	22045	23214	23499	19408
Electronic and communication equipment manufacturing											
Number of enterprises	7781	8606	9963	12871	12831	13425	10220	12215	13465	13973	14634
Average number of employees (10 000 persons)	347	393	455	523	510	602	636	731	748	773	814
Revenue from principal business (100 million yuan)	16646	21069	24824	27410	28466	35984	43206	52799	60634	67584	78310
Medical device manufacturing											
Number of enterprises	3341	3721	4175	4510	5684	5846	3999	4343	4707	4891	5062
Average number of employees (10 000 persons)	62	70	77	74	91	102	103	107	112	115	115

Continued

Industry	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Revenue from principal business (100 million yuan)	1752	2364	3030	3256	4259	5531	6739	7772	8863	9907	10472
Pharmaceutical manufacturing											
Number of enterprises	4971	5368	5748	6524	6807	7039	5926	6387	6839	7108	7392
Average number of employees (10 000 persons)	123	130	137	151	160	173	179	197	209	216	223
Revenue from principal business (100 million yuan)	4020	4719	5967	7402	9087	11417	14484	17338	20484	23350	25730
Information and chemical products manufacturing											
Number of enterprises											466
Average number of employees (10 000 persons)											17
Revenue from principal business (100 million yuan)											2637

Note: The data in this table are based on all state-owned enterprises and non-state-owned legal-person industrial enterprises with annual revenue from principal business of 5 million yuan or more before 2006, legal-person industrial enterprises with annual revenue from principal business of 5 million yuan or more between 2007 and 2010, and legal-person industrial enterprises with annual revenue from principal business of 20 million yuan or more after 2011.

Source: National Bureau of Statistics, National Development and Reform Commission, Ministry of Science and Technology, *China Statistical Yearbook on High-Technology Sector 2016*.

Annexed Table 7-2 High-technology sector on main S&T indicators (2005–2015)

Industry	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total manufacturing											
R&D personnel (10 000 person-years)	54.50	62.20	77.76	92.28	106.99	127.56	147.90	171.04	186.13	192.71	188.81
R&D expenditure (100 million yuan)	1184.52	1551.39	2009.56	2546.37	3012.94	3771.86	4753.75	5666.86	6407.34	6990.66	7476.04
Expenditure on technology import (100 million yuan)	288.49	302.46	434.64	411.87	383.69	377.25	397.04	370.05	365.92	356.55	364.47
New product sales revenue (100 million yuan)	23804.21	30876.90	40517.15	50287.42	57175.83	72310.12	87681.32	96939.94	111221.85	122624.26	128091.76
Number of invention patents in force (Piece)	21870	28168	42455	54223	78884	109732	143397	199128	238501	303855	391732
High-technology sector											
R&D personnel (10 000 person-years)	17.32	18.90	24.82	28.51	32.00	39.91	42.67	52.56	55.92	57.25	59.00
R&D expenditure (100 million yuan)	362.50	456.44	545.32	655.20	774.05	967.83	1237.81	1491.49	1734.37	1922.15	2219.66
Expenditure on technology import (100 million yuan)	84.82	78.58	130.90	84.29	64.42	68.78	62.18	73.31	53.21	56.70	71.74
New product sales revenue (100 million yuan)	6914.66	8248.86	10303.22	12879.47	12595.00	16364.76	20384.52	23765.32	29028.84	32845.19	38111.48
Number of invention patents in force (Piece)	6658	8141	13386	23915	31830	50166	67428	97878	115884	147927	199728
Aircraft and spacecraft and equipment manufacturing											
R&D personnel (10 000 person-years)	2.99	2.74	2.72	1.93	2.30	2.82	2.95	3.79	4.44	3.62	4.21
R&D expenditure (100 million yuan)	27.80	33.34	42.59	51.99	65.78	92.84	143.56	158.68	167.15	184.79	168.00
Expenditure on technology import (100 million yuan)	3.04	3.68	2.19	0.70	2.67	6.49	2.11	0.97	1.63	1.39	0.96
New product sales revenue (100 million yuan)	337.35	305.04	379.13	472.98	272.17	472.16	498.03	601.83	716.15	1080.90	1264.96
Number of invention patents in force (Piece)	192	228	270	400	565	700	1277	1770	2778	3485	5535
Computer and office equipment manufacturing											
R&D personnel (10 000 person-years)	1.75	2.46	2.97	3.11	3.54	6.85	4.57	5.86	5.50	5.49	5.17
R&D expenditure (100 million yuan)	43.45	72.93	81.82	80.90	98.87	117.57	151.33	158.07	137.84	142.11	158.81
Expenditure on technology import (100 million yuan)	11.47	9.89	18.99	2.69	5.64	3.66	0.86	2.41	1.97	0.49	0.36
New product sales revenue (100 million yuan)	2070.09	2963.11	2814.74	4227.74	2253.12	4421.47	6738.85	6613.00	5653.46	5611.37	5345.27
Number of invention patents in force (Piece)	473	1174	3210	3344	4192	7552	10532	14922	13302	12288	7721
Electronic and communication equipment manufacturing											
R&D personnel (10 000 person-years)	9.51	9.78	14.24	17.22	18.31	21.15	24.18	30.14	31.14	32.73	34.50
R&D expenditure (100 million yuan)	234.72	276.89	324.52	402.94	454.85	572.41	700.57	855.50	1045.91	1176.49	1379.06

Continued

Industry	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Expenditure on technology import (100 million yuan)	66.50	60.54	104.42	71.84	48.03	47.47	47.85	56.36	36.26	41.79	58.91
New product sales revenue (100 million yuan)	3852.04	4173.48	6013.02	6759.08	8232.77	9071.49	10411.84	12904.34	18424.62	21059.34	25207.95
Number of invention patents in force (Piece)	4268	3807	6532	15418	21298	33677	44448	64603	79689	105307	150004
Medical device manufacturing											
R&D personnel (10 000 person-years)	1.11	1.38	1.81	2.23	2.74	3.56	4.11	4.58	5.42	5.37	5.11
R&D expenditure (100 million yuan)	16.59	20.70	30.51	40.29	54.93	62.39	86.08	104.35	124.60	129.06	150.38
Expenditure on technology import (100 million yuan)	0.23	1.25	2.26	4.51	3.85	6.32	5.93	8.39	8.28	9.01	5.42
New product sales revenue (100 million yuan)	185.82	237.31	383.65	470.77	588.62	724.12	910.49	1196.81	1243.77	1468.18	1519.29
Number of invention patents in force (Piece)	591	967	892	1583	1864	2565	4644	6510	7320	10686	13470
Pharmaceutical manufacturing											
R&D personnel (10 000 person-years)	1.96	2.54	3.08	4.02	5.11	5.52	6.87	8.19	9.41	10.04	9.24
R&D expenditure (100 million yuan)	39.95	52.59	65.88	79.09	99.62	122.63	156.27	214.89	258.88	289.71	326.21
Expenditure on technology import (100 million yuan)	3.58	3.21	3.03	4.54	4.23	4.84	5.43	5.17	5.08	4.02	5.58
New product sales revenue (100 million yuan)	469.36	569.92	712.69	948.91	1248.32	1675.53	1825.31	2449.34	2990.83	3625.40	3940.76
Number of invention patents in force (Piece)	1134	1965	2482	3170	3911	5672	6527	10073	12795	16161	21563
Information and chemical products manufacturing											
R&D personnel (10 000 person-years)											0.76
R&D expenditure (100 million yuan)											37.21
Expenditure on technology import (100 million yuan)											0.52
New product sales revenue (100 million yuan)											833.25
Number of invention patents in force (Piece)											1435

Note: The above data are of large and medium-sized industrial enterprises.
Source: National Bureau of Statistics, National Development and Reform Commission, Ministry of Science and Technology, *China Statistical Yearbook on High-Technology Sector 2016*.

Annexed Table 7-3 Imports and exports of high-technology products (2004–2015)

Category	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Value of goods exported (USD 100 million)	5934	7620	9689	12180	14307	12016	15779	18986	20490	22100	23427	22749
# Manufactured goods (USD 100 million)	5528	7130	9160	11565	13527	11385	14962	17980	19484	21027	22300	21710
Proportion in total exports of goods (%)	93.2	93.6	94.5	95.0	94.6	94.7	94.8	94.7	95.1	95.1	95.2	95.4
# High-technology products (USD 100 million)	1654	2182	2815	3478	4156	3769	4924	5488	6012	6603	6605	6553
Proportion in total exports of goods (%)	27.9	28.6	29.0	28.6	29.0	31.4	31.2	28.9	29.3	29.9	28.2	28.8
Proportion in total exports of manufactured goods (%)	29.9	30.6	30.7	30.1	30.7	33.1	32.9	30.5	30.9	31.4	29.6	30.2
Value of goods imported (USD 100 million)	5614	6601	7915	9558	11326	10059	13948	17433	18178	19503	19603	16820
# Manufactured goods (USD 100 million)	4441	5124	6043	7128	7702	7161	9623	11391	11832	12927	13129	12089
Proportion in total imports of goods (%)	79.1	77.6	76.4	74.6	68.0	71.2	69.0	65.3	65.1	66.3	67.0	71.9
# High-technology products (USD 100 million)	1613	1977	2473	2870	3418	3099	4127	4632	5069	5582	5514	5493
Proportion in total imports of goods (%)	28.7	30.0	31.2	30.0	30.2	30.8	29.6	26.6	27.9	28.6	28.1	32.7
Proportion in total imports of manufactured goods (%)	36.3	38.6	40.9	40.3	44.3	43.3	42.9	40.7	42.8	43.2	42.0	45.4
Balance of trade (USD 100 million)	319	1019	1775	2622	2981	1957	1831	1553	2312	2597	3825	5930
# Manufactured goods (USD 100 million)	1087	2006	3117	4437	5826	4224	5339	6590	7652	8100	9172	9620
# High-technology products (USD 100 million)	41	205	342	608	738	671	797	856	943	1021	1091	1060

Source: General Administration of Customs, Import and export statistics.

Annexed Table 7-4 Imports and exports of high-technology products by technology field (2013–2015)

Unit: Million US dollars

Technology field	2013			2014			2015		
	Exports	Imports	Balance	Exports	Imports	Balance	Exports	Imports	Balance
Total	6603.3	5581.9	1021.4	6605.4	5513.8	1091.6	6553.0	5492.9	1060.1
Computer and communication technology	4390.9	1274.2	3116.7	4587.4	1212.2	3375.3	4418.9	1169.2	3249.7
Life science and technology	225.8	219.0	6.7	239.4	250.8	−11.4	245.9	267.1	−21.2
Electronic technology	1367.9	2799.6	−1431.7	1145.7	2693.2	−1547.6	1255.4	2786.6	−1531.2
Computer-integrated manufacturing technology	109.6	334.6	−224.9	129.4	386.1	−256.7	125.1	358.5	−233.4
Aerospace technology	51.1	301.9	−250.8	65.5	357.6	−292.2	73.3	349.7	−276.5
Photoelectric technology	393.3	581.3	−188.0	363.0	542.5	−179.5	357.3	493.7	−136.4
Biotechnology	6.1	7.8	−1.7	6.5	10.4	−3.9	6.9	11.3	−4.4
Materials technology	51.6	53.5	−2.0	61.0	54.8	6.3	62.3	48.1	14.3
Others	7.1	10.1	−3.0	7.6	6.2	1.3	8.0	8.8	−0.9

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2014–2016).

Annexed Table 7-5 Imports and exports of high-technology products by mode of trade (2013–2015)

Unit: Million US dollars

Mode of trade	2013			2014				2015	
	Exports	Imports	Balance	Exports	Imports	Balance	Exports	Imports	Balance
Total	660330	558193	102137	660543	551384	109159	655296	549291	106005
General trade	110728	135145	−24417	131153	150312	−19159	149441	151871	−2430
Gratuitous aid and donated materials from foreign governments and international organizations	171	10	161	176	26	150	209	6	203
Other donated materials	1	1	0	1	2	−1	2	41	−40
Processing and assembling trade with supplied materials	28361	33878	−5517	26347	36086	−9739	26002	38824	−12823
Processing trade with imported materials	403055	208922	194133	412760	210984	201776	387224	202484	184740
Cross-border petty trade	1237	1	1236	1806	1	1805	874	1	872

Continued

Mode of trade	2013			2014				2015	
	Exports	Imports	Balance	Exports	Imports	Balance	Exports	Imports	Balance
Imported equipment for processing trade		736	−736		484	−484		501	−501
Exported goods on contracted projects	1068		1068	1238		1238	1137		1137
Leasing trade	13	8077	−8064	15	10081	−10066	8	9818	−9809
Equipment and goods imported by foreign-invested enterprises as investment		4704	−4704		5042	−5042		3739	−3739
Materials exported for processing trade	67	80	−13	90	118	−28	85	116	−31
Inbound and outbound goods in bonded warehouses	9099	19963	−10864	13610	24066	−10456	12894	23402	−10509
Logistics goods in special supervision areas	106260	142730	−36470	72355	109171	−36816	75716	112385	−36669
Imported equipment in special supervision areas		3053	−3053		3921	−3921		5139	−5139
Others	269	865	−596	990	1090	−100	1705	963	742

Source: National Bureau of Statistics and Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (2014–2016).

Annexed Table 7-6 China's trade with selected countries/regions (2013–2015)

Unit: Million US dollars

Country/region	2013			2014			2015		
	Exports	Imports	Balance	Exports	Imports	Balance	Exports	Imports	Balance
US	117893	48331	69561	125304	48871	76434	120749	50831	69918
Hong Kong of China	211500	2090	209411	179916	2014	177901	189640	2002	187638
15 EU states	80880	47570	33310	86195	52732	33463	78837	48751	30085
Japan	38706	47539	−8834	39756	49407	−9650	35914	46325	−10411
Korea	35673	98578	−62905	37920	98823	−60902	40639	103971	−63332
Taiwan of China	18362	107727	−89365	21150	102070	−80920	20780	100022	−79242
Australia	7508	305	7203	7821	327	7494	7597	315	7282

Source: General Administration of Customs, Import and export statistics.

Annexed Table 7-7 High-tech industrial development zones on key economic indicators (2003–2015)

Year	Number of enterprises	Number of employees at year-end (10 000 persons)	Total revenue (100 million yuan)	Gross industrial output value (100 million yuan)	Net profit (100 million yuan)	Actual tax payments (100 million yuan)	Foreign exchange from export (100 million dollars)
2003	32857	395.4	20938.7	17257.4	1129.4	990.0	510.2
2004	38565	448.4	27466.3	22638.9	1422.8	1239.6	823.8
2005	41990	521.2	34415.6	28957.6	1603.2	1615.8	1116.5
2006	45828	573.7	43320.0	35899.0	2128.5	1977.1	1361.0
2007	48472	650.2	54925.2	44376.9	3159.3	2614.1	1728.1
2008	52632	716.5	65985.7	52684.7	3304.2	3198.7	2015.2
2009	53692	810.5	78706.9	61151.4	4465.4	3994.6	1007.2
2010	55243	960.3	105917.3	84318.2	6855.4	5446.8	1648.0
2011	57033	1073.6	133425.1	105679.6	8484.2	6816.7	3180.6
2012	63926	1269.5	165689.9	128603.9	10243.2	9580.5	3760.4
2013	71180	1460.2	199648.9	151367.6	12443.6	11043.1	4133.3
2014	74275	1527.2	226754.5	169936.9	15052.5	13202.1	4351.4
2015	82712	1719.0	253662.8	186018.3	16094.8	14240.0	4732.7

Source: Torch High-Technology Sector Development Center, Ministry of Science and Technology, *China Torch Statistical Yearbook 2016*.

Annexed Table 7-8 Venture capital investment in China by industry (2006–2015)

Unit: %

Industry	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Software industry	14.6	16.0	6.2	10.9	2.9	2.1	2.4	2.0	7.4	7.5
Computer hardware industry	0.4	0.6	3.4	0.1	1.1	0.7	1.1	0.7	4.2	1.7
Network industry	1.5	0.5	2.7	1.8	2.8	2.5	2.1	1.9	4.0	5.1
Telecommunication equipment	4.6	2.9	1.8	1.9	1.0	2.8	3.6	3.1	13.8	18.6
IT services	3.1	1.0	4.6	1.5	3.2	2.8	3.1	3.6	3.0	3.0
Semiconductor	2.1	1.3	2.9	2.3	1.2	1.3	1.4	1.4	1.4	0.7
Other IT industries	3.2	1.3	2.3	2.2	1.2	1.5	1.7	0.4	1.0	0.5
Environmental engineering	1.3	1.5	1.3	1.8	3.3	2.6	2.8	2.9	2.8	2.3
Biological technology	5.4	2.3	5.7	2.5	3.9	3.9	2.8	2.3	3.7	2.1
New materials industry	7.5	7.9	4.4	6.4	9.3	8.7	7.8	7.1	3.7	5.7
Extractive industry	3.7	1.9	3.6	1.5	2.5	0.6	1.3	0.5	0.0	0.1
Optoelectronics and opto-mechatronics	4.1	2.1	4.0	4.1	4.2	3.3	3.5	4.6	1.9	0.9
Technology services	1.2	4.9	2.1	2.0	2.3	1.6	1.6	1.0	2.2	1.8
New energy and energy efficiency technology	7.0	4.6	7.7	8.5	8.3	6.2	7.2	8.7	2.9	3.0
Medicine and health care	2.7	2.0	2.5	4.9	5.3	3.8	4.9	10.0	7.4	5.4
Consumer products and services	4.1	1.4	3.9	4.3	7.1	9.4	6.3	5.0	1.6	2.1
Communications and cultural entertainment	1.1	2.2	1.8	2.5	2.1	2.2	6.4	6.2	5.4	5.5
Traditional manufacturing industry	11.3	12.6	15.6	11.9	10.1	7.7	10.1	7.2	7.6	3.8
Agriculture, forestry, animal husbandary and fishery	9.4	1.2	2.6	3.5	4.1	4.1	6.1	6.3	2.0	1.9
Financial and insurance industry	3.8	22.1	8.2	15.2	7.8	2.4	5.4	10.1	2.9	5.7
Wholesale and retail	0.6	1.1	0.0	0.3	0.7	1.2	0.9	0.5	3.8	1.2
Other industries	7.6	8.3	12.7	10.0	15.7	11.2	7.6	2.7	8.5	10.4
Applied nuclear technology	0.0	0.0	0.0	0.1	0.0	0.4	0.2	0.2	0.1	0.1

Source: Chinese Academy of Science and Technology for Development, *Venture Capital Development in China 2016*.

Annexed Table 8-1 S&T resources by region (2015)

Region	Population (10 000 persons)	Personnel holding a junior college or above diploma (10 000 persons)	Employees (10 000 persons)	R&D personnel in FTE (10 000 person-years)	R&D expenditure (100 million yuan)
Beijing	2170.5	865.2	1341.0	24.57	1384.02
Tianjin	1547.0	343.5	530.0	12.43	510.18
Hebei	7424.9	702.1	3857.2	10.70	350.87
Shanxi	3664.1	475.2	1694.5	4.29	132.53
Inner mongolia	2511.0	384.0	1205.6	3.82	136.06
Liaoning	4382.4	713.1	2277.7	8.54	363.40
Jilin	2753.3	348.0	1270.8	4.93	141.41
Heilongjiang	3811.7	490.4	1774.2	5.66	157.67
Shanghai	2415.3	659.1	941.1	17.18	936.14
Jiangsu	7976.3	1232.2	4815.4	52.03	1801.23
Zhejiang	5539.0	766.8	4059.7	36.47	1011.18
Anhui	6143.6	669.0	3914.8	13.36	431.75
Fujian	3839.0	458.0	2219.9	12.66	392.93
Jiangxi	4565.6	444.3	2346.9	4.65	173.18
Shandong	9847.2	1160.4	5754.7	29.78	1427.19
Henan	9480.0	763.3	6148.4	15.89	435.04
Hubei	5851.5	819.0	3171.6	13.55	561.74
Hunan	6783.0	749.4	4078.6	11.49	412.67
Guangdong	10849.0	1206.1	5879.1	50.17	1798.17
Guangxi	4796.0	401.1	2997.4	3.83	105.91
Hainan	910.8	90.4	453.6	0.77	16.97
Chongqing	3016.6	357.8	1946.0	6.15	247.00
Sichuan	8204.0	851.4	5086.0	11.68	502.88
Guizhou	3529.5	273.4	2444.7	2.35	62.32
Yunnan	4741.8	417.3	2863.9	3.95	109.36
Tibet	324.0	21.1	178.1	0.11	3.12
Shaanxi	3793.0	628.7	1986.6	9.26	393.17
Gansu	2599.6	304.7	1457.2	2.59	82.72
Qinghai	588.4	56.8	299.3	0.40	11.58
Ningxia	667.9	93.8	331.8	0.92	25.48
Xinjiang	2359.7	309.7	867.7	1.69	52.00

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*; National Bureau of Statistics , *China Statistical Yearbook 2016*.

Annexed Table 8-2 Patents filed by region (2015)

Unit: Piece

Region	Patents filed			
		Inventions	Utility models	Designs
Beijing	156312	88930	53243	14139
Tianjin	79963	28510	46845	4608
Hebei	44060	11259	24646	8155
Shanxi	14948	5680	7911	1357
Inner mongolia	8876	2254	5609	1013
Liaoning	42153	19332	19554	3267
Jilin	14800	6154	7345	1301
Heilongjiang	34611	14663	16914	3034
Shanghai	100006	46976	41736	11294
Jiangsu	428337	154608	154281	119448
Zhejiang	307264	67674	150172	89418
Anhui	127709	68314	51559	7836
Fujian	83146	17663	44339	21144
Jiangxi	36936	5722	18620	12594
Shandong	193220	93475	85872	13873
Henan	74373	21338	40778	12257
Hubei	74240	30204	35676	8360
Hunan	54501	19499	23641	11361
Guangdong	355939	103941	135717	116281
Guangxi	43696	30815	9740	3141
Hainan	3127	1211	1521	395
Chongqing	82791	35086	38533	9172
Sichuan	110746	40437	41859	28450
Guizhou	18295	7538	8317	2440
Yunnan	17603	6301	9147	2155
Tibet	309	128	90	91
Shaanxi	74904	17322	21449	36133
Gansu	14584	5504	6825	2255
Qinghai	2590	1103	1184	303
Ningxia	4394	2626	1591	177
Xinjiang	12250	3024	6354	2872

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

Annexed Table 8-3 Patents granted by region (2015)

Unit: Piece

Region	Patents granted	Inventions	Utility models	Designs
Beijing	94031	35308	45773	12950
Tianjin	37342	4624	28486	4232
Hebei	30130	3840	19103	7187
Shanxi	10020	2432	6037	1551
Inner mongolia	5522	797	3757	968
Liaoning	25182	6569	15706	2907
Jilin	8878	2240	5638	1000
Heilongjiang	18943	4024	12502	2417
Shanghai	60623	17601	33131	9891
Jiangsu	250290	36015	119513	94762
Zhejiang	234983	23345	124465	87173
Anhui	59039	11180	41094	6765
Fujian	61621	5730	34086	21805
Jiangxi	24161	1639	13408	9114
Shandong	98101	16881	68776	12444
Henan	47766	5384	32592	9790
Hubei	38781	7766	25298	5717
Hunan	34075	6776	18467	8832
Guangdong	241176	33477	105254	102445
Guangxi	13573	4017	7091	2465
Hainan	2061	417	1148	496
Chongqing	38914	3964	25444	9506
Sichuan	64953	9105	31420	24428
Guizhou	14115	1501	7007	5607
Yunnan	11658	2079	7437	2142
Tibet	198	40	51	107
Shaanxi	33350	6812	16151	10387
Gansu	6912	1238	4478	1196
Qinghai	1217	207	687	323
Ningxia	1865	442	1267	156
Xinjiang	8761	950	5049	2762

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

Annexed Table 8-4 Revenue from principal business of high-technology sector and industrial enterprises above designated size by region (2015)

Region	Revenue from principal business of high-technology sector (100 million yuan)	Revenue from principal business of industrial enterprises above designated size (100 million yuan)	Revenue from principal business of high-technology sector as a percentage of that of industrial enterprises above designated size (%)
Beijing	3997.1	18864.9	21.19
Tianjin	4233.8	27969.6	15.14
Hebei	1705.9	45648.1	3.74
Shanxi	864.7	14624.1	5.91
Inner mongolia	394.3	18925.6	2.08
Liaoning	1813.7	33243.3	5.46
Jilin	1848.5	22322.0	8.28
Heilongjiang	622.2	11719.0	5.31
Shanghai	7213.0	34172.2	21.11
Jiangsu	28530.2	147074.5	19.40
Zhejiang	5288.1	63214.4	8.37
Anhui	3064.1	39064.4	7.84
Fujian	3962.3	39591.3	10.01
Jiangxi	3318.1	32954.8	10.07
Shandong	11535.3	145628.9	7.92
Henan	6653.8	73366.0	9.07
Hubei	3655.1	43179.2	8.47
Hunan	3280.2	35410.5	9.26
Guangdong	33308.1	119157.9	27.95
Guangxi	1791.0	20442.5	8.76
Hainan	155.9	1661.7	9.38
Chongqing	4028.8	20902.2	19.27
Sichuan	5171.7	38645.9	13.38
Guizhou	806.9	9876.8	8.17
Yunnan	350.0	9829.7	3.56
Tibet	9.9	136.4	7.26
Shaanxi	1902.9	19690.7	9.66
Gansu	179.0	8689.4	2.06
Qinghai	100.5	2170.7	4.63
Ningxia	111.8	3472.8	3.22
Xinjiang	71.7	8203.7	0.87

Source: National Bureau of Statistics, National Development and Reform Commission, Ministry of Science and Technology, *China Statistical Yearbook 2016*; National Bureau of Statistics, *China Statistical Yearbook on High-Technology Sector 2016*.

Annexed Table 8-5 Exports of high-technology products by region and proportion in total exports of goods by region (2015)

Region	Exports of high-technology products (100 million dollars)	Exports of goods (100 million dollars)	Exports of high-technology products as a percentage of total exports of goods (%)
Beijing	140.36	290.01	48.40
Tianjin	197.16	483.60	40.77
Hebei	23.62	476.56	4.96
Shanxi	39.60	114.39	34.62
Inner mongolia	3.34	61.34	5.45
Liaoning	45.64	511.00	8.93
Jilin	3.06	53.63	5.70
Heilongjiang	2.19	63.17	3.47
Shanghai	852.31	1786.99	47.70
Jiangsu	1311.10	3488.33	37.59
Zhejiang	167.97	2830.03	5.94
Anhui	66.91	276.54	24.20
Fujian	146.34	937.95	15.60
Jiangxi	51.26	301.40	17.01
Shandong	176.94	1484.94	11.92
Henan	276.63	457.79	60.43
Hubei	80.13	270.98	29.57
Hunan	35.96	190.85	18.84
Guangdong	2325.72	7301.88	31.85
Guangxi	36.98	140.56	26.31
Hainan	2.92	42.68	6.84
Chongqing	281.20	399.38	70.41
Sichuan	151.51	283.87	53.37
Guizhou	13.68	54.50	25.09
Yunnan	11.45	106.65	10.74
Tibet	0.04	5.27	0.76
Shaanxi	99.16	146.22	67.82
Gansu	3.78	21.59	17.51
Qinghai	0.43	3.67	11.72
Ningxia	2.35	23.69	9.92
Xinjiang	3.22	125.23	2.57

Source: National Bureau of Statistics, General Administration of Customs, *China Statistical Yearbook 2016*.

Annexed Table 8-6 R&D personnel by sector of performance by region (2015)

Unit: 10 000 person-years

Region	Total	Research institutes	Higher education institutions	Enterprises and others
Beijing	24.57	9.80	3.45	11.33
Tianjin	12.43	1.01	1.14	10.29
Hebei	10.70	0.88	1.00	8.82
Shanxi	4.29	0.43	0.64	3.21
Inner mongolia	3.82	0.29	0.33	3.21
Liaoning	8.54	1.29	1.67	5.57
Jilin	4.93	0.73	1.49	2.70
Heilongjiang	5.66	0.70	1.48	3.48
Shanghai	17.18	2.94	2.33	11.91
Jiangsu	52.03	2.37	2.39	47.28
Zhejiang	36.47	0.71	1.61	34.14
Anhui	13.36	1.01	1.35	11.00
Fujian	12.66	0.41	0.99	11.26
Jiangxi	4.65	0.54	0.57	3.54
Shandong	29.78	1.19	2.11	26.49
Henan	15.89	1.10	0.78	14.01
Hubei	13.55	1.53	1.53	10.49
Hunan	11.49	0.79	1.43	9.26
Guangdong	50.17	1.33	2.36	46.47
Guangxi	3.83	0.42	0.98	2.43
Hainan	0.77	0.12	0.10	0.55
Chongqing	6.15	0.43	0.78	4.94
Sichuan	11.68	3.19	1.76	6.74
Guizhou	2.35	0.30	0.43	1.62
Yunnan	3.95	0.72	0.71	2.52
Tibet	0.11	0.05	0.03	0.03
Shaanxi	9.26	2.95	1.06	5.25
Gansu	2.59	0.67	0.38	1.54
Qinghai	0.40	0.07	0.06	0.27
Ningxia	0.92	0.05	0.14	0.73
Xinjiang	1.69	0.36	0.38	0.96

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

Annexed Table 8-7 R&D expenditure by sector of performance by region (2015)

Unit: 100 million yuan

Region	Total	Research institutes	Higher education institutions	Enterprises and others
Beijing	1384.02	702.76	162.65	518.61
Tianjin	510.18	44.21	61.18	404.79
Hebei	350.87	40.60	12.74	297.53
Shanxi	132.53	15.46	11.43	105.63
Inner mongolia	136.06	9.35	3.27	123.44
Liaoning	363.40	60.25	46.55	256.59
Jilin	141.41	29.02	22.68	89.71
Heilongjiang	157.67	25.73	40.94	91.00
Shanghai	936.14	264.70	86.65	584.79
Jiangsu	1801.23	130.32	91.39	1579.52
Zhejiang	1011.18	30.28	56.14	924.76
Anhui	431.75	48.05	27.29	356.41
Fujian	392.93	15.48	15.37	362.08
Jiangxi	173.18	12.20	10.38	150.59
Shandong	1427.19	48.09	37.37	1341.73
Henan	435.04	33.14	18.71	383.20
Hubei	561.74	64.42	54.52	442.80
Hunan	412.67	19.60	26.12	366.95
Guangdong	1798.17	63.98	62.97	1671.22
Guangxi	105.91	13.06	11.25	81.60
Hainan	16.97	3.31	1.71	11.96
Chongqing	247.00	17.96	18.99	210.05
Sichuan	502.88	211.64	46.52	244.71
Guizhou	62.32	7.89	6.52	47.91
Yunnan	109.36	22.57	10.55	76.24
Tibet	3.12	1.40	1.13	0.60
Shaanxi	393.17	163.64	39.74	189.80
Gansu	82.72	24.82	6.96	50.94
Qinghai	11.58	2.34	1.05	8.20
Ningxia	25.48	1.57	1.83	22.09
Xinjiang	52.00	8.64	4.01	39.35

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*.

Annexed Table 8-8　SCI papers by region (2015)

Unit: Piece

Region	Volume of SCI papers	Fundamental disciplines	Medical and health sciences	Agriculture and farming	Industrial technology	Others
Beijing	46179	21574	9241	1257	14065	42
Tianjin	8107	3977	1626	41	2451	12
Hebei	3374	1562	834	67	907	4
Shanxi	2596	1480	274	41	799	2
Inner mongolia	870	471	153	42	204	0
Liaoning	9987	4098	2181	178	3522	8
Jilin	6852	4184	1214	110	1339	5
Heilongjiang	7184	3217	1103	216	2644	4
Shanghai	24818	11171	7551	177	5876	43
Jiangsu	27483	13057	5782	881	7749	14
Zhejiang	13674	6182	3745	357	3368	22
Anhui	7155	4110	1017	74	1944	10
Fujian	5383	3034	1047	171	1129	2
Jiangxi	2624	1442	544	40	594	4
Shandong	13250	6380	3730	426	2706	8
Henan	5903	3097	1593	144	1068	1
Hubei	13335	6550	2619	418	3739	9
Hunan	8813	4010	1686	133	2977	7
Guangdong	16127	6759	5695	361	3300	12
Guangxi	1973	850	622	53	446	2
Hainan	543	259	157	63	63	1
Chongqing	5913	2521	1748	99	1542	3
Sichuan	10846	4976	2495	246	3118	11
Guizhou	857	525	199	15	118	0
Yunnan	2643	1573	503	83	484	0
Tibet	25	15	5	4	1	0
Shaanxi	13195	5844	2022	379	4946	4
Gansu	3836	2388	448	136	864	0
Qinghai	186	106	33	9	38	0
Ningxia	276	136	105	5	30	0
Xinjiang	1462	709	477	56	219	1

Note: Chinese mainland SCI papers as published by Chinese author as the first author.

Source: Institute of Scientific and Technical Information of China.

Annexed Table 8-9 Revenue from principal business of high-technology sector by region (2015)

Unit: 100 million yuan

Region	Total	Pharmaceutical manufacturing	Aircraft and spacecraft and equipment manufacturing	Electronic and communication equipment manufacturing	Computer and office equipment manufacturing	Medical device manufacturing	Information and chemical products manufacturing
Beijing	3997.1	715.7	241.5	1866.0	729.6	427.5	16.8
Tianjin	4233.8	571.3	766.4	2363.9	394.2	117.0	21.0
Hebei	1705.9	905.3	15.2	561.0	13.2	134.6	76.5
Shanxi	864.7	173.8	1.2	658.4	4.2	23.0	4.0
Inner mongolia	394.3	262.5	0.3	58.5	2.0	13.5	57.5
Liaoning	1813.7	618.0	282.2	586.4	63.3	221.0	42.9
Jilin	1848.5	1639.2		88.3	17.9	102.9	0.2
Heilongjiang	622.2	389.7	145.4	49.0	6.7	30.6	0.8
Shanghai	7213.0	659.3	192.9	3677.6	2208.0	452.0	23.1
Jiangsu	28530.2	3479.5	328.3	15864.9	3972.0	3876.6	1008.8
Zhejiang	5288.1	1158.1	5.9	2980.2	176.6	818.8	148.4
Anhui	3064.1	715.6	14.1	1439.1	615.3	258.8	21.4
Fujian	3962.3	263.2	110.4	2506.1	899.2	132.8	50.7
Jiangxi	3318.1	1148.3	9.3	1485.2	155.9	229.1	290.3
Shandong	11535.3	4161.7	37.4	4755.7	1272.3	1172.9	135.4
Henan	6653.8	1976.2	86.4	3817.6	101.4	541.0	131.2
Hubei	3655.1	1067.4	93.6	1978.3	189.2	196.7	130.0
Hunan	3280.2	924.5	60.9	1893.8	92.2	290.8	18.0
Guangdong	33308.1	1407.9	80.3	26881.7	4010.9	821.8	105.5
Guangxi	1791.0	354.8	19.4	589.5	729.8	69.8	27.7
Hainan	155.9	137.6		16.0		2.2	
Chongqing	4028.8	518.6	0.8	1329.9	1950.1	183.7	45.8
Sichuan	5171.7	1164.6	246.3	1892.1	1699.4	123.8	45.6
Guizhou	806.9	334.6	136.6	232.9	84.7	18.1	
Yunnan	350.0	255.3	0.3	29.4	17.5	38.3	9.1
Tibet	9.9	9.9					
Shaanxi	1902.9	507.5	528.8	623.6	2.1	154.8	86.0
Gansu	179.0	109.1	8.9	55.3		5.7	
Qinghai	100.5	35.4		25.6		3.0	36.4
Ningxia	111.8	36.6		0.6		9.1	65.6
Xinjiang	71.7	28.3		3.4		1.9	38.2

Source: National Bureau of Statistics, National Development and Reform Commission, Ministry of Science and Technology, *China Statistical Yearbook on High-Technology Sector 2016*.

Annexed Table 8-10 Performance of regions on main S&T indicators (2015)

Region	R&D personnel in FTE per 10 000 employees (person-years/10 000 persons)	R&D expenditure as a percentage of regional GDP (%)	S&T expenditure as a percentage of local fiscal expenditure (%)	Invention patents per 10 000 population (Pieces / 10 000 persons)	SCI papers per 10 000 population	Revenue from principal business of high-technology sector as a percentage of that of industrial enterprise above designated size (%)	Exports of high-technology products as a percentage of total exports of goods (%)	Technology market contract turnover as a percentage of local GDP (%)
Beijing	183.25	6.01	5.02	158.91	430.79	21.19	48.40	15.01
Tianjin	234.57	3.08	3.74	67.08	100.57	15.14	40.77	3.04
Hebei	27.73	1.18	0.81	11.63	9.82	3.74	4.96	0.13
Shanxi	25.30	1.04	1.09	9.28	13.96	5.91	34.62	0.40
Inner mongolia	31.72	0.76	0.84	6.69	7.24	2.08	5.45	0.09
Liaoning	37.48	1.27	1.54	20.76	47.63	5.46	8.93	0.93
Jilin	38.78	1.01	1.29	10.55	48.74	8.28	5.70	0.19
Heilongjiang	31.90	1.05	1.07	15.42	41.57	5.31	3.47	0.84
Shanghai	182.56	3.73	4.39	103.99	177.63	21.11	47.70	2.64
Jiangsu	108.05	2.57	3.84	84.51	64.69	19.40	37.59	0.82
Zhejiang	89.84	2.36	3.77	120.76	43.93	8.37	5.94	0.23
Anhui	34.12	1.96	2.82	26.40	22.08	7.84	24.20	0.87
Fujian	57.02	1.51	1.91	42.32	24.44	10.01	15.60	0.20
Jiangxi	19.83	1.04	1.69	11.35	12.35	10.07	17.01	0.39
Shandong	51.76	2.27	1.93	27.51	22.55	7.92	11.92	0.49
Henan	25.84	1.18	1.22	13.33	11.94	9.07	60.43	0.12
Hubei	42.72	1.90	2.57	20.40	45.78	8.46	29.57	2.67
Hunan	28.16	1.43	1.16	15.79	26.43	9.26	18.84	0.36
Guangdong	85.34	2.47	4.44	73.97	23.82	27.95	31.85	0.91
Guangxi	12.77	0.63	1.22	7.76	7.37	8.76	26.31	0.04
Hainan	17.00	0.46	1.00	7.04	9.73	9.38	6.84	0.06
Chongqing	31.61	1.57	1.20	31.48	36.68	19.27	70.41	0.36
Sichuan	22.97	1.67	1.29	20.62	26.31	13.38	53.37	0.94
Guizhou	9.63	0.59	1.49	9.89	4.38	8.17	25.09	0.25
Yunnan	13.80	0.80	1.03	7.18	9.63	3.56	10.73	0.38
Tibet	6.34	0.30	0.39	2.23	1.36	7.26	0.77	
Shaanxi	46.62	2.18	1.31	22.69	75.33	9.66	67.82	4.01
Gansu	17.75	1.22	1.01	7.15	26.69	2.06	17.51	1.91
Qinghai	13.39	0.48	0.74	5.06	5.25	4.63	11.79	1.94
Ningxia	27.87	0.88	1.52	7.96	6.80	3.22	9.91	0.12
Xinjiang	19.53	0.56	1.09	9.19	9.42	0.87	2.57	0.03

Source: National Bureau of Statistics, Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2016*; National Bureau of Statistics, *China Statistical Yearbook 2016*; National Bureau of Statistics, National Development and Reform Commission, Ministry of Science and Technology, *China Statistical Yearbook on High-Technology Sector 2016*; Institute of Scientific and Technical Information of China, *China S&T Papers Statistics and Analysis 2015*; General Administration of Customs.

Explanatory Notes to Major Statistic Indicators

Science and Technology Activities refer to organized and systemic activities that are in close relation to the production, development, transmission and application of science and technology knowledge in fields like natural science, engineering technology, medical science, agricultural science, social sciences and the humanities. Science and technology activities are divided into three types, i.e. research and development activities, application activities of research and development achievements, and science and technology service activities.

Research and Development Activities, or briefly R&D activities, refer to systemic and innovative activities conducted in the science and technology field to increase the aggregate of knowledge and create new applications for such knowledge. R&D activities include basic research, applied research and experimental development, with the former two called "science and research activities".

Basic Research refers to experimental or theoretic work conducted to acquire new knowledge about the fundamental principles of phenomena and observable facts (and reveal the essence and motion law of things and have new findings and theories). It does not aim for any special or specific application or utilization. The main form of its fruits is science papers and works.

Applied Research refers to innovative research conducted to acquire new knowledge, but mainly aims for a certain special purpose or target. Applied research is a new (theoretic) method or way of identifying the possible purposes of basic research fruits or realizing the predetermined target of exploration. The main form of its fruits is science papers, works, theoretic models or invention patents.

Experimental Development refers to systemic work conducted, based on existing knowledge acquired from basic research, applied research and practical experience, to produce new products, materials and devices, build new processes, systems and services, and make fundamental improvements to them. The main form of its fruits is patents, proprietary technology, product prototypes having the basic characteristics of new products, or original prototypes having the basic characteristics of new devices. In the field of social sciences, experimental development refers to a process that turns knowledge acquired from basic research and applied research into a feasible plan (including demonstration projects for examination and evaluation). In contrast, the humanities domain has no experimental development activities.

Science and Technology (S&T) Personnel refer to those who are directly engaged in science and technology activities, manage science and technology activities, or provide direct services for such activities. They do not include personnel whose aggregate working hours in science and technology activities accounts for 10% and below of their annual working hours.

a. Personnel directly engaged in science and technology activities include research personnel, engineering technology personnel, skilled workers and other personnel in the research rooms, labs, technology development centers and semi-works (bases) of government research institutes, higher education institutions, enterprises of various types and public institutions; personnel who do not work in above institutions but are included in science and technology projects (subjects); postgraduate students engaged in paper design.

b. Personnel who manage and provide direct services for science and technology activities include heads of science and technology work in government research institutes, higher education institutions, enterprises of various types and public institutions; and personnel engaged in planning, administration, personnel matters, finance, material supply, equipment maintenance and data management for science and technology activities, but exclude those who provide indirect services like security personnel, health care personnel, drivers, plumbers, cleaners and those providing catering services.

Research and Development (R&D) Personnel refer to personnel engaged in the research, management and supporting work of R&D projects (subjects), including members of projects (subjects), management personnel and auxiliary personnel who provide direct services. By the amount of annual working hours, R&D personnel consist of full-time personnel and part-time personnel. Full-time personnel refer to those whose working hours in R&D activities account for 90% and above of their total annual working hours; part-time personnel refer to those whose annual working hours in R&D activities account for 10% to 90% (not including 90%) of their total annual working hours. Full-time equivalents of part-time personnel refer to part-time personnel who are converted to full-time personnel by workload. For instance, if there are 3 part-time persons whose annual working hours in R&D activities are 20%, 30% and 70% of the total respectively, their full-time equivalents are 0.2+0.3+0.7=1.2 person-years. The number of R&D personnel, by full-time equivalents, refers to the sum of full-time persons and full-time equivalents of part-time persons converted by workload. For instance, if there are 2 full-time persons and 3 part-time persons (whose annual working hours in R&D activities are 20%, 30% and 70% of the total respectively), the full-time equivalents are 2+0.2+0.3+0.7=3.2

person-years.

R&D Researchers refer to personnel engaged in the conception or innovation of new knowledge, products, processes, methods and systems, and senior management personnel in R&D projects (subjects) or institutions. R&D researchers usually have an intermediate title or a doctoral degree. PhD candidates engaged in R&D activities are regarded as R&D researchers.

Intramural Expenditures on R&D Activities refer to the actual expenditures of institutions on R&D activities (basic research, applied research, and experimental development). These expenditures include direct expenditures on R&D projects (subjects) and indirect expenditures on R&D management and services, R&D-related infrastructure, outsourcing and processing. They do not include expenditures on production activities, loan repayment and expenses paid to external institutions that jointly or independently undertake R&D activities.

Government Research Institutes refer to research institutions above the county level, including those in fields like natural sciences, technology, social sciences, the humanities, and technology information and literature.

The Number of Projects (Subjects) refers to the number of ongoing science and technology projects (subjects) built in the present year or previous year, including those completed or announced aborted but excluding those outsourced by external institutions.

Full-Time Equivalents of Subjects (Projects) Personnel refer to the sum of various personnel who have participated in subjects (projects) in a year, calculated based on the method of full-time equivalents. Method of statistics: convert the part-time personnel of subjects (projects) to full-time equivalents and then add the number of full-time personnel.

Internal Expenditures on Projects (Subjects) refer to the actual expenditures of investigated institutions on the research, trial and production of projects (subjects). They include labor costs, other current expenses, purchase or construction of fixed assets, and outsourcing and processing fees, and do not include expenditures paid to external institutions for independently or jointly undertaking projects (subjects).

S&T Papers refer to original science and research fruits published in academic journals and should meet three conditions: research fruits published for the first time; the conclusions and experiments of the author able to be repeated and verified by his peers; able to be applied by the science and technology field.

The Patent is an abbreviation for the patent right and refers to the exclusive right of ownership by the inventors or designers for a creation or an invention, granted by the patent office after due process of assessment and approval in accordance with the *Patent Law.* Patents have three types, i.e. inventions, utility models and industrial designs. Inventions refer to new technical proposals to products or methods or their modifications. Patented utility models refer to new and practical technical proposals on the shape and structure of products or the combination of both. Industrial designs refer to aesthetic and industrially applicable new designs for the shape, pattern and color of products or their combinations.

Resident Patent Applications and Non-resident Patent Applications are two types of patent applications based on the identity of the applicant (legal person or natural person). Patent applications from Mainland China, Hong Kong, Macau and Taiwan are regarded as domestic applications, and others are non-resident applications.

Service Inventions and Non-Service Inventions: Invention patents can be divided into service inventions and non-service inventions based on the patent application right and ownership of patent right. Service inventions refer to innovations and creations made in the implementation of institutional tasks or by using the material conditions of an institution, and their patent application right and ownership of patent right belongs to the institution. They include innovations and creations made in the implementation of institutional work; innovations and creations made outside the implementation of institutional tasks; innovations and creations made within one year after resignation, retirement or transfer of work and related with former institutional work or assigned tasks. Non-service inventions refer to innovations and creations made outside one's work and the right of patent application belongs to the inventor or creator. After the application's approval, the inventor or designer becomes the patentee.

Triadic Patents refer to invention patents filed at the European Patent Office (EPO), the Japan Patent Office (JPO) and the United States Patent and Trademark Office (USPTO) at the same time.

High-Technology Sector refers to manufacturing industries with a high R&D intensity (ratio of R&D expenditure to revenue from principal business) in the national economy, including the six categories of pharmaceutical manufacturing, aircraft and spacecraft and equipment manufacturing, electronic and communication equipment manufacturing, computer and office equipment manufacturing, medical equipment and measuring instrument manufacturing, and information and chemical products manufacturing.

Hi-Tech Products: In accordance with *The Import and Export Catalogue of Chinese High and New Technology Products*, hi-tech products include nine classifications of products, i.e. computer and communication technology, life sciences and biotechnology, electronic technology, computer integrated manufacturing system, aerospace technology, photoelectric technology, biotechnology, materials technology and others.

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