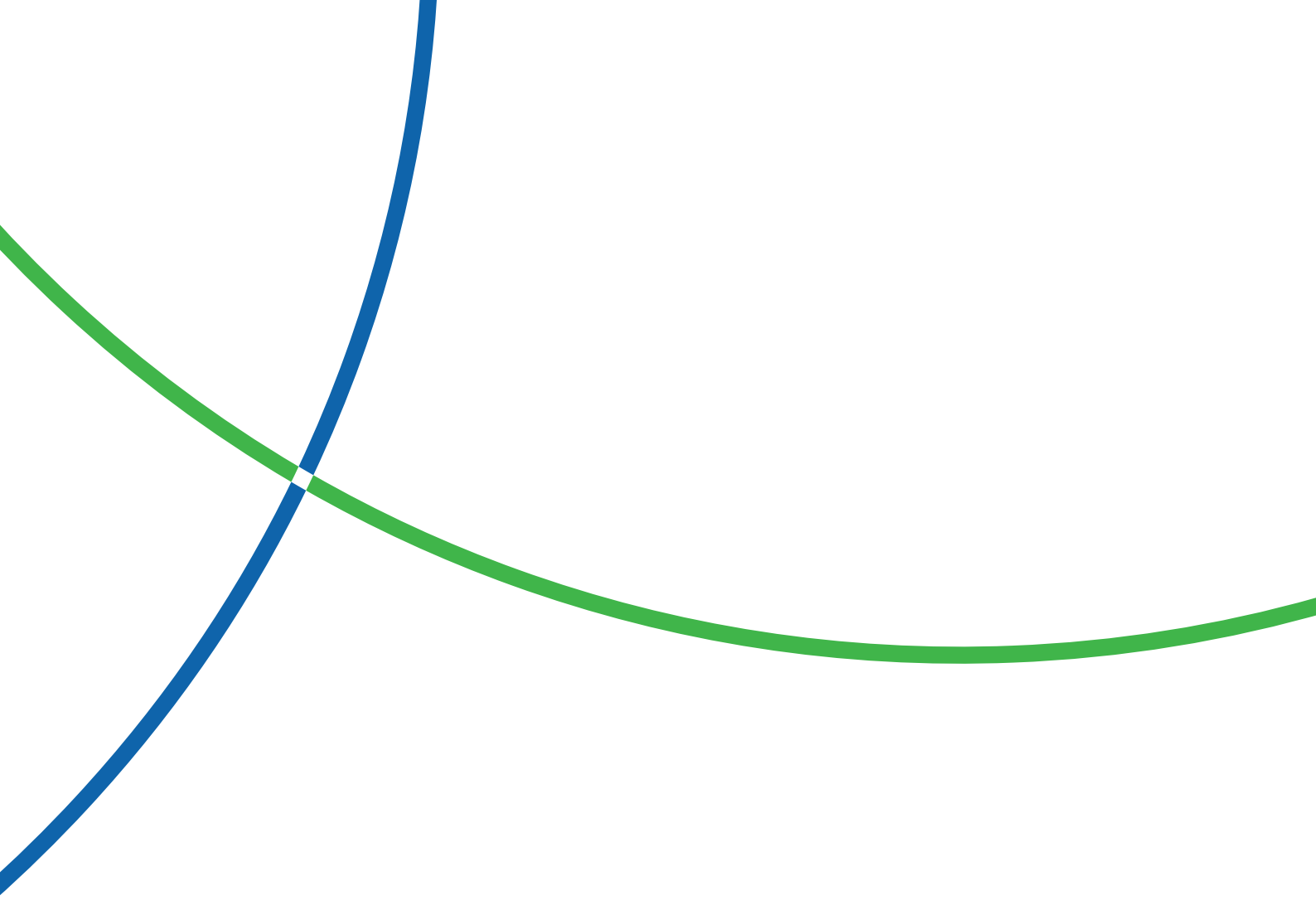
国家科技评估中心
National Center for S&T Evaluation

Clarivate Analytics | 科睿唯安

China's International Scientific Research Collaboration

– A Bibliometric Analysis



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Abbreviations

Abbreviation	Glossary
collab. pub.	international collaborative publications
int. collab.	international scientific research collaboration
11-5	11th Five-Year Plan Period
12-5	12th Five-Year Plan Period
HCP	Highly Cited Papers
CNCI	Category Normalized Citation Impact
OECD	Organization for Economic Cooperation and Development
BRICS	Brazil, Russia, India, China, South Africa
OBOR	One Belt One Road
WoS	Web of Science

Executive Summary

With the economic globalization, the internationalization of science and technology has become a major trend in the world today. Fueled by the rapid economic growth and increasing market opening, China's scientific research and innovation landscape has been undergoing a steady process of internationalization. Since 2006, the Chinese central government and local authorities have been actively promoting the international collaboration in science and technology by putting policies in place and strengthening international cooperation mechanisms, increasing R&D inputs and mobilizing the scientific community and social forces to foster international cooperation.

The proportion of R&D expenditures in China's GDP increased from 1.42% in 2006 to 2.1% in 2016. The proportion of publications funded by domestic expenditures in international collaborative publications (collab. pub.) increased from 31.6% during the 11th Five-Year Plan period (11-5) to 65.2% during the 12th Five-Year Plan period[1] (12-5). Due to the favourable policies, continuous inputs, gradual increase of the mobility of R&D talents within and beyond China, and constant enhancement of independent R&D capability, China's international scientific research collaboration (int. collab.) has undergone both qualitative and quantitative transformations over the past decade[2]. Therefore, a timely understanding of the current trend of China's int. collab. can help decision-makers allocate national scientific and technological resources and help researchers carry out international collaboration in a more efficient way against the background of scientific and technological

1 The 11th Five-year Plan Period refers to 2006-2010 while the 12th Five-year Plan Period refers to 2011-2015.
2 In this Report, "the past decade" or "the past 10 years" refers to 2006-2015.

internationalization, and further lead to the rapid improvement of China's scientific and technological innovation.

Against this background, the National Center for Science & Technology Evaluation and Clarivate Analytics jointly analyzed the current state and the trend of China's int. collab. using bibliometrics and network analysis based on publications between 2006 and 2015 in the Web of Science database. This study analyzes collaborating countries, domestic and international institutions, regions and international organizations, and research fields, as well as large-scale int. collab. By combining the results of quantitative analysis and the experts review, this report reveals the scale, activity, and quality of China's int. collab. Moreover, the report investigates the extent to which China's researchers took a leading position in international collaboration, as well as examining the existing int. collab. network.

Through the above analysis, the report attempts to provide answers to the following research questions: What is China's position in the current int. collab. network? What trends characterize the collaboration with developed countries and emerging economies? Which role has China played in the collaboration network with major world regions or international organizations? Which international research institutions collaborate with China more closely? Which Chinese institutions are most active in int. collab.? What are the main characteristics of different research fields in int. collab.? And finally, how is China engaged in multi-institution and multi-author collaborations? Those data, analysis and conclusions will effectively support decision-making in China's policies on international scientific and technological innovation and collaboration.

From 2006 to 2015, the scale and scope of China's int. collab. gradually expanded. The quality of collaboration continuously improved and China's leading position in the collaboration constantly enhanced. China's collab. pub. in 2015 reached 71,000 (18.6% of the world total in the same year), 4.4 times higher than that in 2006. One hundred and sixty-one countries and regions had scientific collaboration with China during the 11-5 and the figure increased to 188 during the 12-5. The centrality of China's int. collab. increased from the 10th during the 11-5 to the 7th during the 12-5. Research conducted by Chinese researchers has attracted more attention in the international society than before and China has become an important partner for other countries in the int. collab. network.

The citation impact of China's collab. pub. was also improved and well above the average citation impact of China's overall publications and the average citation impact of world's collab. pub. The percentage of Highly Cited Papers (HCP) in the collab. pub. co-authored by China and key countries was significantly higher than the global baseline, demonstrating the notable citation impact of the collaborative research. The high percentage (over 40%) of Chinese reprint authors in the HCP also shows that in the high-quality int. collab. with Australia, Singapore and the US, Chinese researchers played a relatively leading role. While cooperating with the key countries, Chinese researchers participated in equal dialogues and collaboration to different extends. Substantial evidence shows that international collaboration has played a prominent role in improving the academic influence of China's scientific research

and has helped China further integrate into the global scientific and technological collaboration network.

Regional analysis of China demonstrates that Beijing, Shanghai and Jiangsu Province produced the greatest numbers of collab. pub. For domestic institutions, the Chinese Academy of Sciences is the biggest producer of both collab. pub. and HCP. Peking University, Zhejiang University, Shanghai Jiao Tong University, Tsinghua University and Fudan University are in the second tier based on the number of collab. pub. The high percentages of collab. pub. of Peking University and Beijing Normal University demonstrate that they are more active in international collaboration. The percentages of HCP among the collab. pub. for Harbin Institute of Technology, University of Science and Technology of China, Peking University and Tsinghua University are all over 3.0%, well above 1.0%, the global baseline. In terms of research fields, the collab. pub. of Chinese key institutions are mainly from four ESI fields — Physics, Clinical Medicine, Chemistry, and Engineering.

In the past decade, both the scale and impact of China's collaboration with international research institutions deepened. The data show that Chinese and American research institutions had the closest collaboration. The French National Centre for Scientific Research (CNRS) and institutions affiliated to the United States Department of Energy (DOE) had the largest-scale collaboration with China. Publications co-authored by China and international institutions had a higher citation impact, and the percentage of HCP deriving from these collaborations was also well above the global baseline. In terms of collaboration by research fields, China's collaboration with key international institutions was mainly distributed in five ESI fields — Physics, Chemistry, Engineering, Materials Science, and Clinical Medicine.

China has attached high importance to scientific and technological collaboration with major world regions and organizations around the world. Analysis demonstrated that during the ten-year period, both the scale and the impact of China's scientific collaboration with relevant regions and organizations continuously enhanced. Statistics show that China's scientific collaboration with OECD countries, the European Union and the Asian-Pacific Region were the top three in terms of scale. Both the scale and quality of the scientific collaboration between China and OECD countries steadily improved during the 12-5. In particular, the scientific collaboration between China and the US was the largest in scale, and China replaced the UK and Germany to become the No. 1 partner of the US in terms of scientific collaboration during the 12-5. At the same time, the scale and the impact of China's scientific research collaboration with the other BRICS countries greatly improved. The collaboration between the five countries became more and more active, and a closer, more comprehensive and solid partnership in scientific collaboration was formed.

In the past decade, the scientific collaboration between the "One Belt One Road" (OBOR) countries witnessed a diversified development trend. More and more countries participated in collaborative researches. The collaboration network became more and more intensive and the international collaboration framework

between the OBOR countries started from scratch and then prospered. The scale, scope and closeness, as well as the influence and quality of China's collaboration with the OBOR countries, all drastically increased during the 12-5 compared to the previous five years. China is now playing a more and more significant linking role in the OBOR scientific collaboration network.

The accelerated development in China's int. collab. has led to a large increase in the scale and level of international research collaboration in various research fields. In the past 10 years, the amount of collab. pub. in various research fields largely increased and the citation impact of collab. pub. was well above the overall citation impact of publications in these fields. China's Chemistry, Physics, Engineering, Clinical Medicine and Materials Science had the largest amount of publications as well as collab. pub. The percentage of HCP in collab. pub. of the above five research fields also far exceeded the global baseline.

The data also showed that international research collaboration contributed more in Engineering than in Chemistry in terms of producing HCP. By the measure of international collaborative HCP by research fields, Chinese researchers took a leading position (with over 50% reprint authors) in Engineering, Materials Science, and Chemistry. Meanwhile, China played a secondary role in Clinical Medicine (with only 19.1% reprint authors). All in all, int. collab. has provided a substantial impetus for the increase in the quality and influence of China's scientific research by research fields in the world. Chinese researchers are playing an increasingly important role in international collaboration in relevant research fields.

As the scientific research enterprise is becoming more complex, research activities tend to be carried out in coordination and collaboration, and large-scale int. collab. has become an indispensable research mode. Analysis shows that the US made the biggest contribution in multi-author and multi-institution publications in the world and China ranked 9th in this regard. China made contributions to more than half of the world's multi-author and multi-institution publications and 89.4% of such publications are from Physics. Among Chinese research institutions, the Chinese Academy of Sciences and University of Science and Technology of China produced the greatest numbers of multi-author and multi-institution publications, while the citation impact of multi-author and multi-institution publications from Shanghai Jiao Tong University was the highest.

During the Thirteenth Five-Year Plan period [3], international scientific and technological collaboration has become an important part of China's scientific and technological innovation activities. China's international scientific and technological collaboration is at a stage of rapid development and the scale, activity, quality and influence of int. collab. have been constantly increasing. Chinese researchers are playing a more and more important linking or leading role in int. collab. in some regions and research fields. At the same time, the internal motivation

3 Thirteenth Five-Year Plan Period refers to 2016-2020.

for excellence of the scientific community also served as a driving force for scientists to carry out international collaboration from bottom to top. China is trying to build a new scientific and technological innovation mode that centers on the nation's independent R&D ability but also integrates openness and collaboration. Pooling international and domestic resources and attracting resources for innovation such as talented researchers, technology and funds from across the world in an all-dimensional and multistoried manner through int. collab. will definitely be conducive to the implementation of the innovation-driven development strategy and finally the realization of the Chinese Dream.

Introduction

In the face of economic globalization, internationalization of science and technology has become a major development trend in today's world. Developed countries are actively implementing the strategy of open innovation and emerging economies are becoming increasingly significant players in global scientific and technological collaboration. An increasing number of countries are actively integrating themselves into the global scientific collaboration network and encouraging domestic institutions and researchers to participate in international collaboration drawing resources from bilateral and multilateral funding mechanisms. Solving cross-border and global scientific issues requires international joint research. The pursuit of excellence in research also drives scientists from various countries to conduct int. collab. Multiple factors are driving the development of global research collaboration in intensity and scale.

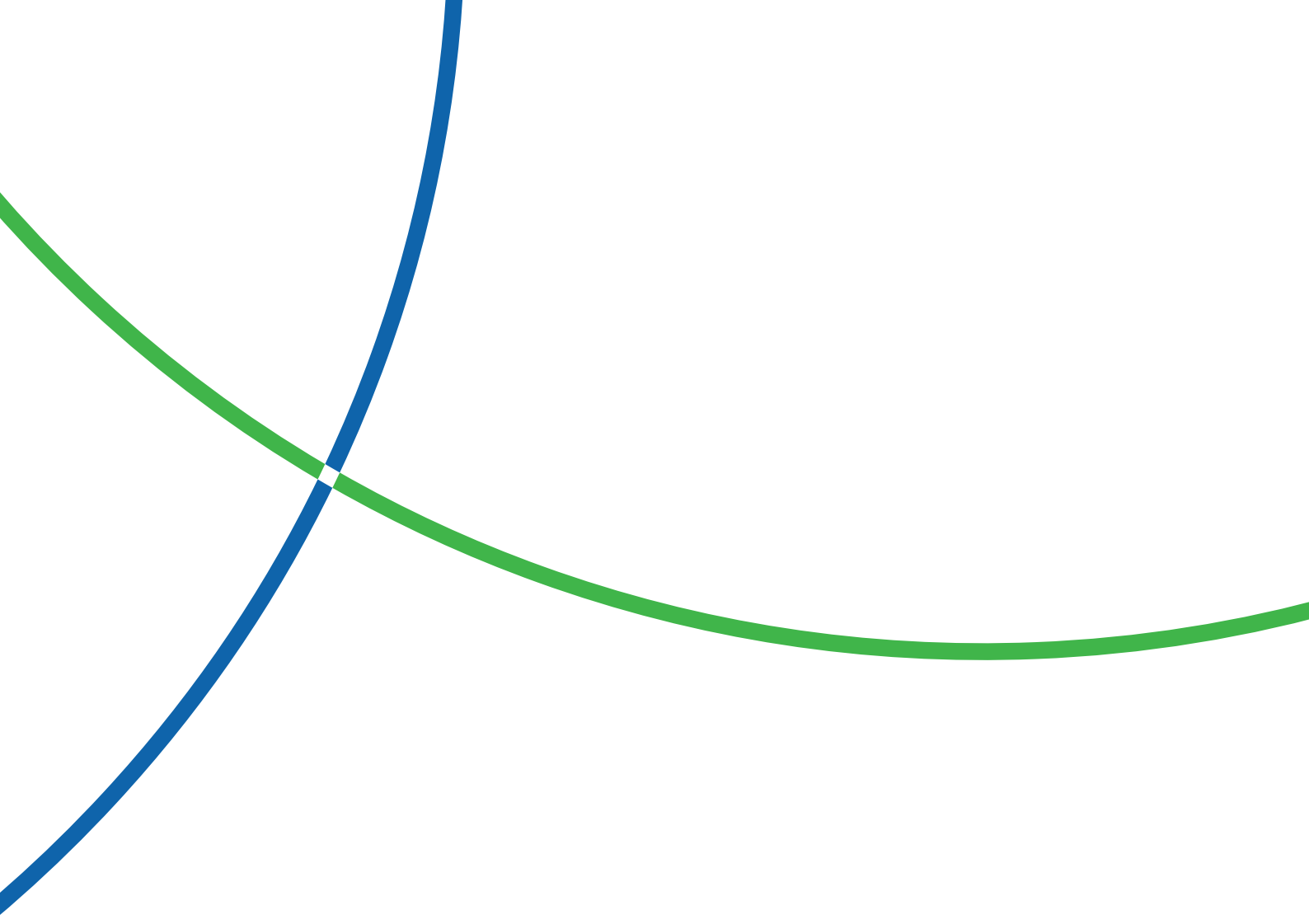
With rapid economic growth and openness, the scientific and technological innovation in China is also going international. The Outline of the National Medium and Long-term Science and Technology Development Program (2006-2020) specified that "enlarging international and regional scientific and technological collaboration and exchanges is an important policy measure." The International Science and Technology Innovation and Collaboration Program During the Thirteenth Five-Year Plan Period highlighted that "innovation should be designed and promoted with a global perspective and a new era be intitiated for innovation in an all-dimensional and multifaceted way of thinking, objectives and task deployment." With the gradual deepening of collaboration, an effective methodology should be applied in the analysis of the foundation and status quo of China's int. collab., its position in the collaboration network with key countries, and collaboration results and achievements.

According to the literature, bibliometrics and network analysis are commonly applied to conduct quantitative analysis of int. collab. by countries, regions, research fields or disciplines and institutions. Qualitative analysis includes strategies, policies and collaboration model analysis. The Statistical Data of Chinese S&T Papers regularly released by the Institute of Scientific and Technical Information of China covers the bibliometric analysis results on the distribution of international publications by country (region) and research field as well as multi-author publications. The National Science Library, the Chinese Academy of Sciences conducted bibliometric analysis of the international collaboration in Chemistry and Medicine. The Royal Society combined the bibliometric data with expert review and conducted comprehensive analysis on the current situation, the motives and effectiveness of int. collab. around the world in the report *Knowledge, Networks and Nations: Global Scientific Collaboration in the 21st Century.*

In this report, based on the collab. pub. published between 2006 and 2015, the National Center for

Science & Technology Evaluation and Clarivate Analytics collaborated to integrate bibliometric analysis with the reviews of research and management experts to reveal the current state and trend of China's int. collab. with countries, domestic and international institutions, world regions and international organizations, and research fields, as well as large-scale int. collab. in these ten years. In-depth analysis was further dedicated to the scale, activity, quality (citation impact, reprint author), centrality of China's international research collaboration and the existing int. collab. network. This report made some innovative explorations in indicator design and the width and depth of analysis. For example, the report put forward the centrality of countries in the international collaboration network to evaluate the general position of a country's scientific collaboration; and the percentage of publications with reprint authorship in HCP was used to evaluate the leading role of Chinese researchers in international collaboration.

It's worth noting that bibliometric analysis is only one of the methodologies for the evaluation of int. collab., and collab. pub. can only reflect one side of China's current situation in international research collaboration. This report mainly applied bibliometrics to analyze int. collab. and it is by no means free of limitations. It is hoped that this report can help break the ice and attract more professionals engaged in int. collab. to participate in relevant researches and evaluations so that more robust and comprehensive evidences and information will be provided to support the decision-making in policies regarding international scientific innovation and collaboration in China.



Chapter I Methodology

Based on collab. pub., bibliometrics is used in this report to study int. collab. from the perspective of collaborating countries, regions and international organizations, institutions, and volume of publications as well as their citation impact. The data sources in this report are Web of Science (WoS) publications published by China between 2006 and 2015. Only publications with document type *Article* and *Review* are considered. The following indicators are used in the analysis:

Collab. Pub. : WoS publications co-authored by two or more countries and/or regions. In this report, China's collab. pub. refer to the publications co-authored by researchers from Mainland China and overseas. The whole-counting method is used in this report, i.e., every collaborative publication is considered as one whole publication in any of the countries or regions involved in the collaboration.

Number of publications: the number of publications indexed in the three citation indexes—SCI, SSCI and A&HCI of the WoS Core Collection and categorized as *Article* or *Review.*

Citations: the number of times cited by publications from WoS Core Collection.

Category Normalized Citation Impact (CNCI): the relative citation performance of a publication compared with peer publications. This indicator eliminates the impact of Research Field, time of publication and document type on the citations of the publications and is a normalized indicator independent from the volume of the publications. If the actual citation rate of a paper is C, the CNCI of this paper:

$$CNCI = \frac{C}{reference}$$

The reference is the average citation rate of all publications with the same year of publication, Research Field and document type. If the CNCI value is 1, the citation performance of the paper is on a par with the global baseline. This indicator is also called "citation impact" or "impact" in this report.

Highly Cited Papers (HCP): SCI and SSCI papers whose citations are among top 1% of publications with the same publication year and Research Field.

Percentage of HCP: the number of internationally collaborative HCP divided by the total number of collaborative publications. If the number of HCP in collab. pub. is A and the total number of collab. pub. is B, the percentage of HCP is:

$$H\_index = \frac{A}{B}$$

Percentage of collab. pub.of a Research Field in all Research Fields: the number of collab. pub. in a Research Field divided by the total number of international publications in all Research Fields. If the number of collab. pub. in a Research Field is G, and the total number of collab. pub. in all Research Fields is N, the indicator value is $\frac{G}{N}$.

Percentage of collab. pub. within a Research Field: the number of collab. pub. in a Research Field divided by the total number of publications in the same Research Field. If the number of collab. pub. in a Research Field is G, and the total number of publications in the same Research Field is M,

the indicator value is $\frac{G}{M}$.

Centrality of int. collab. (hereinafter referred to as centrality): an indicator to measure the position and importance of a country in the int. collab. network. It is calculated as follows:

If the number of publications co-authored by country A and country B is P, the total number of collab. pub. of country B is *N*, *P/N* refers to the activity of country A among all the countries that country B collaborates with. The higher the value of *P/N* is, the higher country A's position is among country B's partners. Country A's centrality is obtained by summing *P/N* value over all A's partners.

Relative activity of international collaboration of a Research Field (hereinafter referred to as relative activity) [4]: the relative scale of a Research Field in a country's int. collab. is used to measure the relative activity of the Research Field in the country's int. collab. It is calculated as follows:

$$PAI_j = \frac{P_j / P_{wj}}{P / P_w}$$

P_j- The number of collab. pub. of a country in a Research Field

P_{wj} -The number of collab. pub. around the world in a Research Field

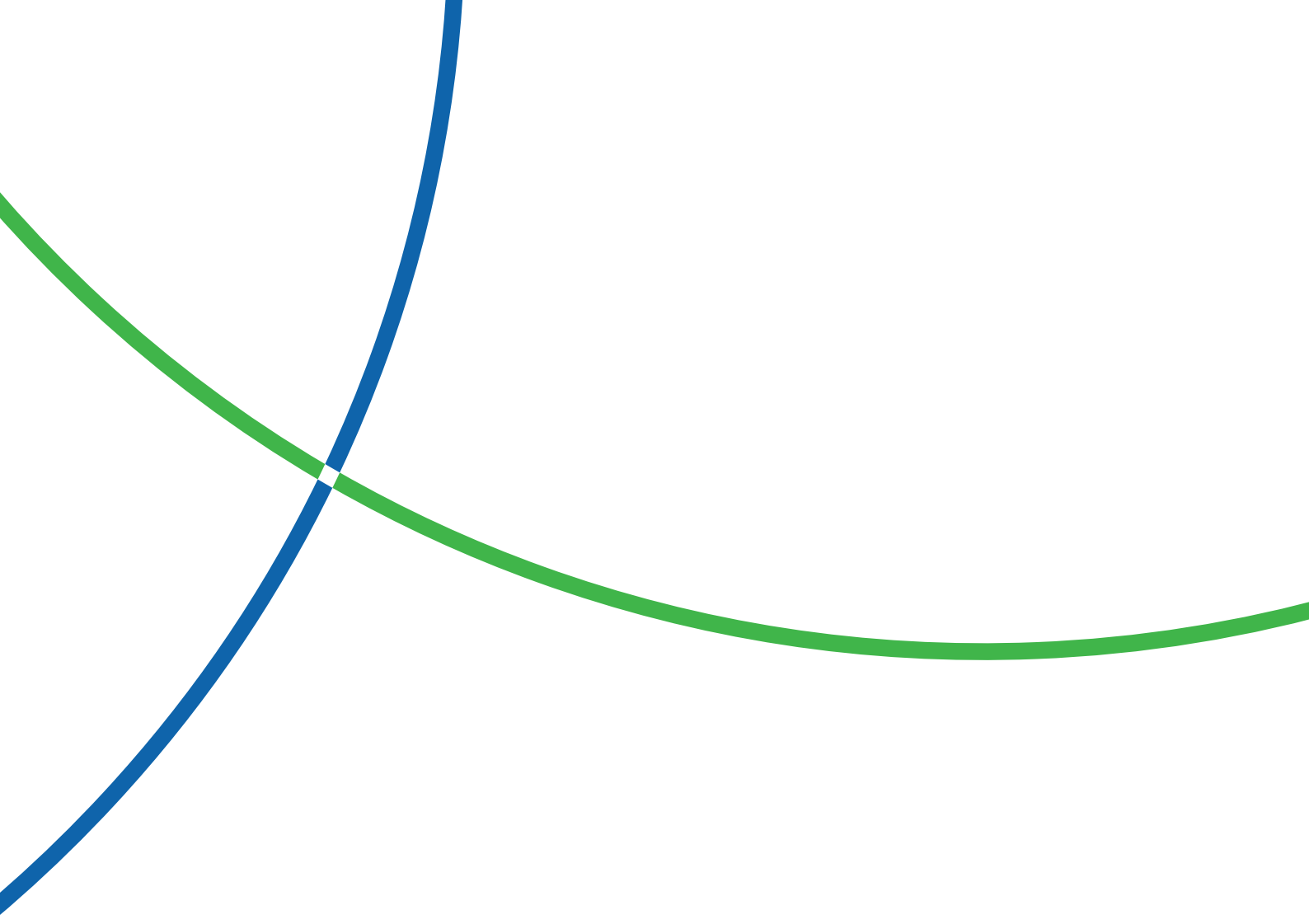
P- The total number of collab. pub. of a country

P_w-The total number of collab. pub. around the world

This indicator eliminates the impact of differences in the amount of collab. pub. among different Research Fields and therefore there is comparability among different Research Fields of the same country. If PAI>1, the international collaboration activity of the Research Field is higher than that of the whole country.

In this report, the number of collab. pub. is used to indicate the scale of int. collab.; the percentage of collab. pub. in all publications represents the activity of scientific collaboration; the citation impact of collab. pub. as well as number and percentage of HCP in the collab. pub. demonstrates the impact and quality of int. collab.; the percentage of HCP with reprint authorship demonstrates the role China plays in int. collab.

4 This indicator derives from *Ten Years of Chemistry: The World and China—Bibliometric Analysis Based on the 2001-2010 WoS Papers (2014)* authored by Yang Liying, et al.



Chapter II Scale and Impact of China's International Scientific Research Collaboration

Main Findings

Compared to the 11-5, global scientific research collaborations during the 12-5 were closer and the intensity and scale of cross-border research collaborations also expanded. The US still took an absolutely leading position in int. collab. China's scientific collaboration centrality increased from the 10th during the 11-5 to the 7th during the 12-5. With an absolute growth of about 1.4 in centrality, China grew the fastest among the top 20 countries in terms of international collaboration centrality. The position and importance of China's international research collaboration in global scientific collaboration rapidly increased, and China has become an important partner for various countries in the int. collab. network.

From 2006 to 2015, the scale of China's int. collab. saw a rather positive upward trend. The number of collab. pub. rocketed and the number in 2015 was 4.4 times that in 2006. Overall, 188 countries and regions carried out int. collab. with China during the 12-5, up from 161 during the 11-5. This demonstrates that China's int. collab. is becoming more and more active and that China is actively integrating into the global scientific collaboration network.

China's scale of int. collab. was behind Canada and ranked 6th in the world during the 11-5. However, during the 12-5, China's scale of int. collab. exceeded France and ranked 4th in the world. At the same time, China became the biggest collaborator of the US. Besides the US, China also had relatively large-scale and relatively close collaboration with Australia, the UK and Japan. From the perspectives of both collaboration scale and position in the int. collab. network, China's status of int. collab. saw a notable rise during the past decade.

Over the past 10 years, the citation impact of China's collab. pub. also constantly improved and was well above the average citation impact of China's overall scientific publications as well as the global baseline. International collaboration has played a significant role in enhancing the academic impact of China's scientific research in the world. Among the HCP co-authored by China and Australia, Singapore and the US, the percentage of reprint authors from China was over 40%. In general, Chinese researchers were gradually playing a leading role in high-quality int. collab. conducted with some key countries.

At the same time, compared with the US, France and the UK, which had strong scientific research capabilities, China's activity in int. collab. was still relatively low, and there is still room for improvement in terms of academic impact of collab. pub.

This chapter analyzes the changes in the global scientific collaboration network, the position, status and importance of China in the int. collab. network, the overall scale of China's int. collab. and the scale of collaboration with key countries, as well as the impact of scientific collaboration based on the collaborative publications between 2006 and 2015.

2.1 Centrality of International Scientific Research Collaboration

Centrality of int. collab. (centrality) is an indicator used to measure the status and importance of a country in the global scientific research collaboration network. Forty countries[5] with the largest numbers of publications between 2006 and 2015 were selected to illustrate the global collaboration network. The current situation of global scientific research collaboration and China's relation with relevant countries in terms of scientific research collaboration were analyzed by their centralities.

Table 2-1 shows the centrality of the 40 countries based on the collaborative publications between 2006 and 2015. The centrality of the US in global scientific collaboration network is much higher than that of the other countries, which demonstrates that the US is currently the world center for scientific research. The centrality of the UK, Germany and France was also relatively high, which shows that those countries are important nodes in the global scientific collaboration network.

Table 2-1 Int. Collab. Centrality of 40 Countries

Country	Centrality	Country	Centrality	Country	Centrality	Country	Centrality
US	12.0	Switzerland	2.3	South Korea	1.2	Mexico	0.7
UK	6.7	Sweden	2.2	Finland	1.2	South Africa	0.7
Germany	6.5	Japan	2.1	Czech	1.1	Romania	0.7
France	4.7	Belgium	1.7	Norway	1.1	Ireland	0.6
Italy	3.8	Russia	1.6	Greece	1.1	Iran	0.6
Spain	3.5	Poland	1.5	Portugal	1.1	New Zealand	0.6
China	2.8	Brazil	1.5	Turkey	0.9	Egypt	0.6
Canada	2.8	Austria	1.4	Hungary	0.9	Argentina	0.6
Netherlands	2.8	Denmark	1.4	Israel	0.8	Malaysia	0.5
Australia	2.5	India	1.4	Saudi Arabia	0.7	Singapore	0.5

Table 2-2 shows the changes in the global scientific collaboration centrality of the top 20 countries during the 11-5 and 12-5. The centrality of the 20 countries all increased to some extent during the two five-year periods. In particular, China's centrality increased from the 10th during

5 The amount of collab. pub. of the 40 countries accounts for 95.4% of the world's total in the same period and therefore the scientific collaboration between the 40 countries reflect the current picture of global scientific collaboration.

the 11-5 to the 7th during the 12-5. With an absolute growth of about 1.4 in centrality, China grew the fastest among the top 20 countries; with a relative growth of 70.0%, China was only behind Brazil. The position and importance of China's int. collab. in global scientific collaboration rapidly increased and China has become an important partner for various countries in the int. collab. network.

Table 2-2 Changes in the Int. Collab. Centrality of the Top 20 Countries

Country	2006-2010 Centrality	2011-2015 Centrality	Absolute Growth (%)	Relative Growth (%)
US	11.9	12.1	0.2	1.7
UK	6.3	7.0	0.7	11.1
Germany	6.1	6.7	0.6	9.8
France	4.3	4.9	0.6	14.0
Italy	3.1	4.2	1.1	35.5
Spain	2.7	3.9	1.2	44.4
China	**2.0**	**3.4**	**1.4**	**70.0**
Netherlands	2.3	3.0	0.7	30.4
Australia	2.0	2.9	0.9	45.0
Canada	2.6	2.9	0.3	11.5
Switzerland	1.9	2.7	0.8	42.1
Sweden	1.9	2.4	0.5	26.3
Japan	2.0	2.1	0.1	5.0
Belgium	1.5	1.9	0.4	26.7
Poland	1.1	1.8	0.7	63.6
Brazil	1.0	1.8	0.8	80.0
Russia	1.2	1.7	0.5	41.7
Austria	1.0	1.7	0.7	70.0
Denmark	1.1	1.6	0.5	45.5
India	1.1	1.6	0.5	45.5

2.2 International Scientific Research Collaboration Network

Figure 2-1 and Figure 2-2 show the collaboration scale and network[6] among countries with more than 30,000 collab. pub. during the 11-5 and 12-5 respectively.

6 In Figures 2-1 and 2-2, if the number of collaborative publications coauthored by two countries is above 20,000, there is a straight line between the two countries. The size of circle is in proportion to the number of collab. pub. of a country and the width of the line is in proportion to the number of collaborative publications coauthored by two countries.

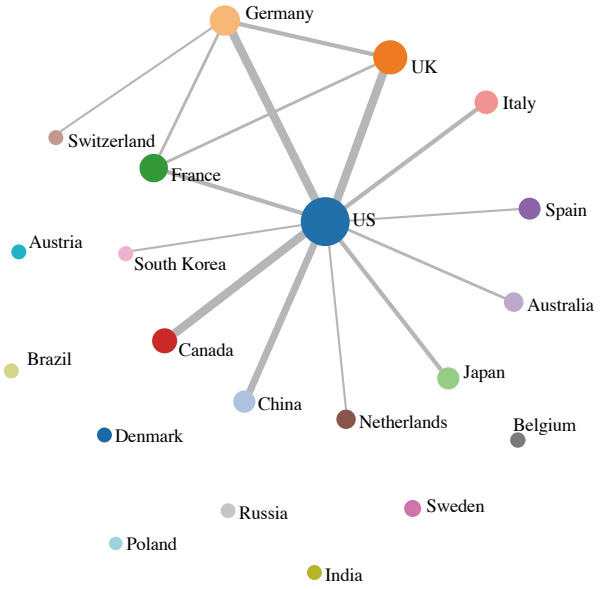


Figure 2-1 Int. Collab. Network during the 11-5

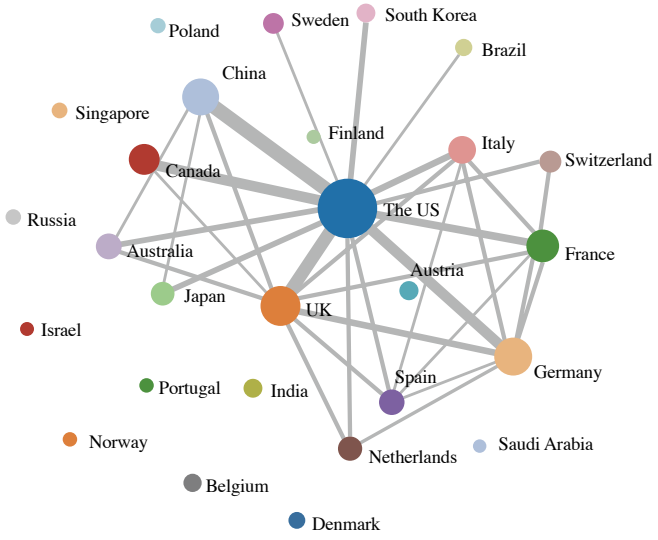


Figure 2-2 Int. Collab. Network during the 12-5

As shown in the above figures, compared with the international collaboration network during the 11-5, the collaboration scale during the 12-5 clearly expanded and the collaboration network became more intensive. Meanwhile, there was a diversified development trend in int. collab. and the status of several countries in the collaboration network strengthened. The number of countries with more than 30,000 collaborative publications increased from 21 during the 11-5 to 27 during the 12-5. The US remained the center of the global scientific collaboration network.

China's scale of int. collab. was behind Canada

and ranked 6th in the world during the 11-5. However, during the 12-5, China's scale of int. collab. exceeded that of France and rose to 4th in the world. At the same time, China became the biggest collaboration partner of the US. As shown in Figures 2-1 and 2-2, besides the US, China also had close collaboration with Australia, the UK and Japan. From the perspectives of both collaboration scale and position in the collaboration network, China's status in int. collab. saw a notable rise during the past decade.

2.3 Overall Scale and Activity of China's International Scientific Research Collaboration

From 2006 to 2015, the number of China's publications indexed in the WoS witnessed a strong momentum of growth. The number of publications in 2015 was 278,000, about 3.5 times that of 2006 and the percentage of China's publications in the world total increased to 18.3% from 8.0% at the beginning of the 11-5. In the past decade, the number of China's collab. pub. also rapidly increased, up from about 16,000 (in 2006) to about 71,000 (in 2015). Figure 2-3 shows that the percentage of China's collab. pub. in the world's total was close to the percentage of China's overall publications in the world's total. This shows that China's int. collab. was more and more active during the past 10 years.

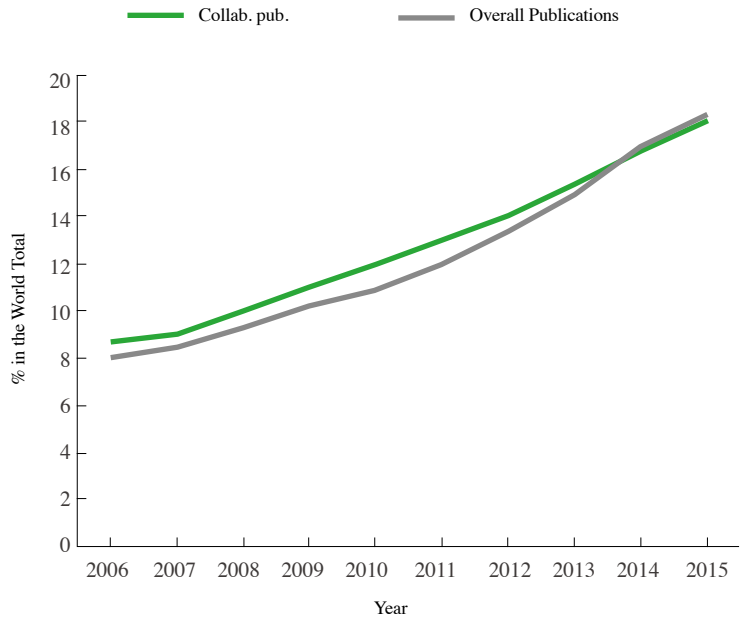


Figure 2-3 Percent (%) of China's Collab. Pub. and Overall Publications in Respective World Total

Figure 2-4 shows that compared with key countries[7] , China had the biggest growth rate in collab. pub. in the past 10 years. During the same period, among the top 10 countries with the most scientific publications, China used to be the last one in terms of collab. pub. and now is the 3rd largest country behind the US and the UK. The number of collab. pub. also shows that

7 Key countries refer to the 10 countries with the most publications in the world.

the number of countries and regions carrying out int. collab. with China increased from 161 during the 11-5 to 188 during the 12-5. This means that China's int. collab. scale dramatically increased and that China is actively integrating into the global scientific collaboration network.

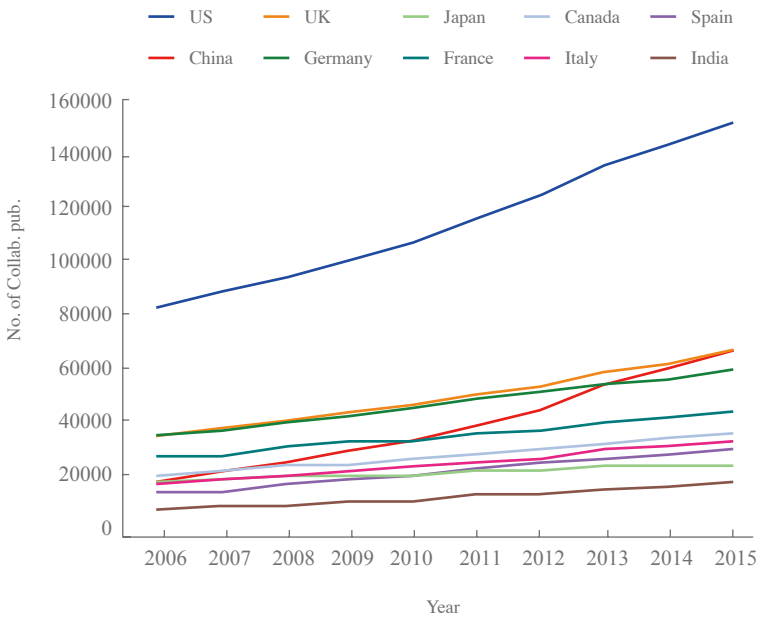


Figure 2-4 Trends of Collab. Pub. of Key Countries

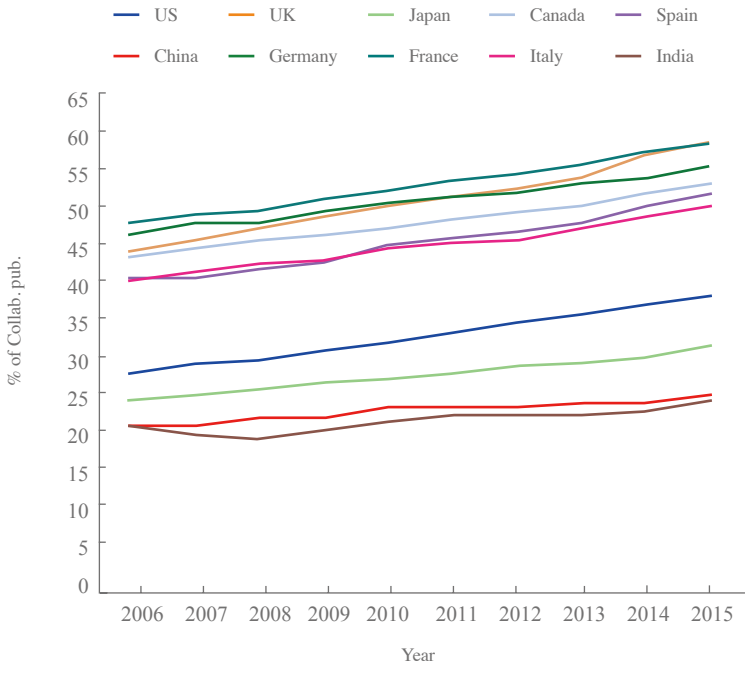


Figure 2-5 Percent (%) of Collab. Pub. in Key Countries

In terms of the percentage of collab. pub. in the total publications of a country, the percentages of the 10 countries all increased during the past 10 years, with similar growth rate. Figure 2-5 shows that the percentage of collab. pub. of France, the UK, Germany and Canada was relatively high. By 2015, among the top 10 countries, the percentage of collab. pub. of China (about 24.7%) was only slightly higher than that of India. This shows that China's current int. collab. activity still lagged behind key countries such as the US, France, the UK and Germany.

2.4 Scale of China's Scientific Research Collaboration with Key Countries

During the 11-5 and 12-5, for the top countries that collaborated most with China, the amount of collaborative publications with China all increased by a large margin. In particular, the biggest growth came from the US – up by more than 70,000, or 2.6 times. During the 11-5, only three countries, namely, the US, Japan and the UK, had over 10,000 collaborative publications with China; and the number increased to nine during the 12-5 (see Table 2-3). The Netherlands became one of the top 10 partners of China during the 12-5. The number of countries and regions with more than 1,000 collaborative publications with China increased from 18 during the 11-5 to 45 during the 12-5. This shows that the scale of China's scientific research collaboration with other countries continued to grow.

Table 2-3 China's Collab. Pub. with Its TOP 10 Partner Countries during the 11-5 and 12-5[8]

Country	2006-2010		2011-2015		Times of Growth in the No. of Collab. Pub.
	Collab. Pub.	Ranking	Collab. Pub.	Ranking	
US	48138	1	122775	1	2.6
UK	10669	3	25551	2	2.4
Australia	8085	6	22618	3	2.8
Japan	14342	2	21640	4	1.5
Canada	8814	5	19187	5	2.2
Germany	9324	4	19185	6	2.1
France	5799	7	11972	7	2.1
Singapore	5157	9	11111	8	2.2
South Korea	5449	8	10665	9	2.0
Netherlands	2596	11	6591	10	2.5

8 This table lists the top 10 countries according to the data of the 12-5. The two tables in this report which compare the data during the 11-5 and 12-5 both applied the same principal.

2.5 Impact of China's International Collaborative Publications

In the past decade, the category normalized citation impact (CNCI) of China's scientific publications continued to increase, which started to exceed the global average in 2011 and reached around 1.1 in 2015. Meanwhile, the citation impact of China's collab. pub. also constantly rose in the past 10 years (with an average of 1.5), obviously above the citation impact of the overall publications (represented by an average of 1.0) as well as the global baseline (see Figure 2-6). International collaboration has played a very active role in enhancing the academic influence of China's scientific research.

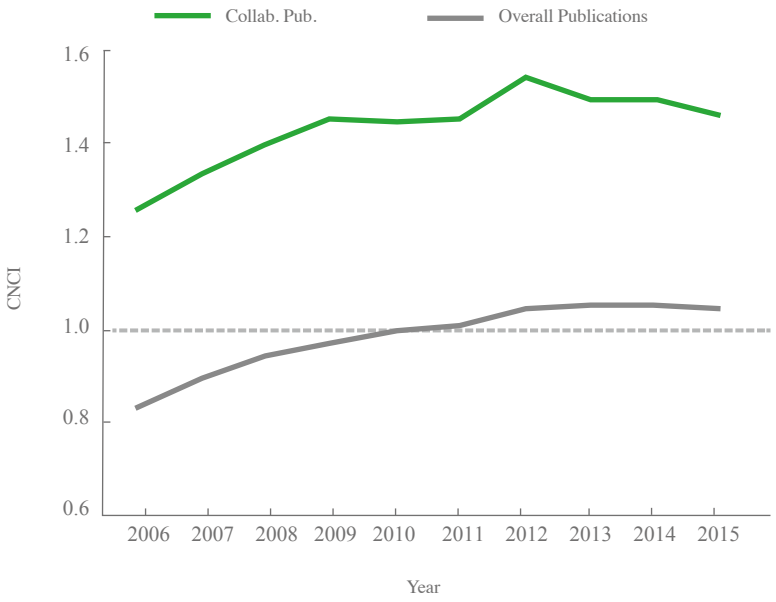


Figure 2-6 Citation Impact of China's Collab. Pub. and Overall Publications

Figure 2-7 shows that in the past 10 years, the CNCI values of key countries' collab. pub. saw an increase in general and was above the global baseline of 1.0. The CNCI values of collab. pub. in seven countries including Italy, Canada and the UK were notable—over 1.5 in 2015. The citation performance of collab. pub. in India, Japan and China was relatively low. The average citation performance of collab. pub. demonstrated that the academic influence of China's collab. pub. could still be improved.

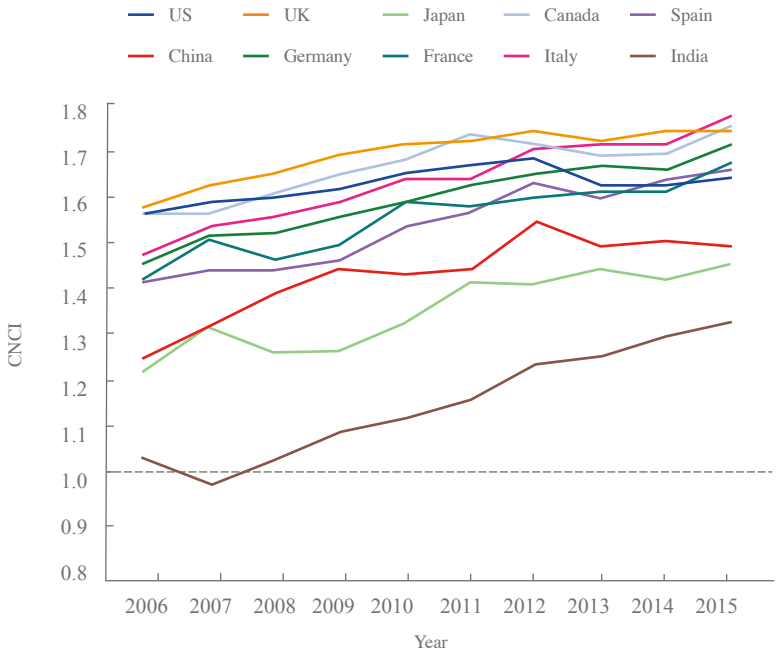


Figure 2-7 CNCI of Key Countries' Collab. Pub.

During the 11-5, the citation impact of publications co-authored by China and its top 10 partners already exceeded the global baseline and was further improved during the 12-5. In particular, the citation impact of publications co-authored by China and the Netherlands, France, Germany and Singapore had the most significant increase (see Figure 2-8).

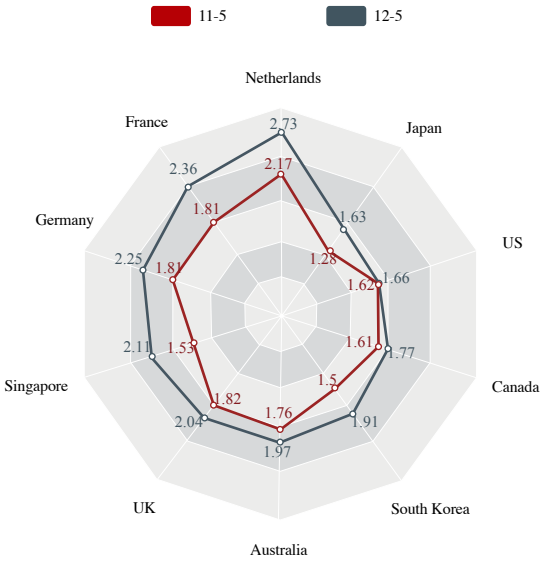


Figure 2-8 Citation Impact of China's Collab. Pub. with Its Top 10 Partners

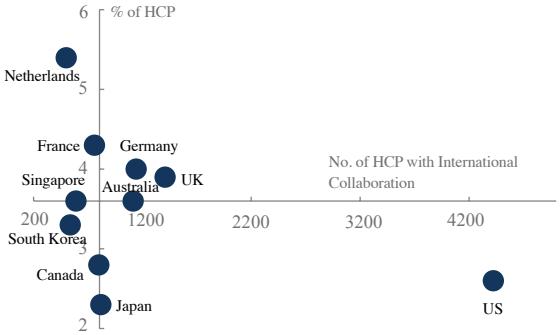


Figure 2–9 Volume and % of HCP Co–authored by China and the Top 10 Partners[9]

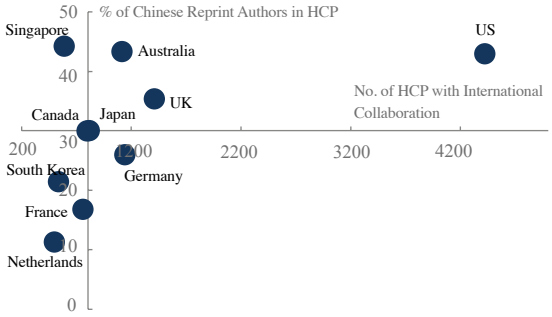


Figure 2-10 Volume and % of Chinese Reprint Authors in the HCP Co-authored by China and the Top 10 Partners[10]

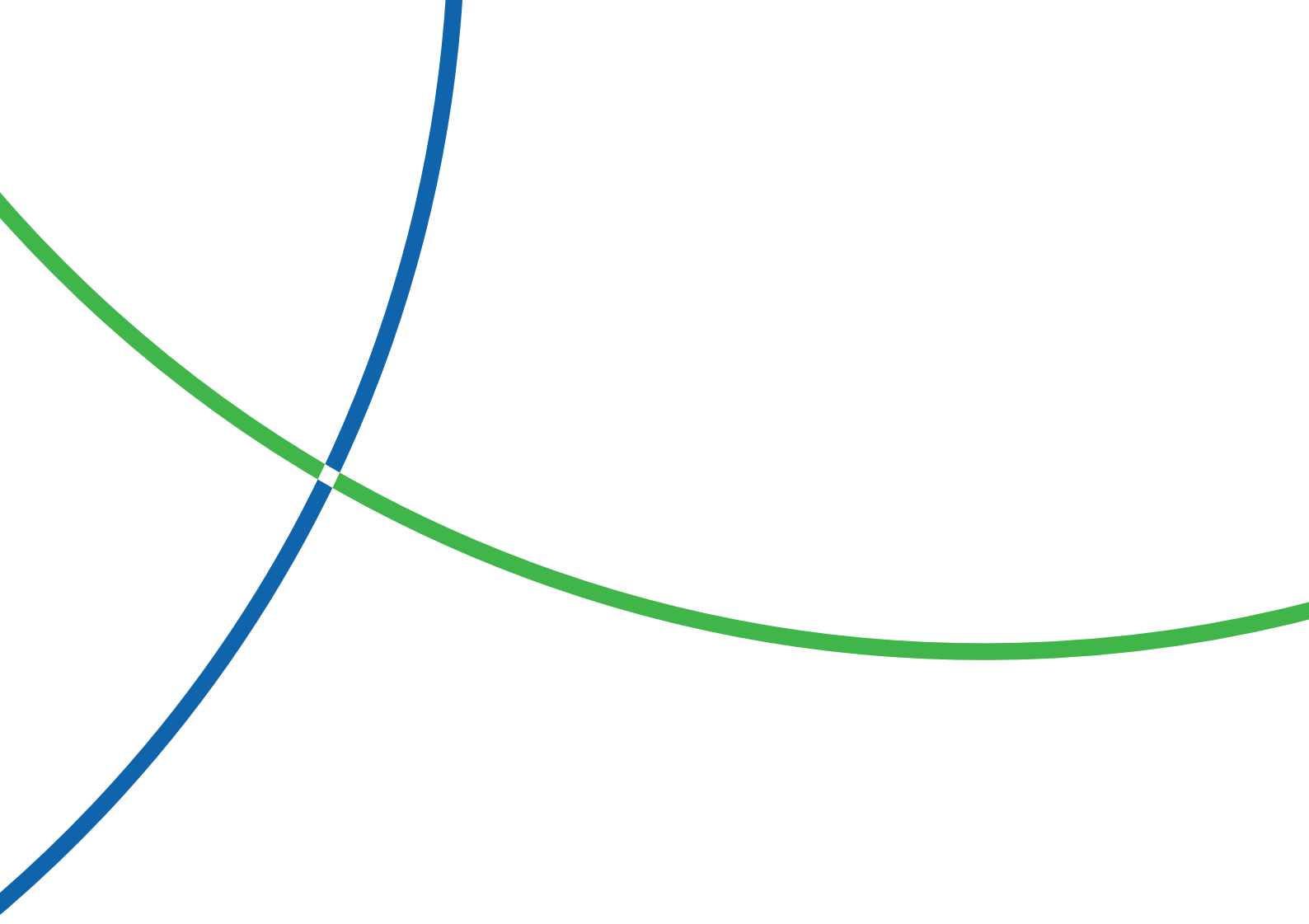
Figure 2-9 shows that the percentage of HCP in the co-authored papers by China and the top 10 countries was much higher than the global baseline (1.0%) representing the distinct citation impact of the collaborative publications. The number of HCP co-authored by China and the US was much higher than other countries. The percentage of HCP China collaborated with the Netherlands was the highest.

In order to further illustrate the leading role that Chinese researchers played in high-quality int. collab., this report analyzed the percentage of Chinese reprint authors in the HCP co-authored by China and key countries.

Figure 2-10 shows that China played a relatively leading role in high-quality international collaboration with Australia, Singapore and the US, with over 40% of co-authored HCP with Chinese reprint authors .In general, Chinese researchers were engaged in equal dialogues and collaboration in the high-quality int. collab. carried out with key countries.

9 The origin of x-axis is the median of the number of coauthored HCP between China and the top 10 countries. The origin of y-axis is the median of the percentages of coauthored HCP.

10 The percentage of Chinese reprint authors in HCP was based on the data from 2007 to 2017.



Chapter III Active Domestic Regions and Institutions in International Scientific Research Collaboration

Main Findings

In the past 10 years, Beijing, Shanghai and Jiangsu Province have taken a leading position in China's int. collab.

The Chinese Academy of Sciences had the greatest number of collab. pub. (about 65,000) and its collaboration scale was larger than any other domestic institutions. The second echelon in overall scale of international research collaboration consisted of Peking University, Zhejiang University, Shanghai Jiao Tong University, Tsinghua University, and Fudan University. The percentages of collab. pub. from Peking University and Beijing Normal University were much higher than the average in China (23.4%).

For the top 20 domestic institutions with the most collab. pub., the citation impact of collaborative publications and the percentage of HCP all exceeded the global baseline. The number of internationally collaborative HCP from the Chinese Academy of Sciences was higher than any other domestic institutions. The percentage of HCP in the collab. pub. from Harbin Institute of Technology, the University of Science and Technology of China, Peking University, and Tsinghua University (>3.0%) was well above the global baseline.

Among the top 10 domestic institutions with the largest scale of int. collab., Physics, Clinical Medicine, Chemistry and Engineering were the four fields with the largest amount of collab. pub.

All the top 10 domestic institutions had a closer collaboration with the US. In addition, they collaborated more closely with institutions affiliated to the DOE and CNRS.

This chapter focuses on the analysis of domestic regions and institutions in terms of the scale, citation impact and main Research Fields in China's int. collab.

3.1 Scale of International Scientific Research Collaboration in Key Regions in China

From 2006 to 2015, the number of collab. pub. in Beijing was over 100,000, much more than other provinces and municipalities in China. Shanghai and Jiangsu Province had more than 30,000 collab. pub. The number of collab. pub. in the above three regions accounted for over a half of China's total collab. pub., which demonstrated their leading positions in China's int. collab.

Table 3-1 China's Top 20 Provinces and Municipalities with the Most Collab. Pub.

Province/Municipality	No. of Collab. Pub.	% of China's Int. Collab.
Beijing	109404	30.24%
Shanghai	52637	14.55%
Jiangsu	38972	10.77%
Guangdong	25206	6.97%
Zhejiang	24072	6.65%
Hubei	23649	6.54%
Shaanxi	19309	5.34%
Liaoning	16515	4.57%
Shandong	16092	4.45%
Sichuan	14598	4.04%
Anhui	12562	3.47%
Hunan	12052	3.33%
Tianjin	11770	3.25%
Heilongjiang	10571	2.92%
Jilin	9930	2.75%
Fujian	8445	2.33%
Chongqing	7983	2.21%
Gansu	6376	1.76%
Yunnan	5857	1.62%
Henan	5455	1.51%

3.2 Scale and Impact of Domestic Institutions' International Collaborative Publications

Table 3-2 shows that from 2006 to 2015, the Chinese Academy of Sciences produced about 65,000 collab. pub., which was about a half of the total number of collab. pub. from institutions with over 10,000 publications. Peking University, Zhejiang University, Shanghai Jiao Tong University, Tsinghua University and Fudan University all had more than 10,000 collab. pub. and formed the second tier.

The percentage of internationally collaborative publications in Peking University and Beijing Normal University was relatively high (over 30.0%), which means that these two institutions were very active in terms of international partnerships.

Table 3-2 also shows that both the citation impact of collab. pub. and the percentage of HCP in collab. pub. of the top 20 domestic institutions were higher than the global baseline. The number of HCP from the Chinese Academy of Sciences was much higer than the ones of other domestic institutions, and the percentage of HCP in collab. pub. from Harbin Institute of Technology, The University of Science and Technology of China, Peking University, and Tsinghua University was all above 3.0%.

Table 3-2 Top 20 Domestic Institutions in Terms of Collab. Pub.

Domestic Institutions	No. of Collab. Pub.	% of Collab. Pub.	Citation Impact of Collab. Pub.	No. of HCP among Collab. Pub.	% of HCP among Collab. Pub.
Chinese Academy of Sciences	65440	25.8	1.7	1866	2.9
Peking University	16921	33.5	1.9	564	3.3
Zhejiang University	13961	23.8	1.6	347	2.5
Shanghai Jiao Tong University	13608	26.7	1.8	366	2.7
Tsinghua University	13591	25.1	1.9	444	3.3
Fudan University	10745	28.3	1.8	278	2.6
University of Science and Technology of China	8635	28.3	2.0	303	3.5
Nanjing University	8048	24.9	1.9	212	2.6
Sun Yat-sen University	8017	24.2	1.8	209	2.6
Huazhong University of Science and Technology	6878	22.1	1.6	147	2.1
Shandong University	6810	22.0	1.7	139	2.0

Domestic Institutions	No. of Collab. Pub.	% of Collab. Pub.	Citation Impact of Collab. Pub.	No. of HCP among Collab. Pub.	% of HCP among Collab. Pub.
Xi'an Jiaotong University	6197	24.0	1.5	141	2.3
Harbin Institute of Technology	5736	20.6	1.8	224	3.9
Jilin University	5425	18.8	1.4	100	1.8
Sichuan University	5231	16.3	1.5	101	1.9
Tongji University	5167	25.5	1.5	105	2.0
Wuhan University	4992	21.9	1.6	97	1.9
Beijing Normal University	4946	32.6	1.5	99	2.0
Central South University	4793	20.4	1.5	83	1.7
Dalian University of Technology	4472	20.9	1.5	96	2.2

3.3 Key International Collaboration Partners and Research Fields of Domestic Institutions

Table 3-3 shows that for the top 10 domestic institutions in terms of the amount of collab. pub., Physics, Clinical Medicine, Chemistry and Engineering are the Research Fields with the most collaborative publications. Five other Research Fields, including Geosciences, Materials Science, and Computer Science, also had a relatively large number of collab. pub.

Table 3-3 Active Research Fields of the Top 10 Institutions of Int. Collab. in China

Domestic Institutions	Physics	Chemistry	Clinical Medicine	Engineering	Materials Science	Geosciences	Molecular Biology & Genetics	Environment/ Ecology	Computer Science
Chinese Academy of Sciences	1	2				3		4	
Peking University	1	3	2			4			
Zhejiang University	1	3	4	2					
Tsinghua University	2	3		1					4

Domestic Institutions	Physics	Chemistry	Clinical Medicine	Engineering	Materials Science	Geosciences	Molecular Biology & Genetics	Environment/ Ecology	Computer Science
Shanghai Jiao Tong University	3		1	2	4				
Fudan University	2	3	1				4		
University of Science and Technology of China	1	2		3	4				
Sun Yat-sen University	2	3	1				4		
Nanjing University	1	2	4			3			
Huazhong University of Science and Technology	3		1	2					4

* "1" in the Table indicates the Research Field with the most collab. pub.; "2" represents the Research Field with the second most collab. pub. and so on.

Table 3-4 shows that the top 10 domestic institutions in terms of amount of collab. pub. had the most collaboration with institutions affiliated to the DOE[11] (appearing 7 times in Table 3-4) and CNRS (6 times). In particular, five domestic institutions including Shanghai Jiao Tong University and Fudan University had close collaboration with Harvard University. The data also shows that these domestic institutions had much closer collaboration with institutions from the US.

Table 3-4 Close International Collaborators of China's Top 10 Int. Collab. Institutions

Domestic Institutions	International Institution No.1	International Institution No.2	International Institution No.3	International Institution No.4
Chinese Academy of Sciences	Max Planck Society	institutions affiliated to DOE	CNRS	Russian Academy of Sciences
Peking University	institutions affiliated to DOE	CNRS	Russian Academy of Sciences	UCLA

11 Institutions affiliated with the DOE refer to the 24 national laboratories and technology centers, including Oak Ridge National Laboratory, Argonne National Laboratory, Los Alamos National Laboratory, Thomas Jefferson National Accelerator Facility, etc.

Domestic Institutions	International Institution No.1	International Institution No.2	International Institution No.3	International Institution No.4
Zhejiang University	KTH	National University of Singapore	Nanyang Technological University	Scientific Research Institutes under the DOE
Tsinghua University	Scientific Research Institutes under the DOE	MIT	University of California, Berkeley	CNRS
Shanghai Jiao Tong University	Harvard University	University of Michigan	CNRS	The University of Sydney
Fudan University	Harvard University	National University of Singapore	Scientific Research Institutes under the DOE	UTMD Anderson Cancer Center
University of Science and Technology of China	Scientific Research Institutes under the DOE	CNRS	The University of Chicago	Indiana University Bloomington
Sun Yat-sen University	Harvard University	Russian Academy of Sciences	University of Pennsylvania	Indiana University Bloomington
Nanjing University	CNRS	Scientific Research Institutes under the DOE	Harvard University	Russian Academy of Sciences
Huazhong University of Science and Technology	Nanyang Technological University	Harvard University	National University of Singapore	NIH

Chapter IV Collaboration with International Institutions

Main Findings

During the past 10 years, international institutions that had the most collaborative publications with China were CNRS and institutions affiliated with the US DOE. Among the top 20 international institutions with the most collaborative publications with China, half are located in the US. This shows that the collaboration between Chinese and American institutions was the closest.

The citation impact of publications co-authored by China and international institutions is generally high. 85% of the top 20 international institutions collaborated with China published collab. pub. with citation impact above 2. Moreover, the percentage of HCP co-authored by China and the top 20 international collaborators was much higher than the global baseline. The international institutions with which China collaborated to produce notably high percentages of HCP included the Massachusetts Institute of Technology (MIT), the University of California Berkeley, the University of Chicago, and Université Paris-Saclay.

From 2006 to 2015, the collaboration between the top 10 international institutions and China mainly focused on Physics, Chemistry, Engineering, Materials Science, and Clinical Medicine. The citation impact of publications co-authored by key international institutions and China in these fields all exceeded the global baseline. The percentages of HCP in the collaborative publications in most Research Fields was well above the global baseline, particularly in eight Research Fields such as Physics, Chemistry, Materials Science, and Geosciences etc.

This chapter analyzes the scale and impact of the collaboration between China and key international institutions as well as the major Research Fields of the international collaboration.

4.1 Overall Scale and Impact of the Collaboration with Key International Institutions

As shown in Table 4-1, international institutions that had the most collaborative publications with China during the 11-5 and 12-5 were CNRS and institutions affiliated with the US DOE, each with over 9,000 collaborative publications. Most of the top 20 international institutions collaborating with China came from eight countries, notably the US and France. Among the top 20 international institutions in terms of the number of collaborative publications, 11 came from North America (10 from the US), six from neighboring countries including Japan and Russia, and the remaining three were from the EU. This indicates that the collaboration between Chinese and American institutions was the closest and that the collaboration between institutions in China and neighboring countries was also relatively close.

The publications co-authored by China and the top 20 international institutions all had a relatively high citation impact. 85% of the top 20 international institutions collaborating with China have the citation impact above 2. In particular, the citation impact of collaborative publications with the University of California Berkeley, Université Paris-Saclay, the University of Chicago, the Ohio State University and Massachusetts Institute of Technology (MIT) was much higher than the global baseline.

As shown in Table 4-1, the percentages of HCP co-authored by China and the top 20 international institutions were well above the global baseline. Among them, the percentages of HCP collaborated with 12 institutions including MIT, the University of California Berkeley, the University of Chicago, Université Paris-Saclay, institutions affiliated to DOE, Max Planck Society, etc. were extremely high (over 5%) .

Table 4-1 Publications Co-authored by Top 20 Int. Collab. Partners and China

Sequence No.	International Institutions	Country	No. Collab. Pub.	Citation Impact of Collab. Pub.	% of HCP among Collab. Pub.
1	CNRS	France	9592	2.3	4.4
2	Institutions affiliated to DOE	US	9013	2.9	6.3
3	National University of Singapore	Singapore	7384	2.0	3.6
4	Nanyang Technological University	Singapore	6993	2.0	4.1

Sequence No.	International Institutions	Country	No. Collab. Pub.	Citation Impact of Collab. Pub.	% of HCP among Collab. Pub.
5	Harvard University	US	6631	3.0	5.8
6	Max Planck Society	Germany	5656	2.8	6.3
7	University of Michigan	US	4338	2.6	4.5
8	The University of Tokyo	Japan	4230	2.7	4.9
9	University of California, Berkeley	US	4201	3.4	7.0
10	Russian Academy of Sciences	Russia	4120	2.8	5.5
11	Université Paris-Saclay	France	4073	3.1	6.7
12	UCLA	US	3993	2.7	5.2
13	The University of Chicago	US	3828	3.4	6.9
14	The University of Sydney	Australia	3559	2.7	4.1
15	University of Toronto	Canada	3473	2.9	5.6
16	The Ohio State University	US	3467	3.1	5.7
17	NIH	US	3419	2.9	5.6
18	MIT	US	3387	3.8	7.8
19	Tohoku University	Japan	3371	1.7	2.5
20	The Pennsylvania State University	US	3297	2.1	4.2

During the 11-5, the four international institutions that had the most collaborative publications with China were CNRS, institutions affiliated to the DOE, National University of Singapore, and Nanyang Technological University (Table 4-2). During the 12-5, the above four institutions continued to carry out extensive scientific collaboration with China, and the number of collaborative publications with China steadily increased.

Compared with the 11-5, the number of collaborative publications that China undertook with Université Paris-Saclay, Harvard University, the University of Chicago, Russian Academy Sciences, and the University of California Berkeley witnessed the biggest increase during the 12-5. Among them, the growth rate in the number of collaborative publications from Université Paris-Saclay was the highest—201.3%. In terms of the amount of collaborative publications, Harvard University was among the top three collaborative institutions.

During the 12-5, The Ohio State University, the University of Toronto, MIT, the University

of Wisconsin-Madison, and Université Paris VI replaced Tohoku University (Japan), the US National Institutes of Health, and three other institutions and therefore advanced to China's top 20 collaborators list.

Table 4-2 Top International Institutions Collaborated with China during the 11-5 and 12-5

2006-2010		2011-2015		
International institutions	No. Collab. Pub.	International institutions	No. Collab. Pub.	Growth Rate
CNRS	3058	CNRS	6534	113.7
institutions affiliated to DOE	2505	institutions affiliated to DOE	6508	159.8
National University of Singapore	2443	Harvard University	4975	200.4
Nanyang Technological University	2218	National University of Singapore	4941	102.3
Max Planck Society	1806	Nanyang Technological University	4775	115.3
Harvard University	1656	Max Planck Society	3850	113.2
The University of Tokyo	1528	University of Michigan	3137	161.2
Tohoku University (Japan)	1237	University of California, Berkeley	3070	171.4
University of Michigan	1201	Russian Academy of Sciences	3065	190.5
UCLA	1170	Université Paris-Saclay	3058	201.3
University of California, Berkeley	1131	The University of Chicago	2852	192.2
NIH	1077	UCLA	2823	141.3
Russian Academy of Sciences	1055	The University of Tokyo	2702	76.8
Université Paris-Saclay	1015	The Ohio State University	2694	—
The University of Sydney	998	University of Toronto	2659	—
The University of Chicago	976	MIT	2590	—
KTH	908	The University of Sydney	2561	156.6
The Pennsylvania State University	907	University of Wisconsin-Madison	2417	—
The University of Queensland	891	Université Paris VI	2395	—
The Johns Hopkins University	882	The Pennsylvania State University	2390	163.5

4.2 Scale and Impact of Collaborations with Key International Institutions by Research Fields

In terms of Research Fields, the collaboration between the top 10 most productive international institutions and China mainly centered on Physics, Chemistry, Engineering, Materials Science, and Clinical Medicine (Table 4-3). The data also shows that China had relatively close collaboration with these institutions in Geosciences, Molecular Biology & Genetics, Biology & Biochemistry, Space Science, and Plant & Animal Science.

As shown in Table 4-3, the citation impact of publications co-authored by key international institutions and China in these Research Fields were all above the global baseline. The percentage of HCP co-authored with most of these institutions was also much higher than the global baseline.

The 10 institutions with which China collaborated to produce very high percentages (> 5.0%) of HCP include institutions affiliated with the DOE, Max Planck Society, University of California Berkeley, Harvard University, and the University of Tokyo. Research Fields with percentages of HCP above 5.0% in collaborative publications include Physics (8 institutions), Chemistry (6 institutions), Materials Science (3 institutions), and Geosciences (3 institutions), etc.

Table 4-3 Scale and Citation Impact of Collaboration with Key International Institutions across Research Fields

International Institutions	Research Field	No. Collab. Pub.	Citation Impact of Collab. Pub.	% HCP in Collab. Pub.
CNRS	Physics	3250	3.1	5.8
	Chemistry	1413	1.5	1.7
	Geosciences	887	2.5	7.1
	Materials Science	666	1.2	0.8
institutions affiliated to DOE	Physics	4725	3.2	6.1
	Chemistry	1372	2.5	5.9
	Materials Science	900	2.6	6.1
	Engineering	469	2.2	6.2
National University of Singapore	Engineering	1256	1.9	3.8
	Physics	1221	1.6	2.1
	Chemistry	1033	2.2	5.4
	Clinical Medicine	669	3.0	4.3
Nanyang Technological University	Engineering	1671	1.8	3.1
	Physics	1389	1.6	2.7
	Chemistry	1360	2.6	6.4
	Materials Science	1032	2.6	6.8

International Institutions	Research Field	No. Collab. Pub.	Citation Impact of Collab. Pub.	% HCP in Collab. Pub.
Harvard University	Clinical Medicine	1777	3.5	6.5
	Molecular Biology & Genetics	869	3.6	7.0
	Physics	840	3.8	7.9
	Biology & Biochemistry	513	1.8	3.7
Max Planck Society	Physics	1996	3.2	5.9
	Space Science	1049	2.1	5.3
	Chemistry	730	2.6	7.0
	Materials Science	427	3.4	8.9
University of Michigan	Physics	1370	3.3	6.0
	Clinical Medicine	488	1.9	4.5
	Engineering	410	2.0	2.9
	Materials Science	304	2.0	2.0
The University of Tokyo	Physics	1617	3.1	5.6
	Geosciences	332	2.4	6.9
	Chemistry	288	2.2	5.2
	Engineering	246	1.2	0.8
University of California, Berkeley	Physics	1732	4.0	7.5
	Chemistry	388	2.7	6.4
	Engineering	258	1.8	4.3
	Space Science	252	3.3	10.3
Russian Academy of Sciences	Physics	2367	3.5	6.5
	Chemistry	404	1.1	2.0
	Geosciences	310	1.9	7.4
	Plant & Animal Science	250	1.4	2.0

Chapter V Collaboration with Major Regions and International Organizations

Main Findings

From 2006 to 2015, China carried out effective scientific research collaboration with a variety of global regions and international organizations. Compared with the 11-5, the scale of international collaboration between China and related regions expanded during the 12-5. The collaboration scale of OECD countries, the EU, and Asian-Pacific countries with China was larger than other regions. They became the major regions and international organizations collaborating with China in scientific research. Meanwhile, the citation impact of China's collaborative publications with these regions was generally improved and exceeded the global baseline.

The number of collaborative publications co-authored by China and OECD countries increased from over 100,000 during the 11-5 to more than 230,000 during the 12-5, an increase of about 1.2 times. Among the OECD countries, the scale of research collaboration between China and the US was the largest, nearly equaling the total number of publications co-authored by China and other OECD countries in the period of 11-5. During the 12-5, with the deepening of collaboration between China and developed countries, China replaced the UK and Germany and became the country displaying the largest scale of research collaboration with the US.

The scale of scientific research collaboration between China and other BRICS countries significantly enlarged during the 12-5, 2.7 times that of the 11-5. The research collaboration among the BRICS countries was increasingly active, and a closer, more comprehensive and solid partnership in scientific collaboration was established during the 12-5.

Among the OBOR countries, Singapore, Russia and India were the top three countries in terms of collaborative publications with China during the 11-5 and 12-5, among which the scale of research collaboration between China and Singapore was the largest. Saudi Arabia had the highest growth rate (15.5 times) in collaboration with China. Ever since the 12-5, China has constantly stepped up cooperation with OBOR countries and has played a more and more important linking role in the OBOR scientific research network.

China has always attached high importance to regional S&T collaboration. This chapter analyzed the scientific research collaboration between China and Organization for Economic Cooperation and Development (OECD), the EU, the BRICS[12] countries, the OBOR countries and the Asian-Pacific, Latin American and African regions.

5.1 Scale and Impact of Scientific Research Collaboration with Major Regions and International Organizations

Compared with the 11-5, the scale of research collaboration between China and related regions expanded during the 12-5 (Table 5-1). The scale of collaboration between China and OECD countries, the EU and the Asian-Pacific region was larger than other regions. The number of collaborative publications with all three regions was over 70,000 during the 12-5, much more than the publications produced in collaboration with other regions.

Meanwhile, the citation impact of publications co-authored by China and these regions was also greatly improved and was well above the global baseline, demonstrating the effective collaboration between China and these regions.

Table 5-1 Regions/International Organizations with the Most Collab. Pub. with China

Region/Int. Org.	2006-2010		2011-2015		Growth times of Collab. Pub.
	No. Collab. Pub.	Citation Impact	No. Collab. Pub.	Citation Impact	
OECD	105665	1.4	237038	1.5	1.2
EU	33456	1.6	73202	1.7	1.2
Asia-Pacific	34544	1.4	70336	1.6	1.0
OBOR	13581	1.6	34954	2.0	1.6
ASEAN	6671	1.5	15053	2.2	1.3
Northern Europe	5159	2.0	12997	2.4	1.5
BRICS Countries	3910	2.0	9755	2.5	1.5
Middle East	1914	2.3	9361	2.9	3.9
Latin America	1714	2.9	5083	3.5	2.0
Africa	1194	2.0	4679	2.8	2.9

5.2 Scale and Impact of Scientific Research Collaboration with OECD Countries

The number of collaborative publications co-authored by China and OECD countries increased from over 100,000 during the 11-5 to more than 230,000 during the 12-5, an increase of about 1.2 times. The citation impact of collaborative publications slightly increased (from 1.4 to 1.5), which was well above the global baseline.

12 BRICS countries include Brazil, Russia, India, China and South Africa.

Among the OECD countries, the scale of collaboration that China had with the US was the largest (48,138 publications), almost on a par with the total publications co-authored by China and other OECD countries during the 11-5 (57,558). As shown in Table 5-2, the scale of research collaboration between China and OECD countries experienced a significant increase. The number of countries with over 10,000 collaborative publications increased from 3 to 8, while those with more than 1,000 but less than 10,000 collaborative publications increased from 12 to 21. The above two categories of countries accounted for 82.9% of all the OECD countries.

Table 5-2 Scale of Research Collaborations between China and OECD Countries

Country / No. / Period	> 10,000 Collab. Pub. (%)	> 1,000 but <10,000 Collab. Pub. (%)	> 100 but < 1,000 Collab. Pub. (%)	< 100 Collab. Pub. (%)
11-5	3 (8.6%)	12 (34.3%)	16 (45.7%)	4 (11.4%)
12-5	8 (22.9%)	21 (60.0%)	5 (14.3%)	1 (2.9%)

As shown in Figure 5-1 and 5-2, during the 11-5 and 12-5, the collaboration among OECD countries was strengthened and the collaborations between China and OECD countries were also constantly stepped up. During the 12-5, China replaced the UK and Germany and became the largest collaborative partner of the US.

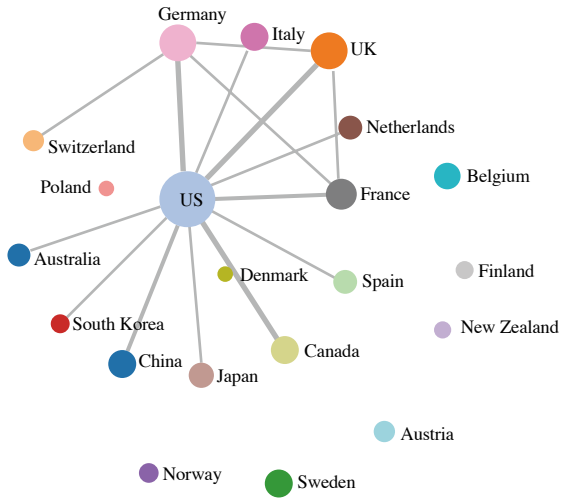


Figure 5-1 Collaboration Network among China and the Top 20 OECD Countries in Terms of Collab. Pub.with China during the 11-5[13]

13 In order to better demonstrate the collaboration among countries, the connecting line between two countries is shown in Figures 5-1 and 5-2 only in instances in which the number of collaborative publications exceeds 20,000

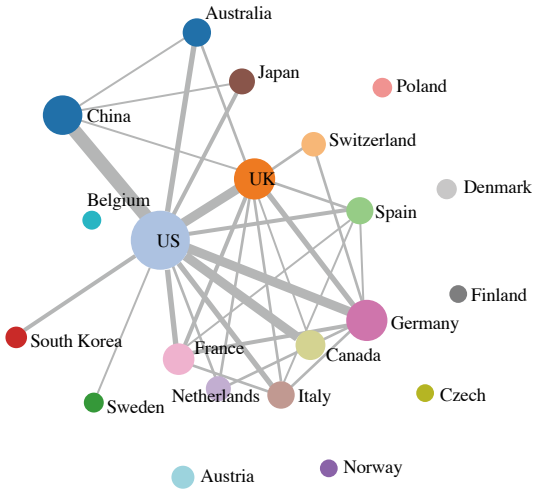


Figure 5-2 Collaboration Network among China and the Top 20 OECD Countries in terms of Collab. Pub. with China during the 12-5

In terms of citation impact, during the 11-5 and 12-5, the impact of publications co-authored by China and the top 10 OECD countries based on the number of collaborative publications with China, far exceeded the global baseline and saw an increase to different degrees (Figure 5-3). This demonstrates that for the past 10 years, China has maintained close research collaboration with these OECD countries and the impact of their collaboration has been relatively high.

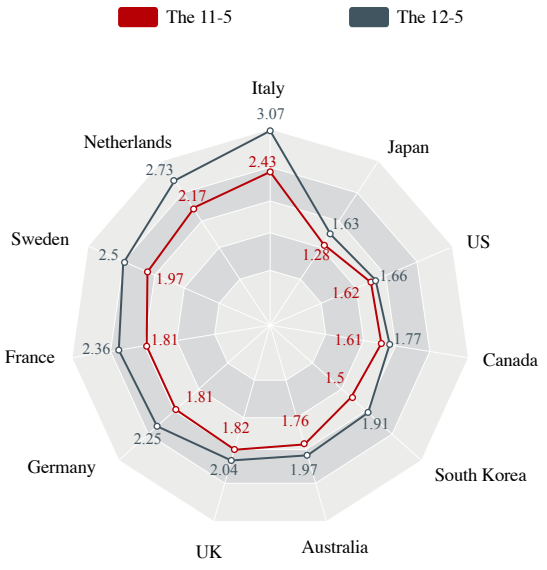


Figure 5-3 Citation Impact of Publications Co-authored by China and Major OECD Countries during the 11-5 and 12-5

Compared with the 11-5, the number of HCP co-authored by China and most OECD countries (except Japan) increased by 0.9 to 3.5 times during the 12-5. The percentage of HCP also witnessed an average increase of about 1.5 times. This means that the research collaboration between China and the OECD countries steadily increased.

Table 5-3 HCP Co-authored by China and Major OECD Countries

2006-2010			2011-2015		
Country	No. Co-authored HCPs	% Co-authored HCPs	Country	No. Co-authored HCPs	% Co-authored HCPs
US	1779	1.8	US	3293	2.7
Japan	1128	2.3	UK	1065	4.2
UK	235	1.6	Australia	871	3.8
Germany	343	3.2	Japan	582	2.7
Canada	292	3.1	Canada	586	3.1
Australia	211	2.4	Germany	849	4.4
France	243	3.0	France	575	4.8
South Korea	184	3.2	South Korea	410	3.8
Sweden	126	2.3	Netherlands	377	5.7
Netherlands	105	3.7	Italy	448	7.0

5.3 Scale and Impact of Scientific Research Collaboration with the BRICS countries

The BRICS nations constitute one of the most important cooperation mechanisms among emerging economies. From 2006 to 2015, the number of China's collaborative publications with Russia and India exceeded 5,000 in both cases. The overall scale of research collaboration between China and other BRICS countries greatly increased during the 12-5, which was about 2.7 times that of the 11-5.

Figure 5-4 shows that compared with the 11-5, the research collaboration among the BRICS countries became closer during the 12-5.

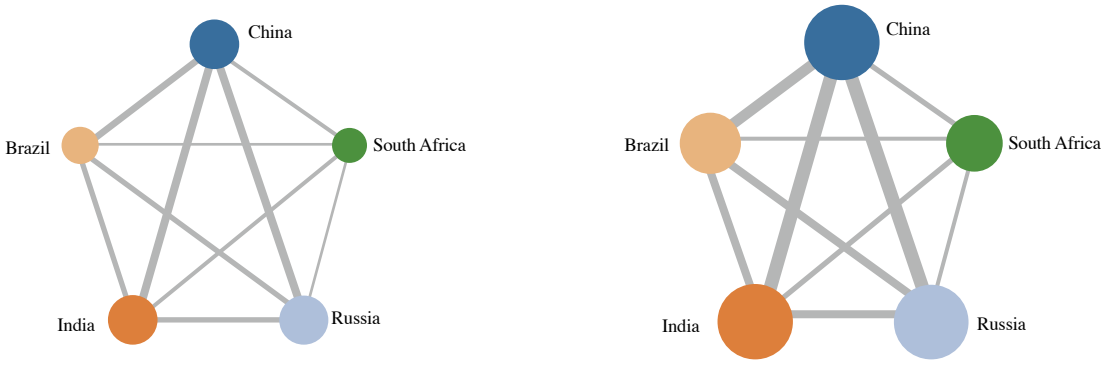


Figure 5-4 Collaboration Network among BRICS Nations during the 11-5 and 12-5

As is shown in Figure 5-5, the citation impact of publications co-authored by China and other BRICS countries was higher than the global baseline in the past 10 years and further increased during the 12-5. The citation impact of China's collaborative publications with South Africa was significantly enhanced during the 12-5.

During the 12-5, the number of HCP co-authored by China and other BRICS countries was markedly increased compared with that of the 11-5. The percentage of HCP also significantly raised and was well above the global baseline (Figure 5-6).

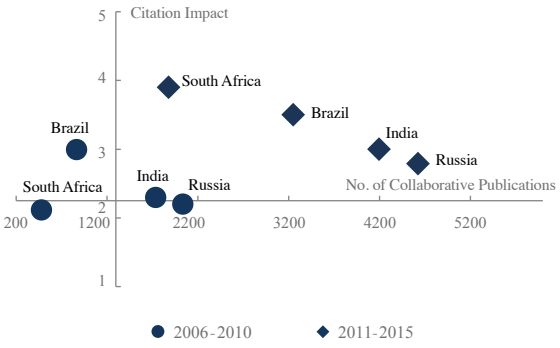


Figure 5-5 Volume and Citation Impact of Collab. Pub. Co-authored by China and Other BRICS Countries

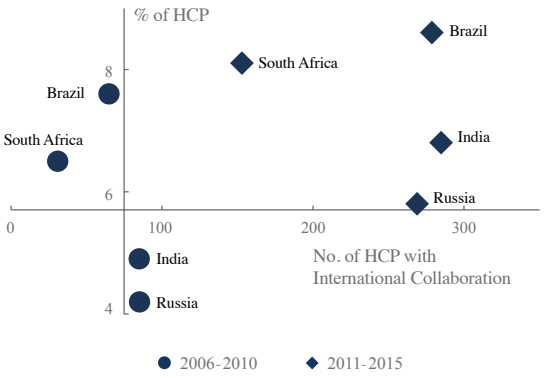


Figure 5-6 Volume and % of HCP Co-authored by China and Other BRICS Countries

5.4 Scale and Impact of Scientific Research Collaboration with OBOR Countries

OBOR is an economic corridor with the largest span in the world. OBOR begins in China, and runs through Central Asia, Southeast Asia, South Asia, West Asia and some European areas. It involves 68 countries[14].

14 This report covers 63 OBOR countries that produced collaborative publications with China.

Table 5-4 shows that from 2006 to 2015, among the OBOR countries, Singapore, Russia and India were China's top three collaborators in terms of the amount of collaborative publications. In particular, the number of collaborative publications between China and Singapore exceeded 10,000 during the 12-5, with a larger scale of collaboration compared to other OBOR countries.

The number of collaborative publications co-authored by China and other OBOR countries during the 12-5 witnessed a large increase compared with the 11-5. The number of collaborative publications China had with Saudi Arabia increased from 217 during the 11-5 to 3,585 during the 12-5, an increase of about 15.5 times. In recent years, Saudi Arabia has made significant investments in scientific research. King Abdullah University of Science & Technology (KAUST), King Saud University (KSU) and King Abdulaziz City for Science and Technology (KACST) established close scientific research collaborations with Peking University, Tsing Hua University, and the University of Chinese Academy of Sciences.

Table 5-4 Top 10 OBOR Countries with the Most Collab. Pub. with China during the 12-5

Country	2006-2010		2011-2015		Growth times in the No. Collab. Pub.
	No. Collab. Pub.	Rank	No. Collab. Pub.	Rank	
Singapore	5233	1	11314	1	1.2
Russia	2031	2	4634	2	1.3
India	1736	3	4177	3	1.4
Saudi Arabia	217	18	3585	4	15.5
Poland	930	4	3071	5	2.3
Pakistan	578	9	3009	6	4.2
Czech	704	5	2308	7	2.3
Turkey	360	11	2094	8	4.8
Israel	687	7	1878	9	1.7
Hungary	437	10	1804	10	3.1

As shown in Figure 5-7 and Figure 5-8, compared with the 11-5, China's collaboration with other OBOR countries was further strengthened during the 12-5. The research collaboration among the OBOR countries was diversified. The collaboration network also shows that during the 12-5, the scale, scope and closeness of collaboration between China and other OBOR countries significantly enhanced compared to the 11-5. China has played an increasingly prominent role in the int. collab. among the OBOR countries.

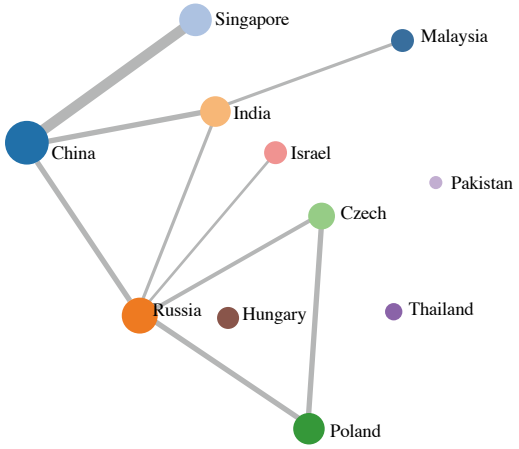


Figure 5-7 Collaboration among China and Its Top 10 OBOR Partners during the 11-5[15]

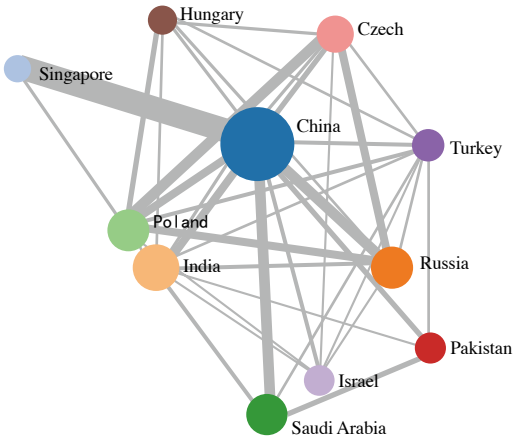


Figure 5-8 Collaboration among China and Its Top 10 OBOR Partners during the 12-5

Among the top 10 OBOR countries in terms of collaborative publications with China, the citation impact of the collaborative publications during both the 11-5 and 12-5 was well above the global baseline (Figure 5-9).

15 In Figures 5-7 and Figure 5-8, in order to better demonstrate the collaboration among countries, the connecting line between the two countries was shown only when the number of collaborative publications was more than 1,000.

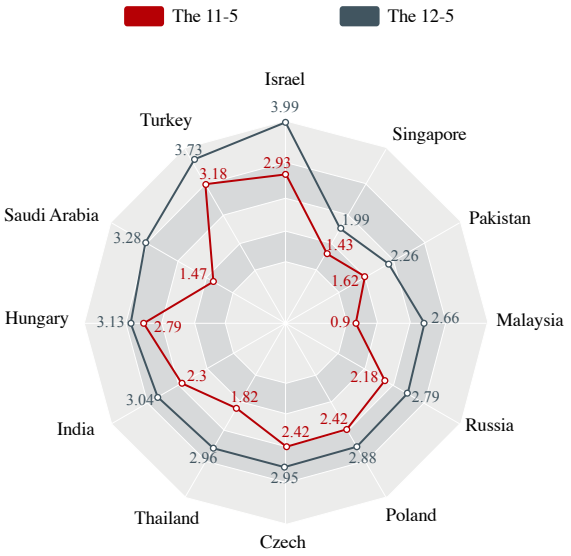


Figure 5-9 Citation Impact of Publications Co-authored by China and Its Top 10 OBOR Partners during the 11-5 and 12-5

As shown in Table 5-5, among the top 10 OBOR countries in terms of collaborative publications with China, the number of HCP during the 12-5 was 3 to 6 times that of the 11-5 and the percentage of HCP also markedly increased.

Table 5-5 No. and Percentage of HCP Co-authored by China and Its Top 10 OBOR Partners

2006-2010			2011-2015		
Country	No. Co-authored HCPs	% Co-authored HCPs	Country	No. Co-authored HCPs	% Co-authored HCPs
Singapore	112	2.1	Singapore	472	4.2
Thailand	23	3.7	Saudi Arabia	316	8.8
India	84	4.8	India	290	6.9
Russia	87	4.3	Russia	263	5.7
Poland	53	5.7	Poland	219	7.1
Malaysia	10	1.4	Malaysia	186	8.9
Czech	42	6.0	Czech	166	7.2
Hungary	34	7.8	Hungary	142	7.9
Israel	46	6.7	Israel	137	7.3
Pakistan	18	3.1	Pakistan	124	4.1

Chapter VI China's International Scientific Research Collaboration by Research Fields

Main Findings

From 2006 to 2015, China's int. collab. was speeding up. The volume of overall publications and collaborative publications in all Research Fields greatly increased. Materials Science, Engineering, and Computer Science were the three most active Research Fields. The relative collaboration activity in Chemistry, Geosciences, Mathematics, Physics, and Agriculture Sciences was above the average level in China. The analysis shows that the citation impact of collab. pub. was higher than that of overall publications in each Research Field. This demonstrates that international collaboration was conducive to the enhancement of China's influence in international scientific research in various Research Fields.

Compared with major countries, China's relative activity in terms of int. collab. in Materials Science, Engineering, Chemistry, and Physics exceeded or was at the same level of the major countries. Regarding Space Science, in which major countries were the most active in the int. collab., the relative activity of China's international collaboration was the lowest. The activity of the US, Spain and Canada in international collaboration by Research Fields was relatively balanced, while the activity of India and China was the least balanced.

For Chemistry, Physics, Engineering, Clinical Medicine and Materials Science, in which China had the most research publications, the scale of international collaboration in these areas was also the largest. China's major collaborative countries in the five areas include 13 countries such as the US, Germany, the UK, France and Japan. The US had the largest number of collaborative publications with China in each of the five Research Fields.

During the past 10 years, China's percentage of internationally collaborative publications in Chemistry, Physics, Engineering, and Materials Science clearly increased, which demonstrated the increased activity of collaboration in these Research Fields. Meanwhile, the percentage of internationally collaborative publications in Clinical Medicine decreased year by year. Compared with major countries, there was still a large gap in China's relative activity of international collaboration in Clinical Medicine (0.64).

The percentage of HCP in international publications in each of the five Research Fields (2 to 3.2%) all exceeded the global baseline. The international collaboration made a larger contribution in Engineering than in other areas to high-quality research outputs. The contribution of international collaboration in Chemistry was relatively low. In terms of high-quality international collaborations, Chinese researchers played a considerable leading role in Engineering, Materials Science, and Chemistry, but took a secondary position in research in Clinical Medicine.

This chapter analyzes the scale, activity and impact of China's int. collab. in 22 ESI Research Fields[16] and further elaborates on the int. collab. in Chemistry, Physics, Engineering, Clinical Medicine, and Materials Science between China and major countries.

6.1 Scale of Collaborations by Research Fields

As shown in Table 6-1, in the past 10 years, Chemistry, Physics, Engineering, Clinical Medicine, and Materials Science are the largest areas in terms of volume of publications and collab. pub. More than half of the international publications in the 22 ESI fields were from these five Research Fields. Among the Research Fields with more than 10,000 collab. pub., the percentage of international publications within Geosciences was the highest (38.3%), which demonstrates that international research collaboration in Geosciences was relatively active.

Table 6-1 China's Collab. Pub. by Research Fields during the 11-5 and 12-5

ESI fields	No. Pub.	No. Collab. Pub.	% Collab. Pub. in All Research Fields	% Collab. Pub. within the Research Fields
Chemistry	327210	46291	12.3	14.1
Physics	199222	44745	11.9	22.5
Engineering	179069	44485	11.8	24.8
Clinical Medicine	155536	35611	9.4	22.9
Materials Science	175166	30444	8.1	17.4
Geosciences	54898	21038	5.6	38.3
Biology & Biochemistry	73004	18477	4.9	25.3
Computer Science	50302	16560	4.4	32.9
Plant & Animal Science	53719	16542	4.4	30.8
Molecular Biology & Genetics	44793	14633	3.9	32.7
Mathematics	68038	14607	3.9	21.5
Environment/Ecology	44484	14567	3.9	32.7
Agriculture Sciences	35270	10525	2.8	29.8
Neuroscience & Behavior	28440	9368	2.5	32.9
Pharmacology & Toxicology	41052	8206	2.2	20.0

16 ESI fields: journals (and papers) indexed in the WoS Core Collection are classified into 22 ESI fields, including Agriculture Sciences, Biology & Biochemistry, Chemistry, Clinical Medicine, Computer Science, Economics & Business, Engineering, Environment/Ecology, Geosciences, Immunology, Materials Science, Mathematics, Microbiology, Molecular Biology & Genetics, Multidisciplinary, Neuroscience & Behavior, Pharmacology & Toxicology, Physics, Plant & Animal Science, Psychiatry/Psychology, General Social Science, and Space Science.

ESI fields	No. Pub.	No. Collab. Pub.	% Collab. Pub. in All Research Fields	% Collab. Pub. within the Research Fields
General Social Science	14350	7056	1.9	49.2
Microbiology	17863	5312	1.4	29.7
Economics & Business	8947	5086	1.3	56.8
Space Science	10483	5069	1.3	48.4
Immunology	14532	4753	1.3	32.7
Psychiatry/Psychology	6210	3516	0.9	56.6
Multidisciplinary	1979	642	0.2	32.4

As shown in Table 6-2, Physics is the largest area in terms of scale of internationally collaborative publications during the 11-5. During the 12-5, the collaboration scale in Engineering and Chemistry exceeded that of Physics and became the top two Research Fields with the most collaborative publications. Among the top 10 Research Fields in terms of the scale of int. collab., the growth of collaboration scale in Computer Science was the largest.

The number of internationally collaborative publications in Chemistry increased from about 15,000 during the 11-5 to around 31,000 during the 12-5, with a growth rate of over 100%. Meanwhile, the number of domestic publications (publications without international collaboration) increased from 105,000 to 176,000 with an increase of 67.0%. This shows that while doing independent research, China also actively strengthened international collaboration in Chemistry.

In order to further elaborate on the relative activity of China's int. collab. by Research Fields and the comparison with the activity of major countries, this report calculated the "Relative Activity of Collaboration" in several countries. In Figure 6-1

Table 6-2 Growth of China's Collab. Pub. by Research Fields during the 11-5 and 12-5

ESI Fields	2006-2010	2011-2015	Growth Rate (%)
Engineering	12424	32061	158.1
Chemistry	14946	31345	109.7
Physics	16245	28500	75.4
Clinical Medicine	10274	25337	146.6
Materials Science	8817	21627	145.3
Geosciences	6487	14551	124.3
Biology & Biochemistry	5707	12770	123.8
Computer Science	4069	12491	207.0
Plant & Animal Science	5504	11038	100.5

ESI Fields	2006-2010	2011-2015	Growth Rate (%)
Molecular Biology & Genetics	3889	10744	176.3
Environment/Ecology	4054	10513	159.3
Mathematics	5340	9267	73.5
Agriculture Sciences	3379	7146	111.5
Neuroscience & Behavior	2794	6574	135.3
Pharmacology & Toxicology	2671	5535	107.2
General Social Science	1932	5124	165.2
Economics & Business	1187	3899	228.5
Microbiology	1692	3620	113.9
Immunology	1475	3278	122.2
Space Science	1863	3206	72.1
Psychiatry/Psychology	830	2686	223.6
Multidisciplinary	89	553	521.3

the projecting portion indicates active Research Field in international collaboration while the recess indicates less active Research Field.

As shown in Figure 6-1, China is most active in the international collaboration in Materials Science, Engineering, and Computer Science. The relative activity of collaboration in Chemistry, Geosciences, Mathematics, Physics, and Agriculture Sciences was also higher than the average level in China and therefore the collaboration in these areas are also relatively active.

The relative activity of international collaboration of key countries in Space Science was relatively high and was the highest in the US, the UK, Germany, France, among others. In comparison, the relative activity of China's international collaboration in Space Science was relatively low. During the 11-5 and 12-5, among the five subjects with the most publications in China, the relative activity of international collaboration in Materials Science, Engineering, Chemistry, and Physics exceeded or nearly matched that of the major countries. The relative activity of international collaboration in Clinical Science (0.64) still lagged behind, compared with major countries.

The layout of international collaboration by Research Fields in the US, Spain, and Canada was relatively balanced, while that of India and China was the least balanced.

6.2 Impact of Collaborations by Research Fields

As shown in Figure 6-2, during the 11-5 and 12-5, the citation impact of China's collab. pub. in each Research Field was higher than that of the overall publications and was well above the global baseline. This means that international collaboration was rather conducive to the

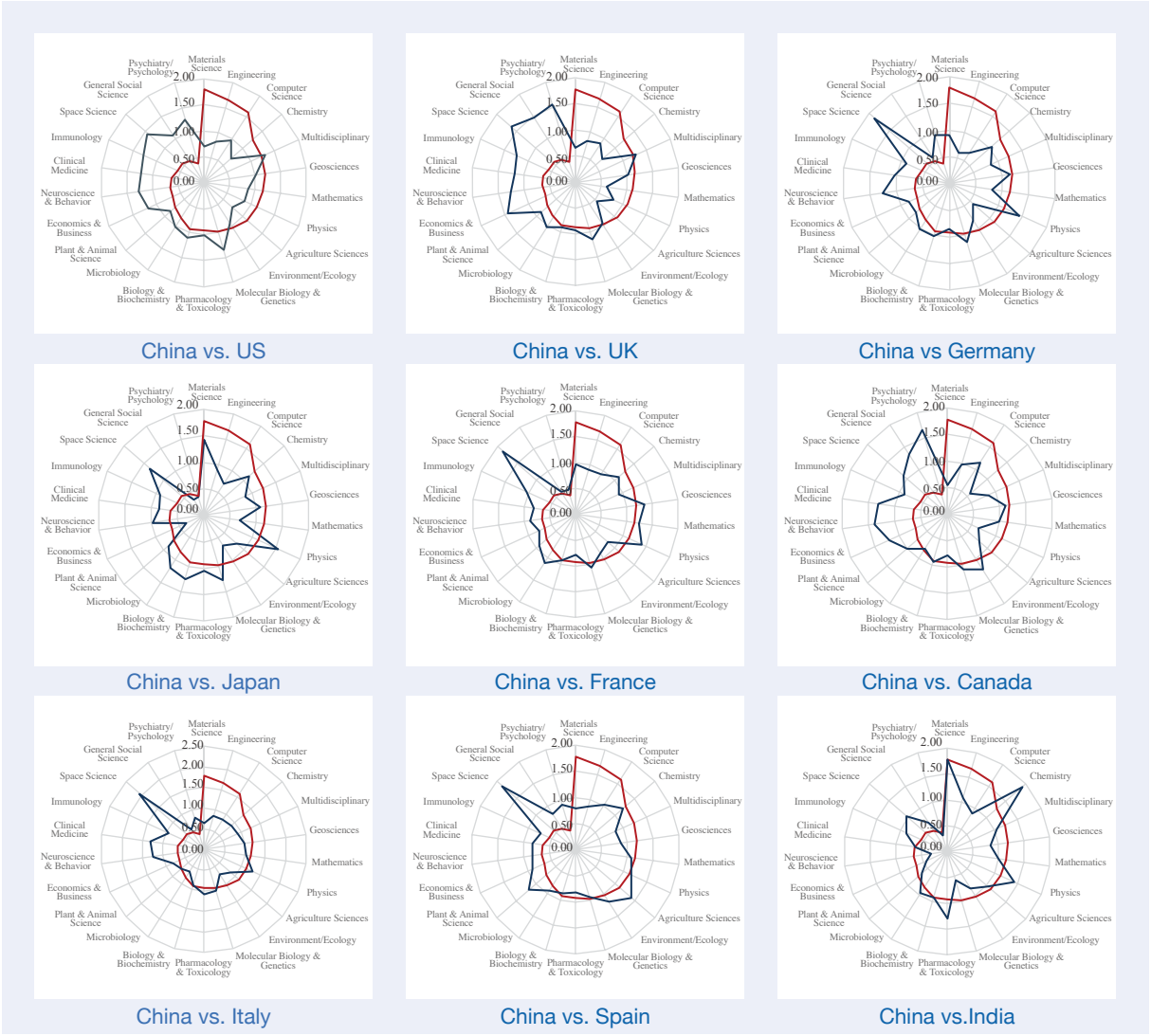


Figure 6-1 Relative Activity of China's Int. Collab. by Research Fields and Comparison with Major Countries[17]

increase of China's citation impact. Compared with the 11-5, the citation impact of international publications in most Research Fields largely increased during the 12-5. Among the top 5 Research Fields in terms of the number of publications, namely, Chemistry, Physics, Engineering, Clinical Medicine, and Materials Science, the citation impact of collab. pub. also greatly improved.

6.3 Activity and Impact of Collaboration in the Top 5 Research Fields with the Most Publications

The number of publications in Chemistry, Physics, Engineering, Clinical Medicine, and Materials Science accounted for over 60% of all

17 In Figure 6-1, the red line and blue line represents the relative activity of int. collab. by Research Fields in China and major countries respectively.

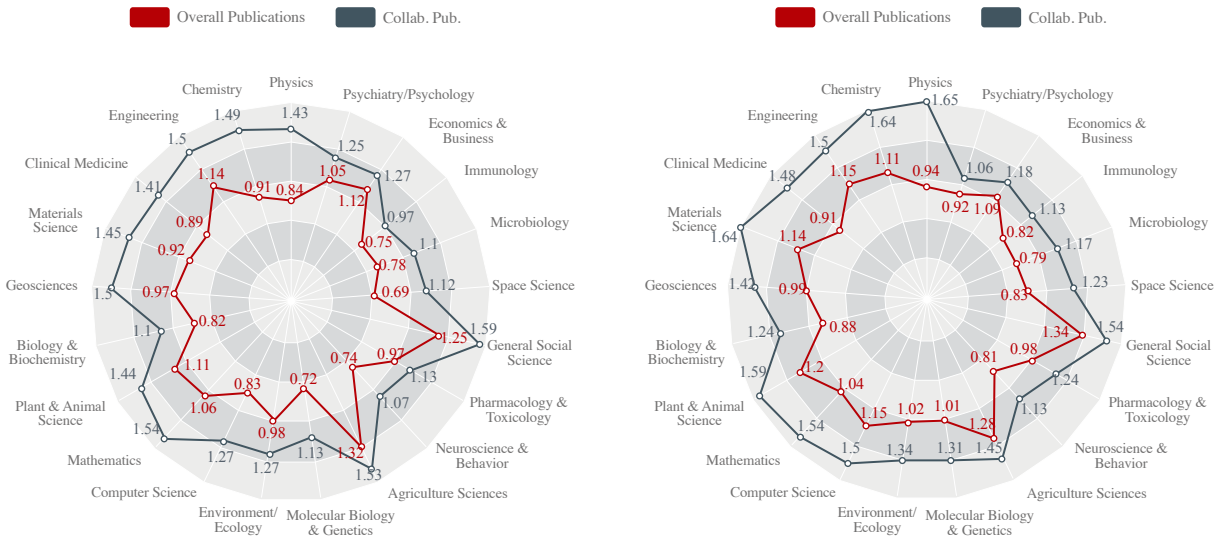


Figure 6-2 Citation Impact of China's Overall Publications and Collab. Pub. by Research Fields during the 11-5 (left) and 12-5 (right)

publications in China during the 11-5 and 12-5. These five Research Fields were also the largest in terms of collab. pub. This section focused on the analysis of the activity and citation impact in those five Research Fields.

In the past decade, the percentage of internationally collaborative publications within Chemistry, Physics, Engineering, and Materials Science saw an upward trend (Figure 6-3). Although the number of collab. pub. in Clinical Medicine increased from 10,274 during the 11-5 to 25,337 during the 12-5 (up by 146.6%, see Table 6-2),

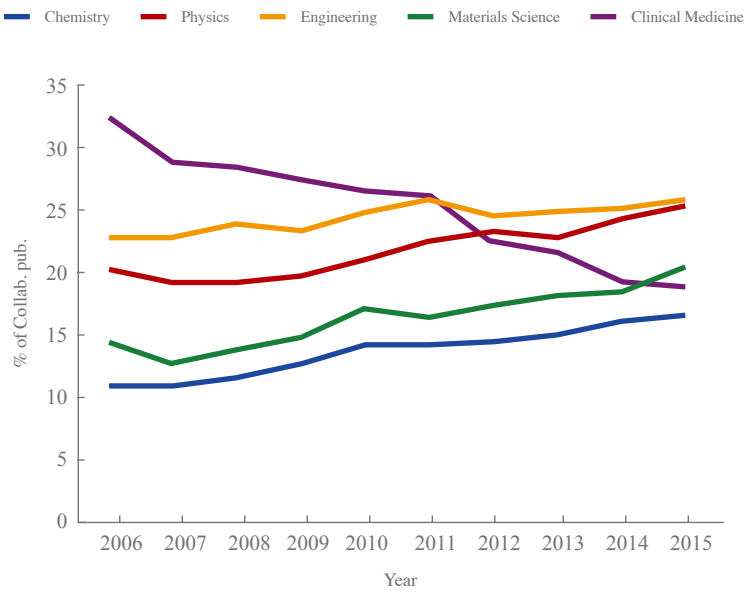


Figure 6-3 Percentage of Collab. Pub. within the Five Research Fields

the percentage of collab. pub. in Clinical Medicine decreased from 32.3% in 2006 to 18.9% in 2015.

For China's top five Research Fields with the most publications, the percentage of HCP in collab.

Table 6-3 Performance of Int. Collab. in China's Major Research Fields during the 11-5 and 12-5

Research Fields	No. Collab. HCPs	% HCPs	% Chinese Reprint Authors Int. Collab. HCPs[18]	% Collab. Pub. within Research Fields
Chemistry	1461	3.2	56.2	14.1
Physics	1122	2.5	38.1	22.5
Engineering	1273	2.9	72.1	24.8
Clinical Science	712	2.0	19.1	22.9
Materials Science	910	3.0	58.1	17.4

pub. was between 2% and 3.2%. In order to investigate the role of international collaboration in those five Research Fields, this report further analyzes the contribution made by international collaboration to high-quality output (HCP) in each Research Field. By calculating the percentage of Chinese reprint authors in the HCP, the report revealed the leading role that Chinese researchers have played in high-quality int. collab.

The percentage of collab. pub. and the percentage of HCP in collab. pub. (Table 6-3) show that the international collaboration made more contributions to the high-quality research output in Engineering than in Chemistry.

Table 6-3 also shows that in the high-quality international collaboration in Engineering, Materials Science, and Chemistry, Chinese researchers played a relatively leading role. In the high-quality international collaboration in Clinical Medicine, Chinese researchers were still in a secondary position.

6.4. Scale and Impact of Collaboration in the Top 5 Research Fields by Countries

This section analyzes China's major collaborative countries in the top five Research Fields.

6.4.1 Chemistry

The number of publications co-authored by China and the US was 16,766 in Chemistry, 3.3 times that of China and Japan. As shown in Figure 6-4,

18 The figures on the percentage of Chinese reprint authors in the collaborative HCP was based on the data between 2007 and 2017.

the citation impact of collab. pub. in Chemistry co-authored by China and other 10 countries including the US and Japan far exceeded the global baseline. The percentage of HCP in the collaborative publications also witnessed the same trend. In particular, the citation impact of collaborative publications with Singapore was twice the global baseline, and the percentage of HCP was more than 5.0%.

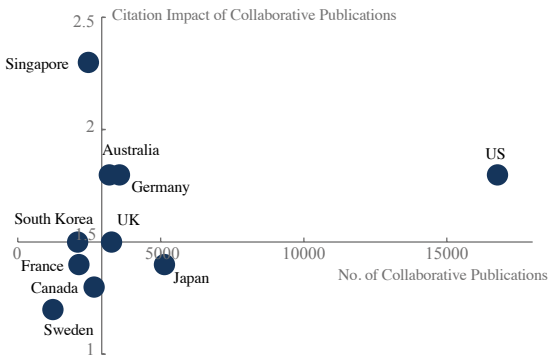


Figure 6-4 (a) Volume and Citation Impact of Collab. Pub. with the 10 Major Partners (Chemistry)

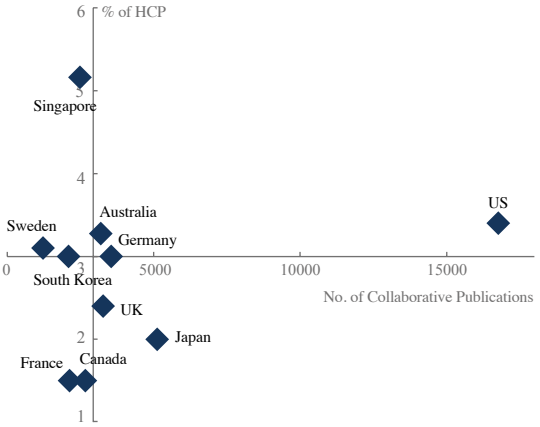


Figure 6-4 (b) Volume of Collab. Pub. and % of HCP Co-authored by China and Its 10 Partners (Chemistry)

6.4.2 Physics

The number of publications co-authored by China and the US was 19,514 in Physics, 2.9 times that of China and Germany.

As shown in Figure 6-5, the citation impact of collab. pub. in Physics co-authored by China and the top 10 countries with the largest scale of collaborative publications far exceeded the global baseline. The percentage of HCP in the co-authored publications also witnessed the same trend. This means that the citation impact of collab. pub. in Physics was high. The citation impact and the percentage of HCP co-authored by China and Italy, Russia, France, South Korea, the UK, and Germany was extremely high, especially the publications co-authored by China and Italy.

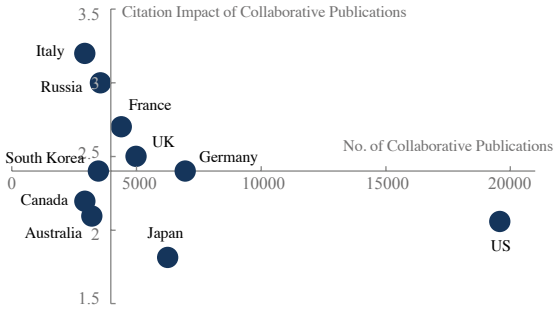


Figure 6-5 (a) Volume and Citation Impact of Collab. Pub. with the 10 Major Partners (Physics)

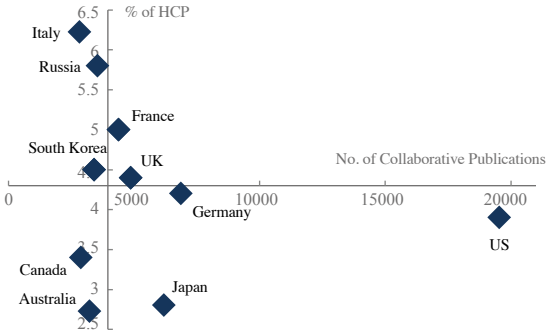


Figure 6-5 (b) Volume of Collab. Pub. and % of HCP Co-authored by China and Its 10 Partners (Physics)

6.4.3 Engineering

The number of publications co-authored of China and the US was 15,779 in Engineering, 2.5 times that by China and the UK. In Figure 6-6, the citation impact of collab. pub. in Engineering co-authored by China and the top 10 countries including the US and the UK far exceeded the global baseline. The citation impact and the percentage of HCP co-authored by China and Australia was the highest, while the percentage of HCP co-authored by China and Japan (0.8%) was lower than the global baseline.

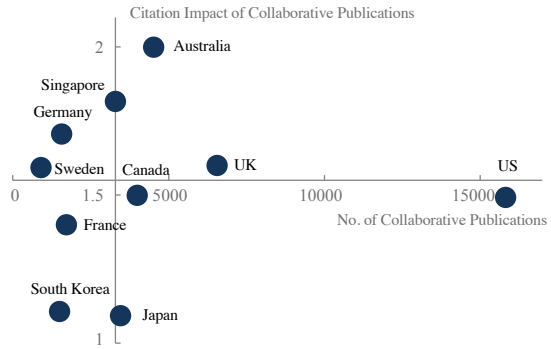


Figure 6-6 (a) Volume and Citation Impact of Collab. Pub. with the Major Partners (Engineering)

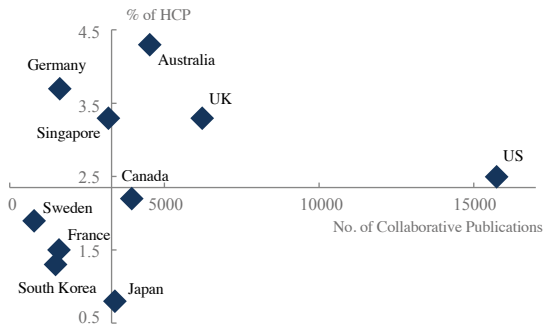


Figure 6-6 (b) Volume of Collab. Pub. and % of HCP Co-authored by China and Its 10 Partners (Engineering)

6.4.4 Clinical Medicine

The number of publications co-authored by China and the US was over 20,000 in Clinical Medicine, 6.7 times that of China and Japan. In Figure 6-7, the citation impact of collab. pub. co-authored by China and the 10 countries including the US and Japan far exceeded the global baseline, and the percentages of HCP

also saw the same trend. The percentage of HCP co-authored by China and 9 countries including France, the Netherlands, and South Korea was more than 4.0%, among which the percentage of HCP co-authored by China and France was as high as 12.7%.

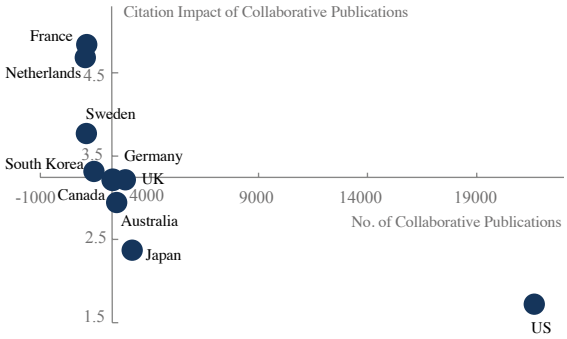


Figure 6-7 (a) Volume and Citation Impact of Collab. Pub. with the 10 Major Partners (Clinical Medicine)

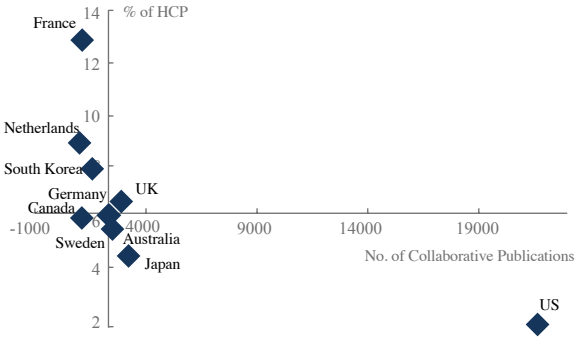


Figure 6-7 (b) Volume of Collab. Pub. and % of HCP Co-authored by China and Its 10 Partners (Clinical Medicine)

6.4.5 Materials Science

The number of publications co-authored by China and the US was over 10,184 in Materials Science, about 2.5 times that of China and Japan. In Figure 6-8, the citation impact of international publications co-authored by China and the 10 countries far exceeded the global baseline and the citation impact of collab. pub. co-authored by China and Singapore was the highest. The percentage of HCP co-authored by China and Singapore, the US, and Germany was more than 3.0%, while the percentage of HCP co-authored by China and France (0.6%), as well as China and Canada (0.9%) was lower than the global baseline.

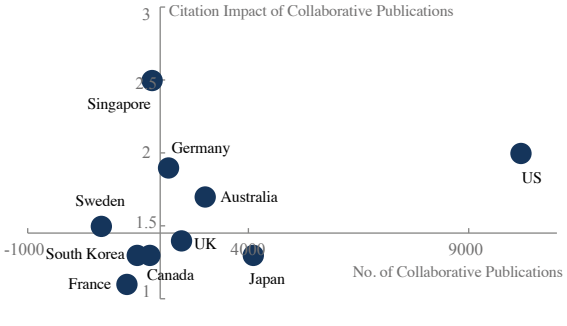


Figure 6-8 (a) Volume and Citation Impact of Collab. Pub. with the 10 Major Partners (Materials Science)

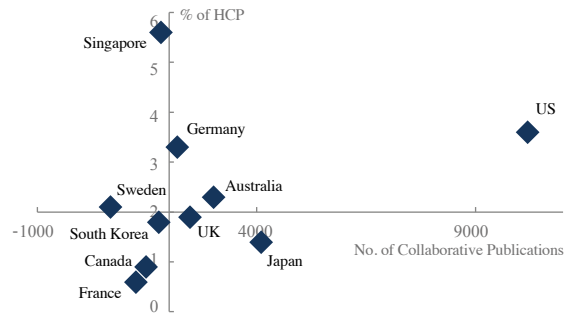
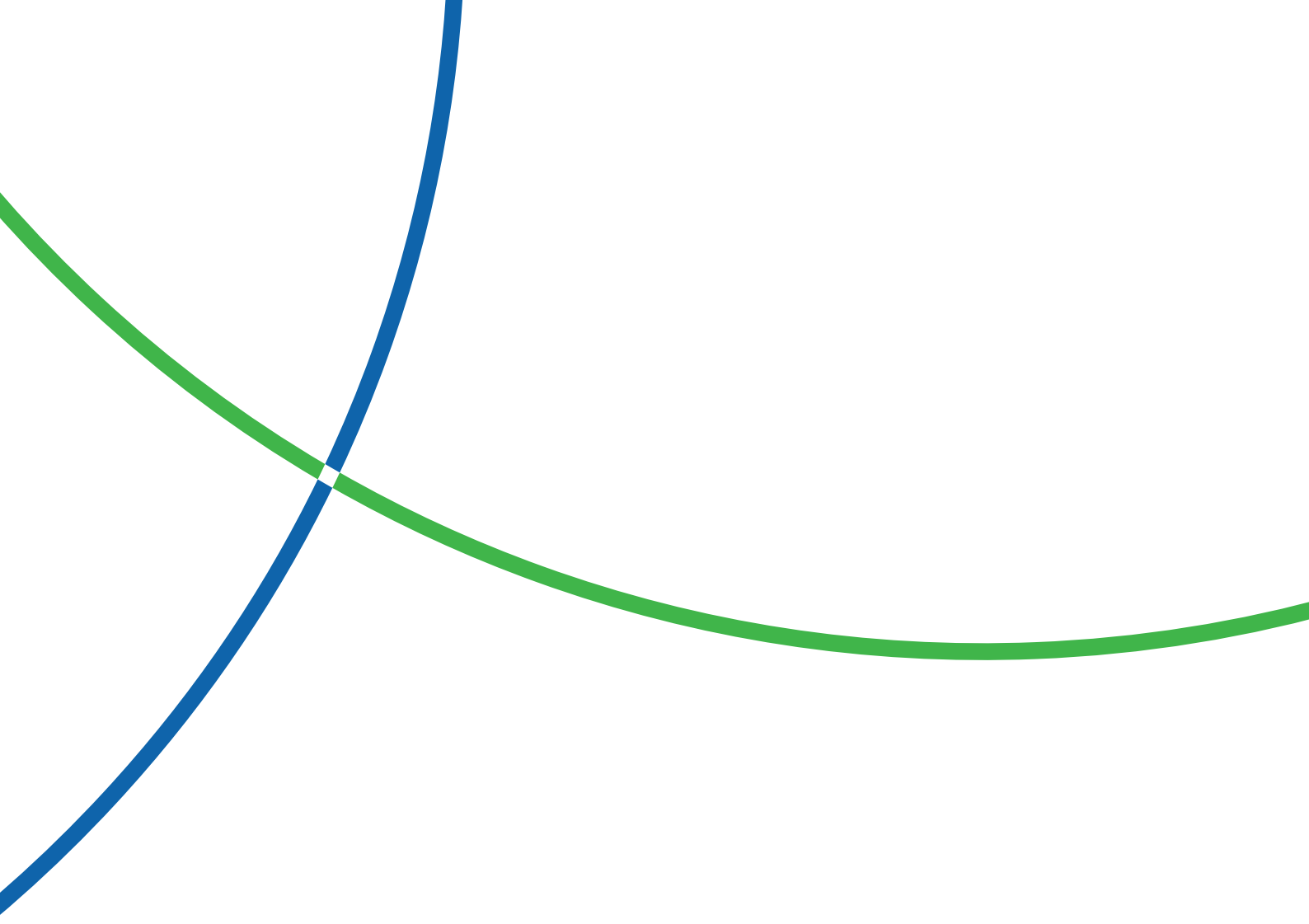


Figure 6-8 (b) Volume of Collab. Pub. and % of HCP Co-authored by China and Its 10 Partners (Materials Science)



Chapter VII China's Participation in Large-scale International Scientific Research Collaboration

Main Findings

Based on publications involving no less than 30 institutions and no less than 100 authors (multi-author publications), this chapter analyzes China's participation in large-scale int. collab.

From 2006 to 2015, China contributed to more than half of the multi-author publications in the world. The US was the largest producer of multi-author publications and China ranked the 9th.

Among the multi-author publications that China participated in, 89.4% were in Physics. China produced the most multi-author publications in the ATLAS and CMS project at the European Organization for Nuclear Research (CERN).

Among domestic institutions, the Chinese Academy of Sciences and the University of Science and Technology of China produced the most multi-author publications (over 1,000). The citation impact of multi-author publications from Shanghai Jiao Tong University was the highest.

Today's int. collab. is much more complex than before. Large-scale interdisciplinary scientific collaboration with substantial investment, large equipment, and facilities as well as the involvement of multiple research teams is common nowadays. Drawing upon multi-author publications, this chapter analyzes China's participation in large-scale int. collab.

7.1 Status and Impact of Large-scale International Scientific Research Collaboration

From 2006 to 2015, there were 4,976 multi-author publications in the world, and China made contribution to 54.7% of them (2,724). The US made the biggest contribution to the global output of multi-author publications, while China ranked 9th (Figure 7-1).

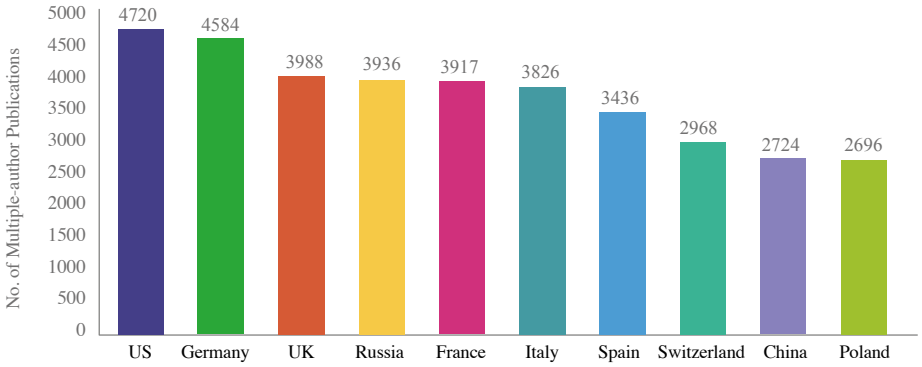


Figure 7-1 Top 10 Countries with the Most Multi-author Publications

As shown in Figure 7-2, the citation impact of multi-author publications was significantly higher than that of general collab. pub. The CNCI scores of multi-author publications in each of the top 10 countries were all above 4.

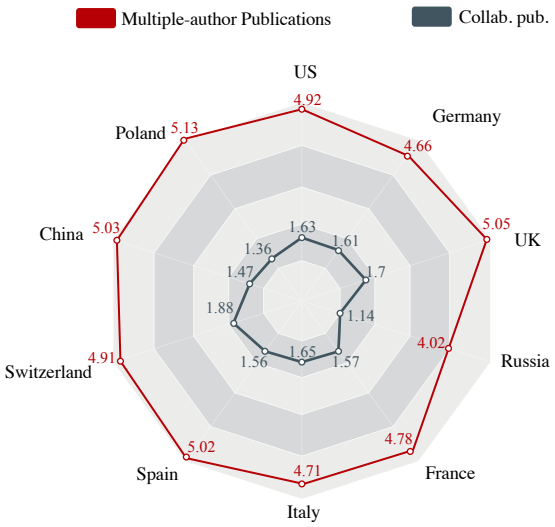


Figure 7-2 Citation Impact of Multi-author Publications in Major 10 Countries

7.2 China's participation in Large-scale International Scientific Collaboration by Research Fields

China contributed to 2,724 multi-author publications and 89.4% of the contribution was in Physics, which mainly included particle physics and field physics, astronomy and astrophysics, and nuclear physics.

Table 7-1 shows that China produced the most multi-author publications on the ATLAS and CMS project at CERN.

Table 7-1 China's Participation in Typical Large-Scale Int. Collab.

Project	Publications
ATLAS Collaboration	436
CMS Collaboration	422
BELLE Collaboration	219
STAR Collaboration	103
BESIII Collaboration	97
BABAR Collaboration	62

7.3 Participation of Chinese Institutions in Large-scale International Scientific Research Collaboration

As shown in Figure 7-3, among the domestic institutions involved in large-scale int. collab., both the Chinese Academy of Sciences and the University of Science and Technology of China produced more than 1,000 multi-author publications. The citation impact of multi-author publications from Shanghai Jiao Tong University was the highest.

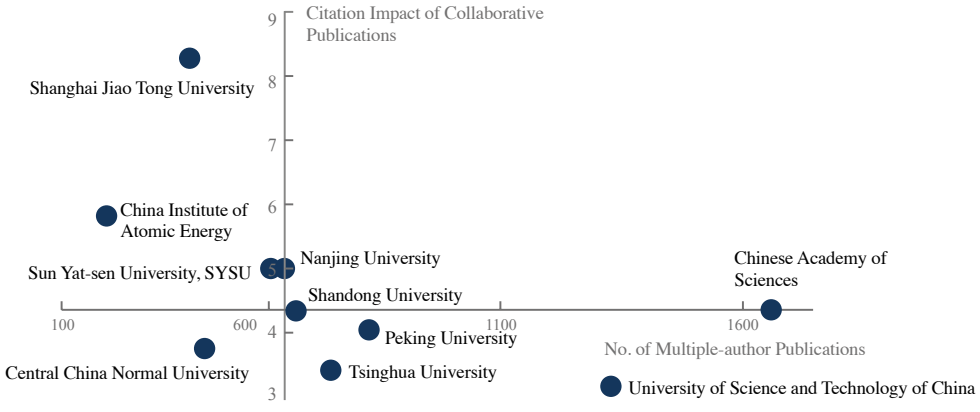


Figure 7-3 Volume and Citation Impact of Multi-author Publications from Key Chinese Institutions

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