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SCIENCE TECHNOLOGY AND INNOVATION PERFORMANCE OF CHINA

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Science, Technology and Innovation (STI) Performance of China

D9: Final Report

Annex

July 2014

Contents

1. Introduction

1. Introduction

This document is the annex to Deliverable 9: Final Report of the Science, Technology and Innovation (STI) Performance of China study.

The contents are presented as follows:

- Section 2 Chinese indicator definitions, sources & notes – relating to Chapter 2 of the main report;
- Section 3 Further results from Chapter 3 of the main report;
- Section 4 Summary of the survey results – relating to Chapters 4-6 of the main report.

2: Chinese indicator definitions, sources & notes – Chapter 2

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2. Chinese indicators definition, sources & notes – Chapter 2

This section presents complementary information relevant to Chapter 2: Measuring China's STI development of the report on the study - Science, Technology and Innovation (STI) Performance of China (N° RTD-2011-C6-China). It provides the definitions, sources and notes necessary for the understanding of the Chapter.

Indicator: Percentage of the population aged 25-34 having completed secondary stage tertiary education (e.g. a Ph.D.)

- Definition of numerator: number of doctorate graduates, resulting in a value of 50,289 graduates in 2011 (Source: China Statistical Yearbook 2012, Table 2-20)
- Definition of denominator: population between 25 and 34 years divided by 1000, resulting in a value of 201,662,073.4 for 2011 (China Statistical Yearbook 2012 Table 3-1)

Percentage population aged 30-34 having completed tertiary education

- Definition of numerator: number of persons aged 30–34 with some form of post-secondary education (ISCED 5 and 6), resulting in a value of 14,782,030 for 2010 (Source: 2010 population census of the People’s Republic of China, Part 1, Table 4-1)
- Definition of denominator: population between 30 and 34 years resulting in a value of 97,138,203 for 2010 (Source: 2010 population census of the People’s Republic of China, Part 1, Table 4-1)

Percentage youth aged 20-24 having attained at least upper secondary education

- Definition of numerator: number of young people having attained at least upper secondary education, resulting in a value of 58,701,838 for 2010 (Source: 2010 Population Census of the People’s Republic of China, Part 1, Table 4-1)

  - Definition of denominator: population between 20 and 24 years, resulting in a value of 127,412,518 for 2010 (Source: 2010 Population Census of the People's Republic of China, Part 1, Table 4-1)

Non-EU doctorate students as a % of all doctorate holders

Note: This is a highly skewed indicator and a square root transformation has been used to reduce the volatility and skewed distribution of this indicator. It is also not clear whether the European indicator uses number of enrolment, number of graduate students or number of students in school.

- Chinese indicator definition: enrolment of non-domestic doctorate students in 2011 as a % of doctorate students enrolled in 2011
  - Definition of numerator: number of non-domestic doctorate students enrolled in 2011, resulting in a value of 6,923 for 2011 (Source: News from Chinese Ministry of Education website: http://www.moe.gov.cn/publicfiles/business/htmlfiles/moe/s5987/201202/131117.html)
  - Definition of denominator: number of doctorate students in 2011 enrolled, resulting in a value of 63,762 for 2011 (Source: China Statistical Yearbook 2012, Table 20-2)

Venture capital (% of GDP)

- Chinese indicator definition: venture capital investment as a % of GDP in China
  - Definition of numerator: venture capital investment in China in 2011. The accumulated venture capital investment till 2010 and 2011 was CNY 149.13 billion (approx. EUR 16.50 billion) and CNY 203.66 billion (approx. EUR 22.09 billion) respectively. Therefore, the venture capital investment in 2011 was CNY 203.66 billion (approx. EUR 22.09 billion) - CNY 149.13 billion (approx. EUR 16.50 billion) = CNY 54.53 billion (approx. EUR 5.59 billion) (Wang Yuan, et al., 2012)
  - Definition of denominator: GDP in China which for 2011 was recorded as CNY 47,288.2 billion (approx. EUR 5,188.9 billion) (China Statistical Yearbook 2012, Table 2-1)

Non-R&D innovation expenditures (% of turnover)

- Chinese indicator definition: Non-R&D innovation expenditures as a % of total turnover for all enterprises
    - Definition of numerator: Non-R&D innovation expenditure resulting in a value of CNY 371,982,795,300 (approx. EUR 37.2 billion) for the period 2004-2006 (Source: Statistics of 2007 Innovation Survey of Industrial Enterprises, Table 4-1, 582,132,700,000*(55.8%+8.1%) =371,982,795,300)
    - Definition of denominator: total turnover for all enterprises resulting in a value of CNY 31,251,046,890,000 (approx. EUR 3.1 billion) for the period 2004-2006 (Source: Statistics of 2007 Innovation Survey of Industrial Enterprises, Table 2-1)
- Note: In 2007, National Bureau of Statistics of China conducted a nation-wide innovation survey, using a questionnaire similar to that of the Community Innovation Survey IV. All the state-owned enterprises and non state-owned enterprise whose revenue is greater than CNY five million (approx. EUR 0.48 million) were surveyed. These enterprises are called above-scale enterprises. The statistical data of the survey is published in National Bureau of Statistics, 2008, Statistics of 2007 Innovation Survey of Industrial Enterprises, China Statistics Press.

SMEs innovating in-house (% of SMEs)

- Chinese indicator definition:
    - Definition of numerator: number of medium and small above-scale enterprises which had in-house innovative activities during the period of 2004–2006: number of innovative medium firms * percentage of medium innovative firms with in-house innovative activities + number of innovative small firms * percentage small innovative firms with in-house innovative activities, i.e. 16,547*55.9%+67,561*63.3%=52,016 (Source: Statistics of 2007 Innovation Survey of Industrial Enterprises, Table 3-3)
    - Definition of denominator: For the period 2004-2006, the number of medium and small above-scale enterprises: number of medium above-scale enterprise (29,622) + number of small above scale enterprise (267,699) = 297,321 (Source: Statistics of 2007 Innovation Survey of Industrial Enterprises, Table 1-1)

- Note: Medium firms in China are defined as the firms employing equal to or more than 300 but less than 2000 employees. Small firms in China are defined as the firms employing equal to or more than 20 but less than 300 employees.

Innovative SEMs collaborating with others (% of SMEs)

- Chinese indicator definition A: number of small and medium above-scale enterprises which have product innovation and cooperate with other enterprises/organizations in product innovation (% of number of total small and medium above-scale enterprises)
    - Definition of numerator: For the period 2004-2006, the number of small and medium above-scale enterprises which have product innovation and cooperate with other enterprises/organizations in product innovation (Number of medium innovative above-scale enterprises 16,547* (percentage of collaborating with other enterprises 5.4% + percentage of collaborating with other S&T institutions 5% + percentage of collaborating with higher education institutions 3.6% + percentage of collaborating with foreign organizations 1.7%) = 2,598. The calculation for small firms is similar to the above for medium firms (Source: Statistics of 2007 Innovation Survey of Industrial Enterprises, Table 1-1)
    - Definition of denominator: For the period 2004-2006, the number of total small (267,699) and medium (29,622) above-scale enterprises (Statistics of 2007 Innovation Survey of Industrial Enterprises, Table 1-1)
- Chinese indicator value A: SMEs with product innovation collaborating with others (% of SMEs) (2004 - 2006): 4.85
- Chinese indicator definition B: number of small and medium above-scale enterprises which have process innovation and cooperate with other enterprises/organizations in process innovation (% of number of total small and medium above-scale enterprises).
    - Definition of numerator: For the period 2004-2006, the number of small and medium above-scale enterprises which have process innovation and cooperate with other enterprises/organizations in process innovation (Number of medium innovative above-scale enterprises 16,547* (percentage of collaborating with other enterprises

9.8% + percentage of collaborating with other S&T institutions 5.2% + percentage of collaborating with higher education institutions 3.3% + percentage of collaborating with foreign organizations 1.4%) = 3,260. The calculation for small firms is similar as the above for medium firms (Source: Statistics of 2007 Innovation Survey of Industrial Enterprises, Table 1-1)

   - Definition of denominator: For the period 2004-2006, the number of total small (267,699) and medium (29,622) above-scale enterprises (Source: Statistics of 2007 Innovation Survey of Industrial Enterprises, Table 1-1)

- Chinese indicator value B: SMEs with process innovation collaborating with others (% of SMEs) (2004–2006): 4.98
- Note: There are no Chinese indicators available on general SMEs collaborating with others. There are indicators on product innovative SMEs collaborating with others and on process innovative SMEs collaborating with others. Hence, the percentage for product and process innovators is provided respectively. The overall share of innovative SMEs collaborating with others in total SMEs would be greater than the smaller value (4.85) but smaller than the sum of the two values (9.83) because product and process innovators overlap.

Community trademarks per billion GDP (in PPP Euro)

- Note: The Chinese data and EU data are not comparable because the Chinese trademark applications are different from the EU-wide community trademark applications. In order to compare results, it is necessary to compare national trademark applications in individual European countries.

Community designs per billion GDP (in PPP Euro)

- Note: The Chinese data are not comparable because the Chinese design applications are different from the EU-wide community design applications. In order to compare results, it is necessary to compare national trademark applications in individual European countries.

SMEs introducing product or process innovations (% of SMEs)

- Chinese indicator definition:
  - Definition of numerator: The number of small and medium above-scale enterprises which have product or process innovation, for the period 2004-2006, recorded as 67561+16547=84108 (Source: Statistics of 2007 Innovation Survey of Industrial Enterprises, Table 1-1)
  - Definition of denominator: For the period 2004-2006, the number of small and medium above-scale enterprises, recorded as 267,699+29,622=297,321 (Source: Statistics of 2007 Innovation Survey of Industrial Enterprises, Table 1-1)
- Chinese indicator value: 28.29 (2004–2006)

SMEs introducing marketing or organizational innovations (% of SMEs)

- Note: In 2007, the National Bureau of Statistics of China conducted a nation-wide innovation survey, using a questionnaire similar to that of the Community Innovation Survey IV. However, in that survey there were no questions asked about marketing or organizational innovations of the firms.

Employment in knowledge-intensive activities as % of total employment

- Chinese indicator definition:
  - Definition of numerator: The number of individuals employed in knowledge-intensive activities in China in 2010, recorded as 10,361,895 (Source: 2010 Population Census of the People’s Republic of China, Part 2, Table 4-6)
  - Definition of denominator: Total employment in 2010, recorded as 71,547,989 (Source: 2010 Population Census of the People’s Republic of China, Part 2, Table 4-6)
- Chinese indicator value: 14.5 (2010)
- Note: The data regarding number of employment in knowledge-intensive activities and total employment in China in 2010 are from Part 2 of the 2010 Population Census of the People’s Republic of China. Only 10% of the total population of China answered Part 2 of the

questionnaire. Therefore, the value of the numerator and denominator is both about 10% of the value for the whole country. However, the ratio of the numerator to denominator is not affected.

Sales of new-to-market and new-to-firm innovations as % of turnover

- Chinese indicator definition: Sales of new-to-market and new-to-firm innovations as % of turnover for product sales
    - Definition of numerator: Sales of new-to-market and new-to-firm innovations recorded as CNY 3,960.61 billion (approx. EUR 400 billion) for 2006
    - Definition of denominator: Total product sales recorded as CNY 31,251.05 billion (approx. EUR 3,1 billion)) for 2006, (Source: China statistics of industry innovation 2006, Table 6)

Business expenditure on R&D by SMEs (0-249 employees), millions of euro

- Chinese indicator definition: Total R&D expenditure by small above-scale enterprises, in millions of euro, R&D expenditure by total above-scale enterprises recorded as CNY 599,380,550,000 (approx. EUR 65 billion) for 2011 - R&D expenditure by large and medium above-scale firms recorded as CNY 503,069,600,000 (approx. EUR 54 billion) for 2011 = CNY 96,310,950,000, equivalent to 11,913 million Euro (Source: China Statistical Yearbook 2012, Table 20-45)
- Note: Small firms in China are defined as the firms employing a minimum of 20 employees but less than 300 employees.

Business expenditure by SMEs (0-249 employees) as % of GDP

- Chinese indicator definition: Total R&D expenditure by small above-scale enterprises as % of GDP
    - Definition of numerator: Total R&D expenditures by small above-scale enterprises, recorded as CNY 96.31 billion (approx. EUR 10.45) for 2011 (Source: China Statistical Yearbook 2012, Table 20-45)

   - Definition of denominator: GDP, recorded as CNY 4,7288.16 billion (approx. EUR 51,289 billion) for 2011 (Source: China Statistical Yearbook 2012, Table 3-1)
- Chinese indicator value: 0.20 (2011)
- Note: Small firms in China are defined as the firms employing equal to or more than 20 but less than 300 employees.

Inward R&D expenditure by foreign affiliates, millions of euro

- Chinese indicator definition: R&D expenditure by enterprises funded by Hong Kong, Macau and Taiwan and foreign investors, recorded as CNY 104,828,020,000 in 2010 and equivalent to 12,967 million Euro (Source: China Statistical Yearbook on Science and Technology 2011, Table 2-8)

Inward R&D expenditure as % of R&D expenditure by business enterprise

- Chinese indicator definition:
   - Definition of numerator: R&D expenditure by enterprises funded by Hong Kong, Macau and Taiwan and foreign investors, recorded as CNY 104,828,020,000 (approx. EUR 11.6 billion) for 2010 (Source: China Statistical Yearbook on Science and Technology 2011, Table 2-8)
   - Definition of denominator: (Domestic) R&D expenditure by business enterprise recorded as CNY 401,539,652,000 (approx. EUR 44.4 billion) for 2010 (Source: China Statistical Yearbook on Science and Technology 2011, Table 2-8)

Investment in knowledge (R&D and Education), millions of euro

- Chinese indicator definition: Investment in education recorded as CNY 1,956,184.71 million (approx. EUR 216,392 million) for 2010 (Source: China Statistical Yearbook 2012, Table 20-39) + Investment in R&D recorded as CNY 706,260 million (approx. EUR 78,126 million) in 2010 (Source: China Statistical Yearbook 2012, Table 20-41) = CNY 2,662,444.71 million which is equivalent to 334,403 million Euro

Investment in knowledge (R&D and Education) as % of GDP

- Chinese indicator definition:
  - Definition of numerator: Investment in education recorded as CNY 1,956,184.71 million (approx. EUR 212,168 million) for 2011 (Source: China Statistical Yearbook 2012, Table 20-39) + Investment in R&D recorded as CNY 706,260 million (approx. EUR 76,600 million) in 2011 (Source: China Statistical Yearbook 2012, Table 20-41) = CNY 2,662.44 billion (approx. EUR 288.78 billion)
  - Definition of denominator: GDP recorded as CNY 47,288.2 billion (approx. EUR 5,129 billion) for 2011 (Source: China Statistical Yearbook 2012, Table 2-1)

New doctoral graduates (ISCED 6), total

- Chinese indicator definition: number of new doctorate graduates recorded as 50,289 in 2011 (Source: China Statistical Yearbook 2012, Table 20-13)

Human Resources in Science and Technology aged 25-64, thousand persons

- Chinese indicator definition: Population aged 25-64 with a tertiary education degree (Source: 2010 Population Census of the People's Republic of China, Part1, Table 4-1)

Human Resources in Science and Technology aged 25-64 as % of labour force

- Chinese indicator definition: population aged 25-64 with a tertiary education degree as % of population aged 25-64
  - Definition of numerator: population aged 25-64 with a tertiary education degree, recorded as 74,086,103 for 2010 (Source: 2010 Population Census of the People's Republic of China, Part 1, Table 4-1)
  - Definition of denominator: population aged 25-64, recorded as 765,259,458 for 2010 (Source: 2010 Population Census of the People's Republic of China, Part 1, Table 4-1)

New S&T graduates (ISCED 5A) with S&E orientation

- Chinese indicator definition: total number of regular undergraduates (1,163,643), life-long learning undergraduates (194,946), and on-line undergraduates (75,260) with a major in science and engineering, recorded as 1,433,849 for 2011 (Source: China statistical yearbook 2012, Table 20-14, 16 and 18)

License and patent revenues from abroad, millions Euro

- Chinese indicator definition: Charges for the use of intellectual property, receipts, in millions of Euro. World Bank Development Indicators indicate a value of USD 743,301,698 for 2011 which equates to 568 million Euro

Female PhD/doctoral graduates, total number

- Chinese indicator definition: Female PhD/doctoral total enrolment. Total PhD/doctoral enrolment was recorded as 271,261 for 2011 (Source: China Statistical Yearbook 2012, Table 20-2). The % of females was recorded as 36.13% for 2011 (Source: China Statistical Yearbook 2012, Table 20-2)
- Note: It was only possible to identify the number of enrolment of female PhD students instead of the number of female Ph.D. graduates.

Share (%) of female PhD/doctoral graduates in total PhD/doctoral graduates

- Chinese indicator definition: % of females of the total number of students enrolled (Source: China Statistical Yearbook 2012, Table 20-2)
- Note: It was only possible to identify the number of enrolment of female PhD students instead of number of the female Ph.D. graduates.

Venture capital (early stage, expansion and replacement), millions Euro

- Chinese indicator definition: The venture capital investment of 2011 in China. The accumulated venture capital investment till 2010 and 2011 was CNY 149.13 billion (approx. EUR 16.5 billion) and CNY 203.66 billion (approx. EUR 22.1 billion) respectively. Therefore, the venture capital investment in 2011 was CNY 203.66 billion - CNY 149.13 billion = CNY 54.53 billion, which is the equivalent of 6,773 million Euro. (Wang Yuan, Zhang, et al., 2012)

Cost of patent application and maintenance for SMEs, in Purchasing Power Standards (PPS) Euro

- Chinese indicator definition: Cost of patent application and maintenance for SMEs, calculated as CNY 88,255, which is equivalent to 14,709 PPS Euro (Source: Authors' calculation)

Cost of patent application and maintenance for SMEs, per billion GDP in Purchasing Power Standards (PPS Euro)

- Chinese indicator definition:
    - Definition of numerator: The cost of patent application and maintenance for SMEs, recorded as 14,709.2 for 2011 (in PPS Euro)
    - Definition of numerator: GDP recorded as CNY 47,288.16 billion for 2011, equalling to PPS Euro 875,86 billion (China Statistical Yearbook 2012, Table 2-1)

Table 3 below shows the cost of obtaining and maintaining an invention patent in China.

Table 1. Cost of obtaining and maintaining an invention patent in China

Procedural Fee Items	RMB
Filling fee	950
Search fee (including examination fee)	2,500
Renewal fees of the application for the 3rd year	900
Renewal fees of the application for the 4th year	1,200
Fee for grant	255
Claims Tax	150
Total Procedural Fees	**5,955**
Maintaining costs for 20 years	82,300
Total including maintaining costs (CNY)	88,255
Total including maintaining costs (PPP€)	14,709.2

Source: http://www.sipo.gov.cn/zlsqzn/sqq/zlfy/200905/t20090515_460473.html

Note: The median number of claims of a Chinese invention patent is six.

Additional Indicators

New ISCED 6 (doctoral) graduates in the fields of science and engineering

- Chinese indicator definition: Graduates in the fields science and engineering (Source: China Statistical Yearbook 2012 Table 20-11)
- Chinese indicator value: 27,584 (2011)

Scientists and engineers as a % of total employment/ or the labour force

- Chinese indicator definition:
    - Definition of numerator: Employment in scientific research, technical service, geological survey, information transmission, software and computer services, construction, manufacture of transport equipment, manufacture of communication equipment, manufacture of computers and other electronic equipment, manufacture of electrical machinery and equipment, manufacture of special equipment, manufacture of chemical raw materials and chemical products, pharmaceutical industry, fiber industry. This was recorded as 78,119,330 for 2010, (Source: 2010 population census of the People's Republic of China, Part 2, Table 4-4)
    - Definition of denominator: Total employment recorded as 715,479,890 for 2010 (Source: 2010 population census of the People's Republic of China, Part 2, Table 4-4)
- Remark: Part 2 of the 2010 population census of the People's Republic of China is Long Table Data, and it is achieved by survey sampling according to a 10% sampling proportion. The raw data in the table was divided by 10% and the result is the data above.
- Chinese indicator value: 10.92%

Public expenditure on education broken down by primary, secondary tertiary level, as a % of GDP and spending on education institutions per students.

- Chinese indicator definition A: Public expenditure on education broken down by primary, secondary, and tertiary level, as a % of GDP (2010).
  - Definition of numerator: Government appropriation for primary schools, secondary schools and higher schools all together for 2010 (including institutions of higher education for adults) (120,8575.71 million CNY or 134,697.77 million Euro), and respectively for primary schools (464,299.53 million CNY or 51746.95 million Euro), secondary schools (4,47744.12 million CNY or 4,9901.82 million Euro) and higher schools (including institutions of higher education for adults: 296,532.06 million CNY or 3,3048.99 million Euro, not including institutions of higher education for adults: 290180.26 million CNY or 32341.07 million Euro).The Exchange Rate of Euro against CNY (Period Average of 2010) is 8.9725. (Source: China Statistical Yearbook 2012 Table 20-40 and China Statistical Yearbook 2011 Table 6-2)
  - Definition of denominator: GDP 40,120.2 billion CNY, which is equivalent to 4471.46 billion Euro (Source: China Statistical Yearbook 2011, Table 2-1 and Table 6-2)
- Chinese indicator value: 3.012% (primary, secondary and higher all together, including institutions of higher education for adults). 0.739% (higher, including institutions of higher education for adults), 0.723% (higher, not including institutions of higher education for adults, i.e. just including regular institutions of higher education), 1.12% (secondary schools), 1.16% (primary schools)
- Chinese indicator definition B: Public expenditure on education broken down by primary, secondary, tertiary level spending on education institutions per students (2010)
  - Definition of numerator: Government appropriation for primary schools, secondary schools and higher schools all together for 2010 (including institutions of higher education for adults) (1208575.71 million CNY 134697.77 millions of Euro), and respectively for primary schools (464299.53 million CNY 51746.95 millions of Euro), secondary schools (447744.12 million CNY 49901.82 millions of Euro) and higher schools (including institutions of higher education for adults: 296532.06 million CNY 33048.99 million Euro, not including institutions of higher education for adults:

290180.26 million CNY 32341.07 million Euro). The Exchange Rate of Euro against CNY (Period Average of 2010) is 8.9725. (Source: China Statistical Yearbook 2012 Table 20-40 and China Statistical Yearbook 2011 Table 6-2)

  - Definition of denominator: Total enrolment of primary schools, secondary schools and higher schools all together in 2010 (including institutions of higher education for adults) (213,333,739 persons), and respectively for primary schools (101,353,616, persons), secondary schools (77,811,653 persons) and higher schools (including institutions of higher education for adults and other degree of higher education, such as employees enrolled, students enrolled in online courses: 34,168,470 persons, just including regular institutions of higher education: 23,856,345 persons) (Source: China Statistical Yearbook 2011 Table 20-2)

- Chinese indicator value: 5,665 CNY/person or 631.39 Euro/person (primary, secondary and higher all together, including institutions of higher education for adults and other degrees of higher education), 8,678 CNY/person or 967.18 Euro/person (higher, including institutions of higher education for adults and other degrees of higher education, such as employees enrolled, students enrolled in Internet-based courses), 12,430 CNY/person or 1355.66 Euro/person (higher, not including institutions of higher education for adults or others, i.e. just including regular institutions of higher education), 5,754 CNY/person or 641.29 Euro/person (secondary schools), 4,581 CNY/person or 510.56 Euro/person (primary schools).

Private expenditure on education as a % of GDP

- Chinese indicator definition:
  - Definition of numerator: Sum of funds from private schools, donations and fund-raising for running schools and other educational funds recorded as 785,71.38 million CNY (approx. EUR 95,82) (Source: China Statistical Yearbook 2012 Table 20-40)
  - Definition of denominator: GDP 40,120.2 billion CNY (approx. EUR 4,351 billion) (Source: China Statistical Yearbook 2011, Table 2-1).
- Chinese indicator value: 0.196% (2010)

3. Further results from Chapter 3

3. Further results from Chapter 3

This section presents further results relevant to Chapter 3: Mapping of China's research and innovation capabilities in selected technologies of the report on the study - Science, Technology and Innovation (STI) Performance of China (N° RTD-2011-C6-China). It provides an analysis of the development of the patent output in eight sectors and the development of patent output in three cross-cutting technologies under consideration in Chapter 3. The patent data for China is compared with that for the EU[1], the US, Japan and the rest of the world (RoW).

Development of patent output in eight sectors under consideration

Figure 1 shows the development of the number of PCT applications from 1990-2010 related to chemical products. Overall, it points to a steep increase of patenting in this sector in the 1990s, levelling off to a moderate growth in the early 2000s, to a slight decrease since 2006. China's patenting behaviour in this sector does not correspond to this overall development. The number of Chinese patents has been increasing since the year 2001, after a slight decrease from 2000 to 2001. In particular it is notable that Chinese patent output in Chemical Products also has increased after 2006 which marks a global turnaround to a decrease in global patenting in this sector. However, the decrease after 2006 is to a large extent devoted to the US patenting behaviour. For the EU27 stagnation is observed in this time period, while growth - as for China - can also be observed for Japan and RoW.

1 EU refers to the EU15 up to 2003, the EU25 from 2004, and the EU27 from 2007. EU28 data was not available at the time of writing.

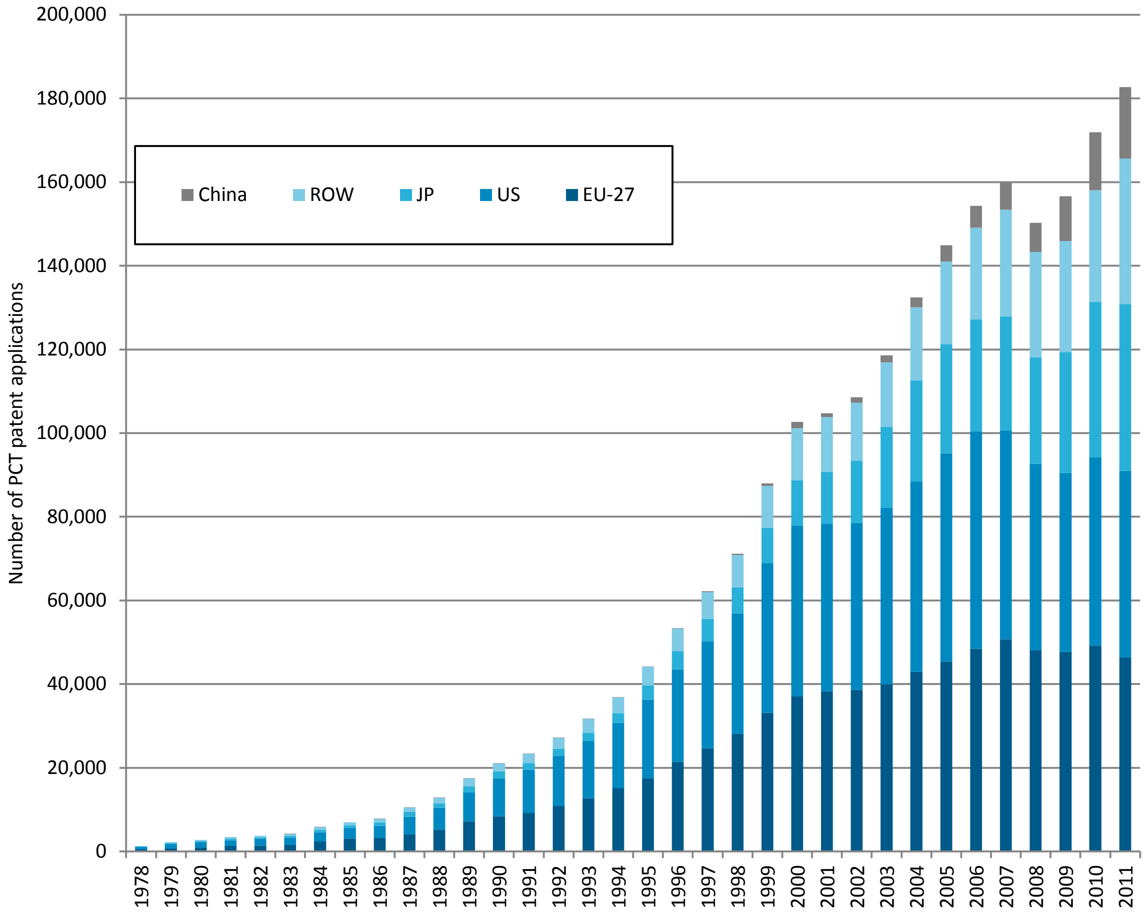

Figure 1. Number of PCT patent applications: chemical products (1990-2011)[2]

Source: OECD, REGPAT database, January 2014, own calculations

A picture similar to that for Chemical Products can be observed for Pharmaceuticals (Figure 2), which may be related to the fact that larger global players in these sectors often patent in both IPC classes. Also for pharmaceuticals there has been significant growth in the number of patents for China after 2001. The year 2000 in this sector seems to constitute some significant outlier, as the number of Chinese patents in this year is nearly as high as that in 2010. While the US seems much more active in Chemical Products than in Pharmaceuticals, the contrary is true for EU27 that shows a much higher number of patents in Pharmaceuticals than in Chemical Products. Japan and RoW show a very high number of patents in Pharmaceuticals, much higher than that of the US.

2 EU refers to the EU15 up to 2003, the EU25 from 2004, and the EU27 from 2007. EU28 data was not available at the time of writing.

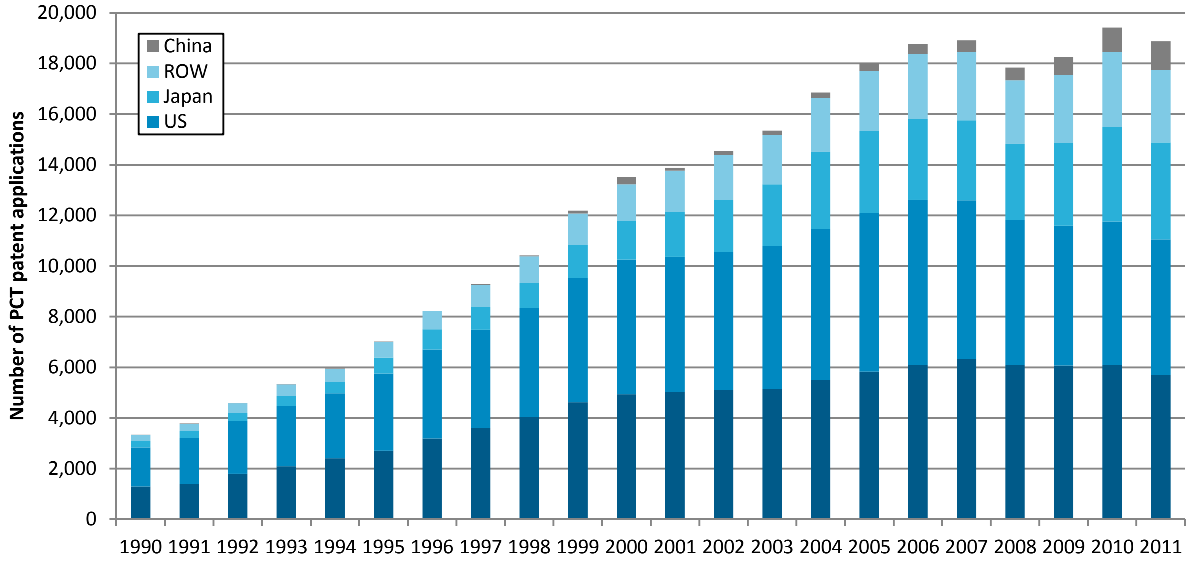

Figure 2. Number of PCT patent applications: pharmaceuticals (1990-2011)[3]

Source: OECD, REGPAT database, January 2014, own calculations

Figure 3 presents the results for Fabricated Metal Products. The development of global patenting was found to differ from the development in Pharmaceuticals and Chemical Products as seen in Figures 1 and 2. It is possible to observe a very regular increase in patenting since the early 1990s until 2007, followed by a short hiatus in 2008, and a significant increase again in 2009 and 2010. However, the growth after 2008 was exclusively subject to higher patent applications from China, Japan and RoW, while patenting in the US and the EU remained at the level of 2008. The Chinese development seems to be the same as for Chemical Products and Pharmaceuticals; patenting intensity gradually increased after 2000 which was nearly non-existent in the 1990s.

3 EU refers to the EU15 up to 2003, the EU25 from 2004, and the EU27 from 2007. EU28 data was not available at the time of writing.

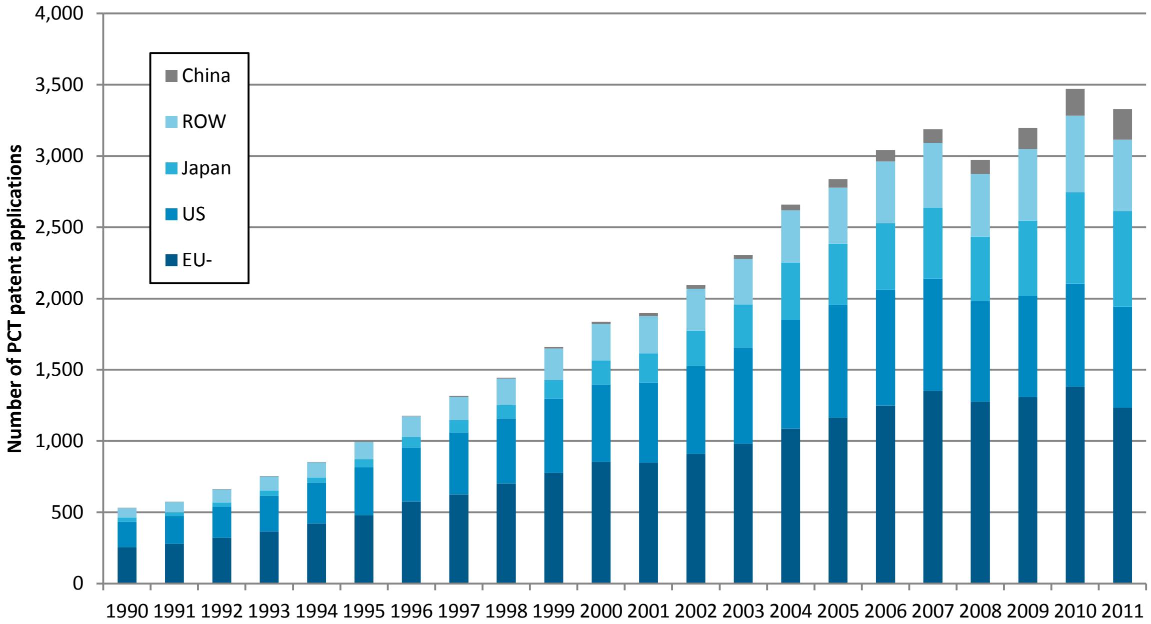

Figure 3. Number of PCT patent applications: metal products (1990-2011)

Source: OECD, REGPAT database, January 2014, own calculations

The sectors Computers, Electronic and Optical Products (Figure 4), and Electrical Equipment (Figure 5), were found to be the strongest sectors of the Chinese economy with respect to patenting intensity. As mentioned above, this is related to an immense patent portfolio of the large multinational companies Huawei and ZTE. In 2010, ZTE and its daughter companies applied for about 3.500 patents, Huawei and its related daughter companies for around 1.500. With these values they were also the top actors in patenting in these areas at a global scale in 2010.

The overall development in the two sectors seems relatively similar, both for the global development and the Chinese development. In Computers, Electronic and Optical Products, Chinese growth seems to be more pronounced especially in the recent past from 2009 to 2010, and from 2004 to 2005. Also for RoW and Japan an increasing trend in both sectors was observed; Japan even showing the highest global patent intensity with a considerable growth over the past few years. For the EU and the US decreasing or stable figures after 2006 were seen. Extrapolating this trend, China will surpass the US and the EU with respect to patenting in electronic related products and devices before 2020. Given the large market size of the Chinese domestic market, competition among the large Chinese players may further stimulate innovation efforts in the near future.

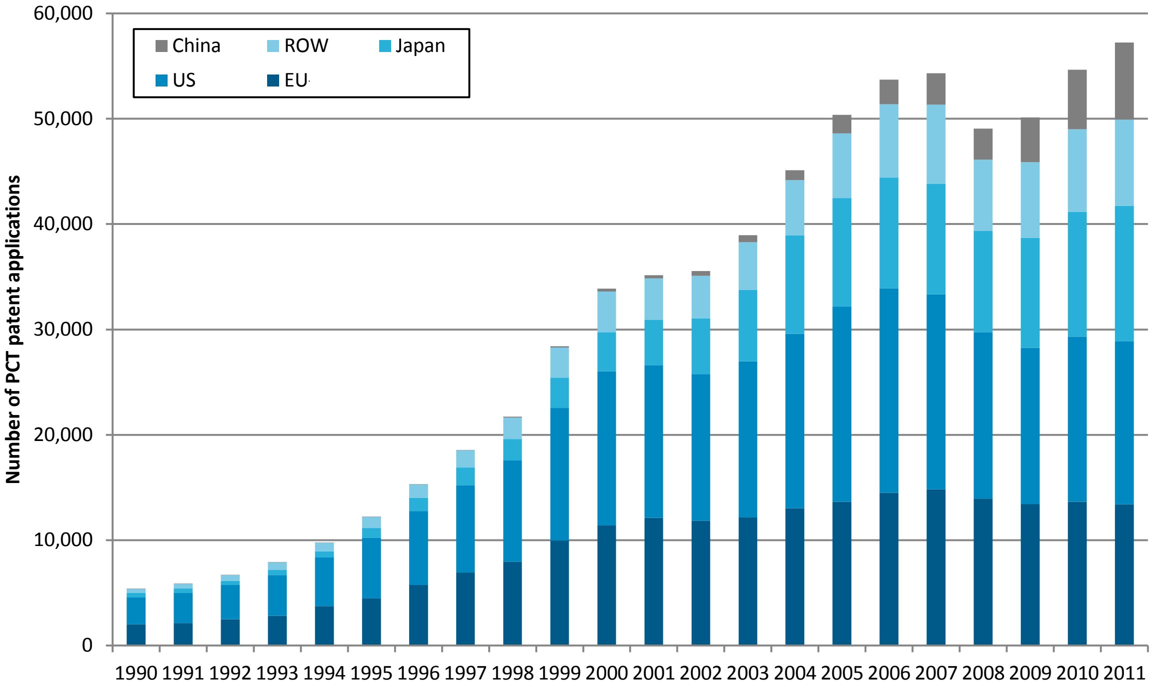

Figure 4 Number of PCT patent applications: computers, electronic, optical products (1990-2011)

Source: OECD, REGPAT database, January 2014, own calculations

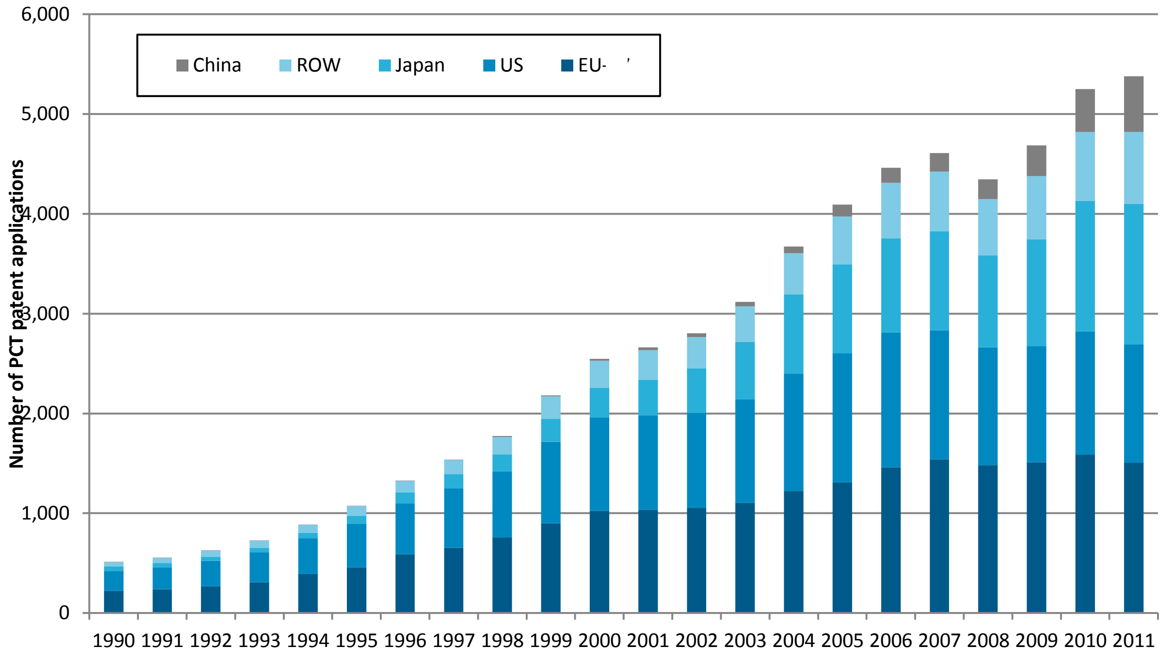

Figure 5. Number of PCT patent applications: electrical equipment (1990-2011)

Source: OECD, REGPAT database, January 2014, own calculations

Figure 6 presents a quite similar picture for the sector Machinery and Equipment, though the number of Chinese patents had not yet reached such a high number as in electronic related products and equipment by 2010. However, also for Machinery and Equipment there were signs of increasing trends for the most recent years for China, and decreasing trends for the US and the EU. RoW and Japan have shown considerable growth in this sector over the past three years.

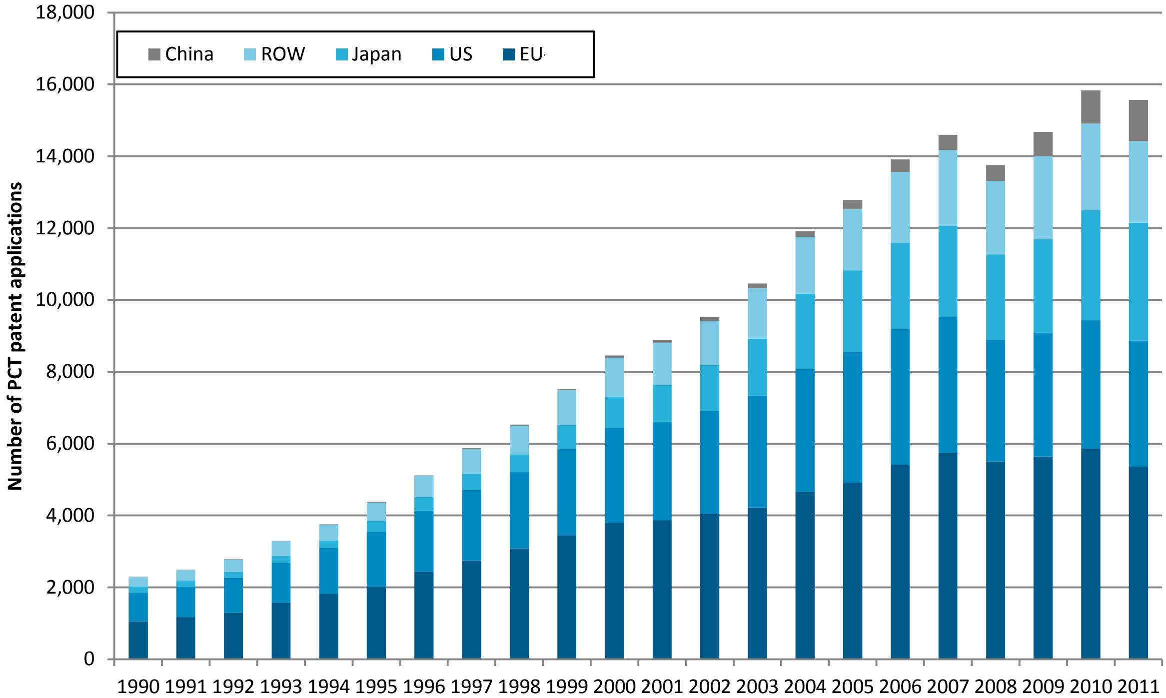

Figure 6 Number of PCT patent applications: machinery and equipment (1990-2010)

Source: OECD, REGPAT database, January 2013, own calculations

In Figure 7and Figure 8 attention is directed to the transport related sectors, Motor Vehicles and Other Transport (mainly ship transport and aerospace). The overall development was comparable to that of Machinery and Equipment in both sectors. It was striking that firms in the EU were by far the most important performers of transport-related inventions as captured by patents. For China, the results for transport related sectors were comparable to those of sectors related to chemical and pharmaceutical industries. Chinese actors began to patent after 2000, showing a rather regular growth until 2010, also after the usual hiatus in patenting intensity during the crisis in 2008.

Though China is still mainly an importer of transport related equipment, such as the high-speed trains introduced in the recent past that were constructed by German or Japanese firms, Chinese firms are improving their technological capabilities in these fields. Having in mind the potential of a huge

Chinese market with immense needs for innovations that have to deal with challenging requirements of the Chinese transport system, the innovation competition between Chinese and foreign actors will most likely increase considerably in the near future.

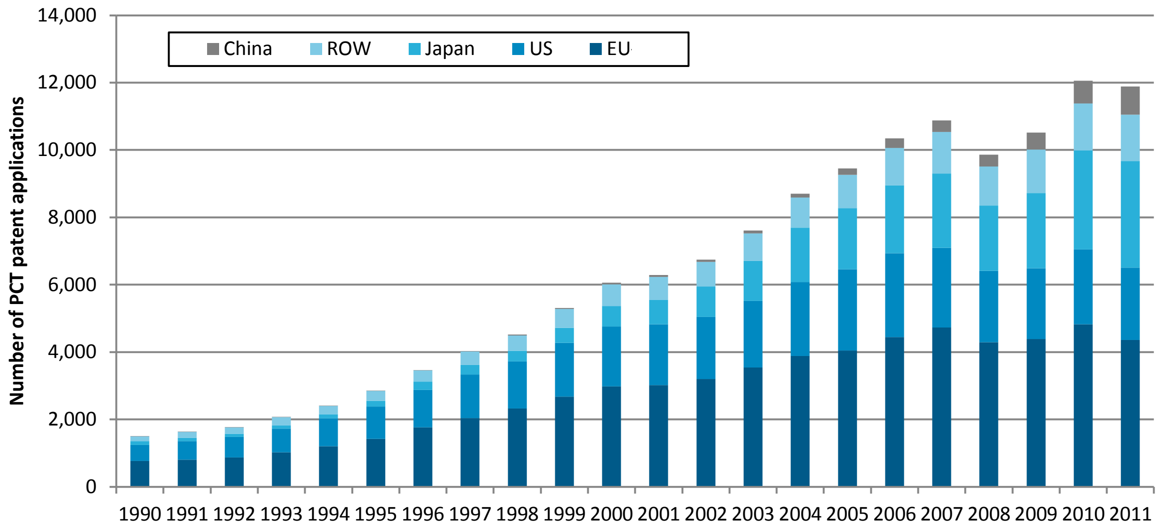

Figure 7 Number of PCT patent applications: motor vehicles (1990-2010)

Source: OECD, REGPAT database, January 2013, own calculations

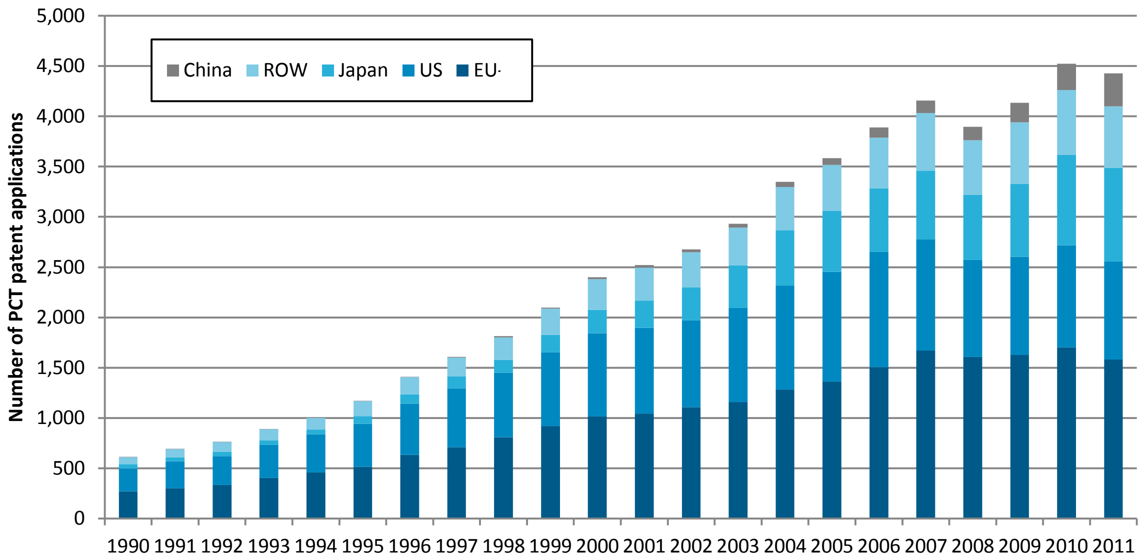

Figure 8. Number of PCT patent applications: other transport equipment (1990-2010)

Source: OECD, REGPAT database, January 2013, own calculations

Development of patent output in three cross-cutting technologies

While the development of patent output was often quite similar across the eight sectors - as demonstrated above - the development of patent output in the cross-cutting technologies was much more diverse and differs to a larger extent from the overall development. In the following paragraphs an analysis of the number of PCT patent applications for the three cross-cutting technologies under consideration is presented. With regard to Environmental Technologies, a more detailed investigation is provided - next to the overall development in Environmental Technologies by disaggregating the key subcategories Wind Energy and Photovoltaics.

Figure 9 initially illustrates the development of the number of PCT patent applications in Biotechnology, clearly a key industry over the past decades in its contribution to worldwide economic growth. It was found that the development of patenting was significantly different from global patenting as a whole. A rather steep growth of biotechnology patenting was seen in the 1990s, with an enormous increase in the number of patents between 1999 and 2000. After 2000, annual patenting in biotechnology rather stagnated or slightly decreased, with the exception in 2007. Surprisingly, China had a very large share of biotechnology patents in the boom year 2000.

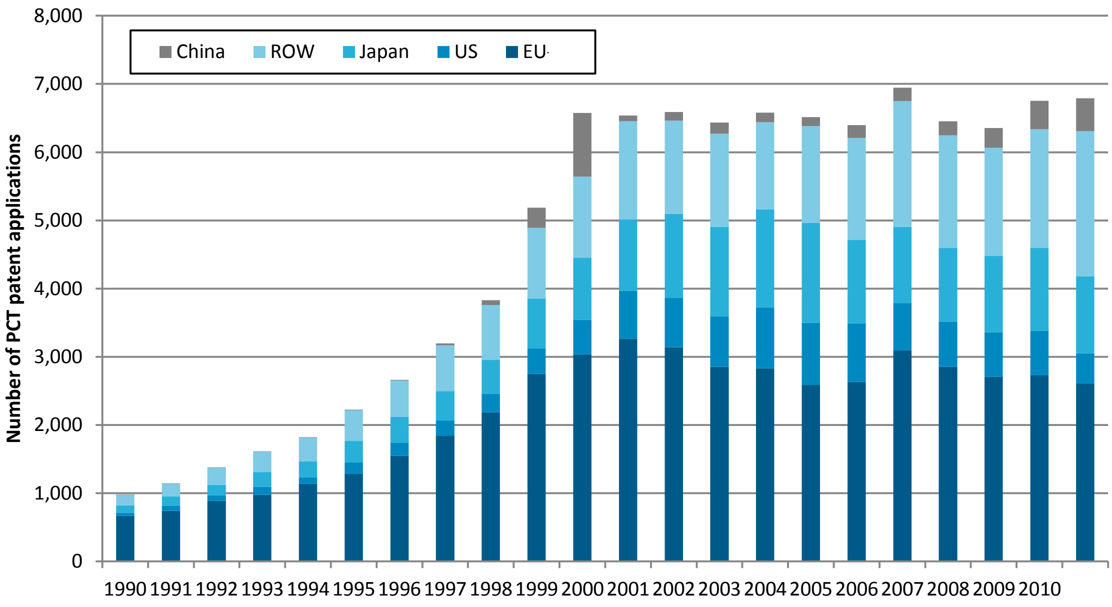

Figure 9. Number of PCT patent applications: biotechnology (1990-2010)

Source: OECD, REGPAT database, January 2013, own calculations

However, this was related to a very high number of patent applications by one single biotechnology company (Biowindow based in Shanghai) that did not patent in the following years. After the year

2000, the share immensely decreased between 2000 and 2001 before it gradually increased again between 2001 and 2010. There are no policy documents or scientific works that provide an explanation for this development. The EU was the undisputed global leader in patenting in biotechnology over the whole time period under consideration, accounting for nearly 50% of global biotechnology patent applications.

Figure 10 shows the number of PCT patent applications in Nanotechnologies. It becomes obvious that the extensive growth phase in nanotechnology research was in the late 1990s and early years of the millennium. Following this, patenting in nanotechnology decreased considerably, in particular after 2007. It may be the case that nanotechnology applications have been more and more directly integrated in concrete products and thus patented in other IPC classes, such as electrical devices and electrical equipment. China showed a low level of patenting in Nanotechnologies over the whole time period under consideration. Although China has high publication intensity in this field, it seems that actors that patent new technological devices integrating nanotechnology rather apply in other IPC classes.

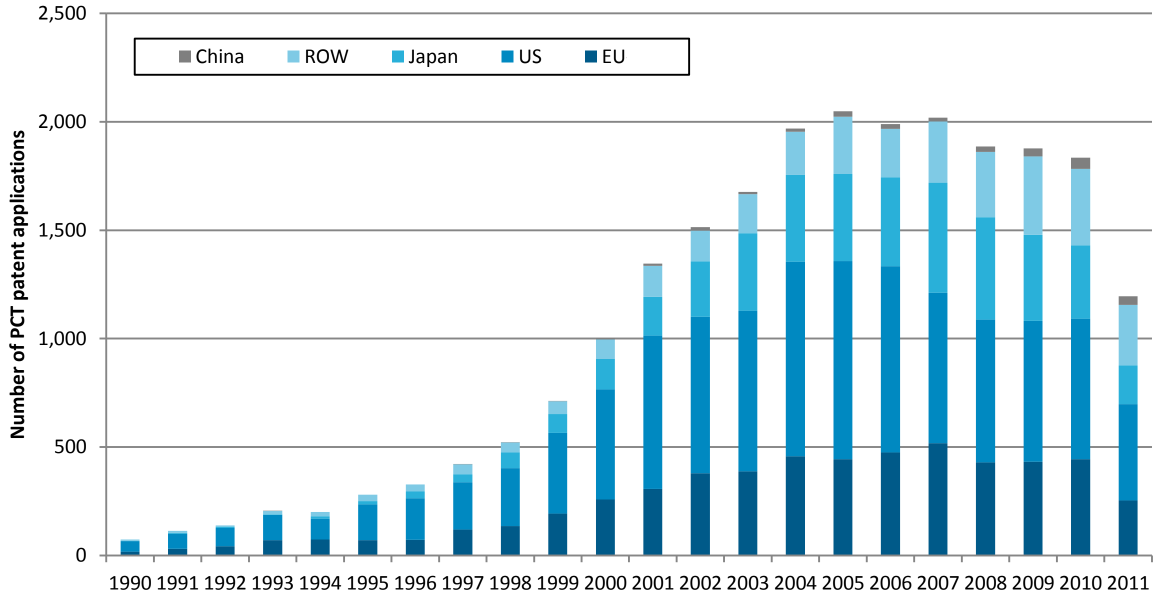

Figure 10. Number of PCT patent applications: nanotechnologies (1990-2011)

Source: OECD, REGPAT database, January 2014, own calculations

As to Environmental Technologies, Figure 11 initially presents the number of PCT patent applications for the whole sector during the time period under consideration. As illustrated a regular growth was seen between 1990 and 2009, with very high growth rates between 2006 and 2009. The year 2010 shows a decline to a scale slightly below 2007. However, this decline was mainly subject to the EU, the US and RoW which may be related to economic constraints in these countries. For China, the results show that patenting was marginal before 2004, but gradually increased after 2004, also during the global decline in 2010. This underlines that massive investment in green technologies by the Chinese government and regional authorities has led to a significant increase in patenting in environmental technologies. Facing huge environmental problems related to increasing emissions of green-house gases and the deterioration of natural resources, the Chinese government and regional authorities have devoted the highest funds globally to new environmental and energy technologies over the past years which may to a large extent explain these results.

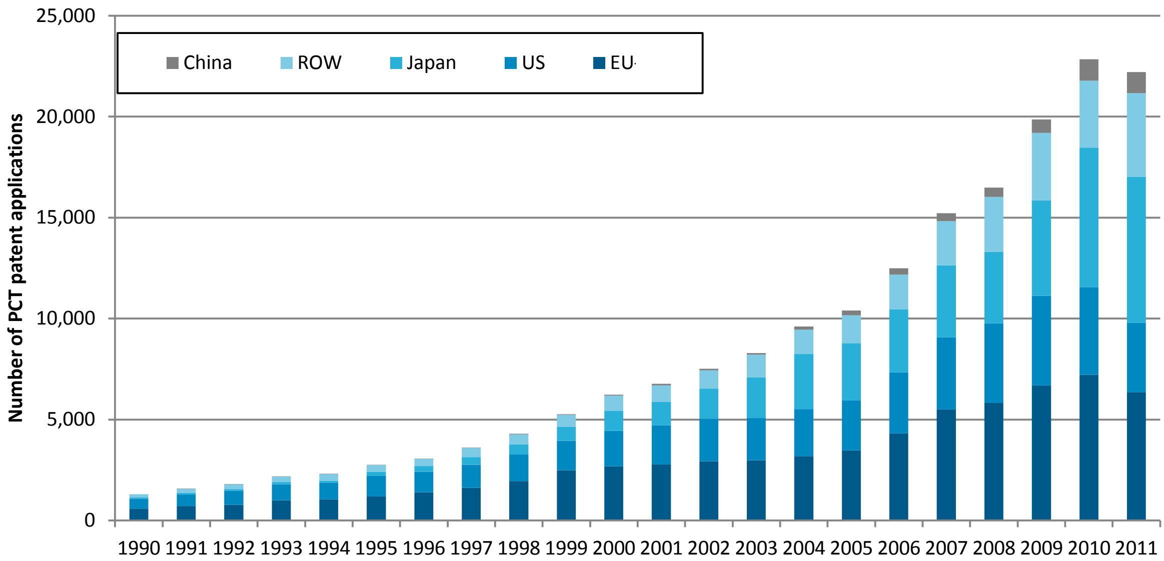

Figure 11. Number of PCT patent applications: environmental technologies (1990-2011)

Source: OECD, REGPAT database, January 2014, own calculations

Figure 12 and Figure 13 underpin China's catching up in environmental technologies by zooming deeper into two key fields of this cross-cutting area. Figure 12 visualizes the global development in patenting in the field of Wind Energy. After a moderate growth between 1998 and 2005, patenting in wind energy increased after 2005. As for environmental technologies as a whole, a sharp decline in the year 2010 was experienced, again presumably related to economic constraints. Although China's patent output also slightly declined in 2010, the decrease was marginal compared to other countries, in particular as compared to the US that showd the largest decline in 2010. A rather similar picture was found for photovoltaic technologies (Figure 13). The development of patenting followed a very similar trend to that of wind energy, including the hiatus in the year 2010. However, China was the only country that did not show a decreasing trend in 2010, while the EU, the US and RoW together nearly decreased by 50%.

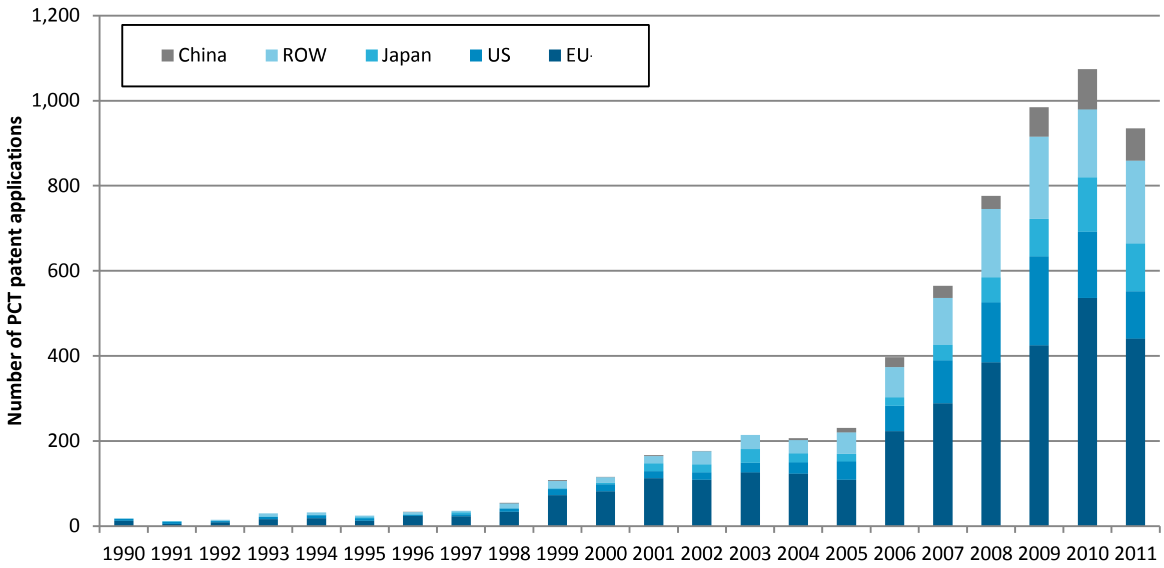

Figure 12 Number of PCT patent applications: wind energy (1990-2011)

Source: OECD, REGPAT database, January 2014, own calculations

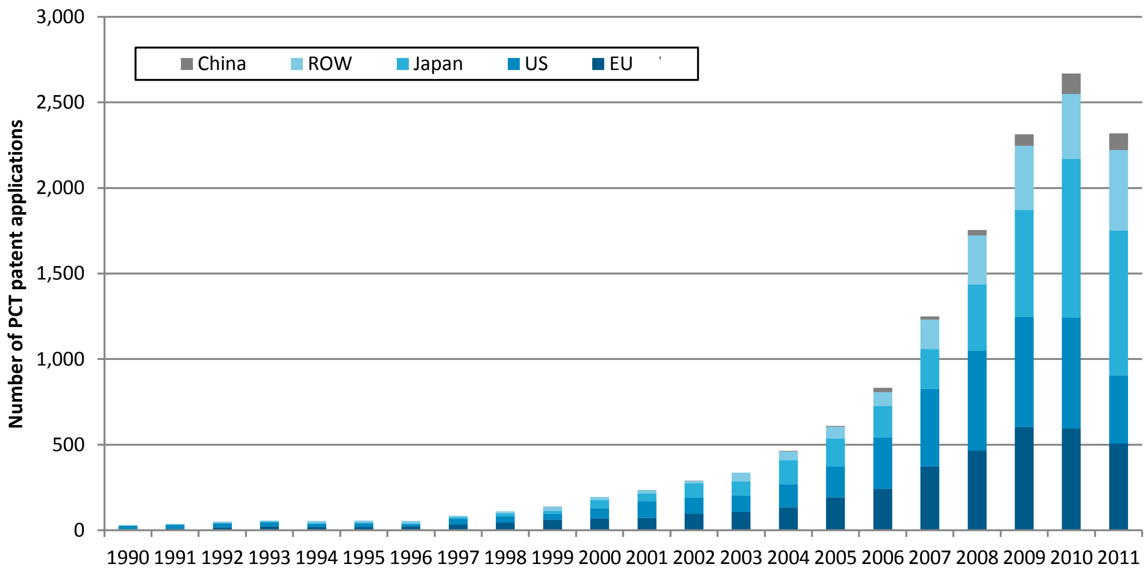

Figure 13 Number of PCT patent applications: photovoltaic (1990-2011)

Source: OECD, REGPAT database, January 2014, own calculations

4. Summary of the survey results

Sociedade Portuguesa de Inovação

UNITED NATIONS UNIVERSITY

UNU-MERIT

AUSTRIAN INSTITUTE OF TECHNOLOGY

TOMORROW TODAY

4. Summary of the survey results

This section presents a summary of the responses provided during the survey performed in the study. The survey aimed at analysing and identifying the main trends in policy-making and funding system for STI development in China, and to analyse China's international strategy concerning STI.

The survey questions covered:

- Current features of STI policies;
- Policy evaluaton;
- Patterns of international cooperation;
- Human capital for innovation;
- Industrial innovation;
- Indigenous innovation and its impact on foreign firms.

The responses have been divided between the Chinese and European respondents so that any differences in opinions can be extracted.

Current Features of STI policies

As shown in Figure 14 and Figure 15, survey respondents were asked their opinion about what the current features are for China’s STI policy development when compared to those at EU level. Since the overwhelming majority of Chinese respondents (78%) and half of European respondents indicated that China’s STI policy development is driven to larger extent by societal needs and problems, if these views are confirmed by other evidence. This may increase opportunities for collaborative efforts, as EU policy is also increasingly driven by societal challenges, particularly since these challenges often need global solutions and have global impacts. However, 57% of European respondents and a large proportion of Chinese respondents (72%) also indicated a focus on market-driven research for economic growth rather than basic/applied research, which seems to contrast a little with the first point and may mean that social/ environmental aspects are currently not been given sufficient consideration within these societal challenges.

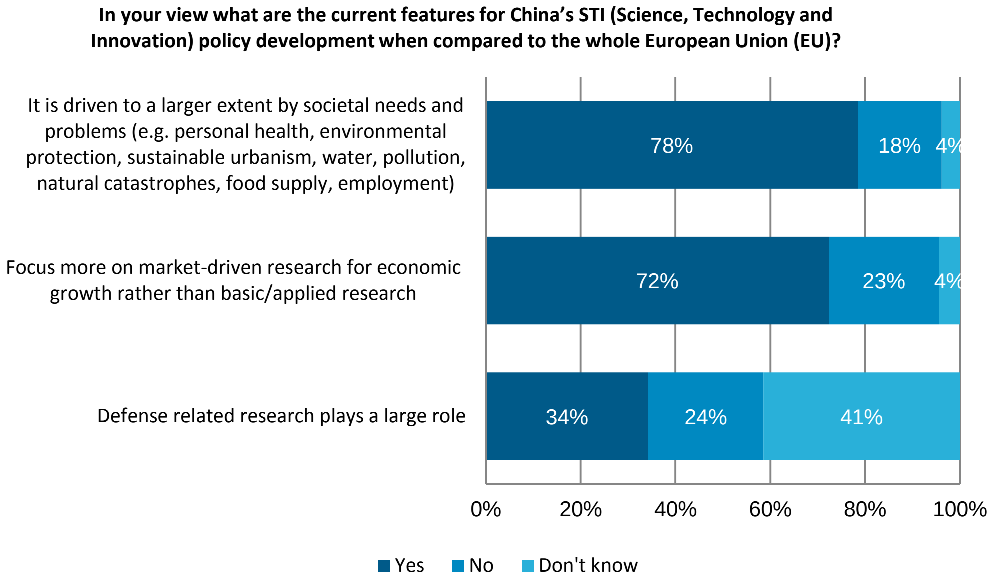

Figure 14 Current features for China's STI policy (Chinese)

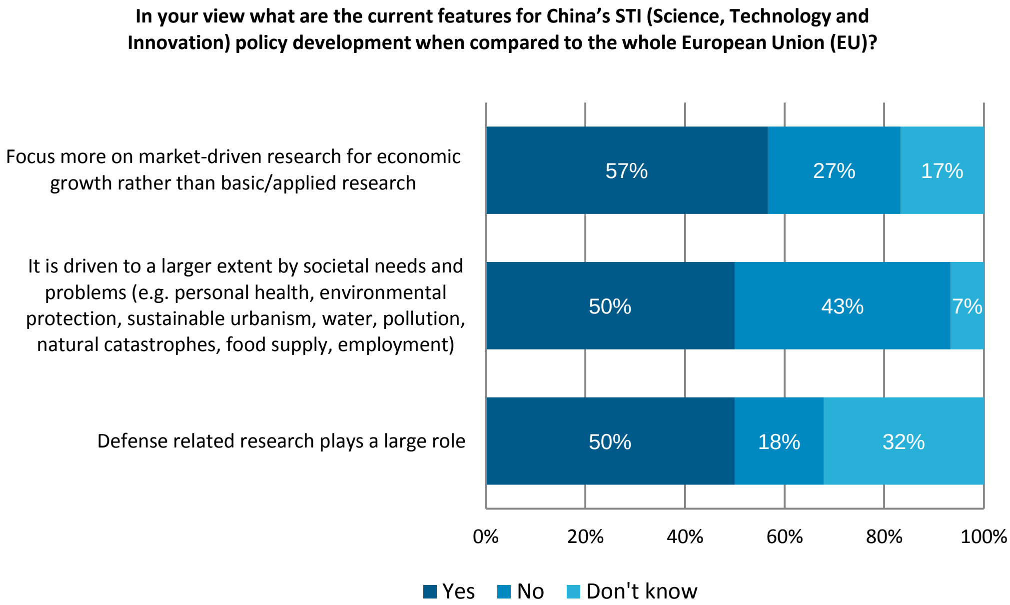

Figure 15 Current features for China's STI policy (European)

On the other hand, only 34% of Chinese respondents considered that defence related research plays a large role, compared to 50% of European respondents Nevertheless it is perhaps interesting to note that a large proportion of stakeholders (41%) stated that they did not know whether or not defence related research played a large role in STI policy development. Such a result could be interpreted in a number of ways. For example, it could mean that respondents didn't have information about this, which could mean that the funding of such sensitive research is not publicised within STI policy or that respondents had not the ability to make the comparison between the situation in China and that in the EU, among other reasons. Thus, this aspect perhaps needs further investigation to determine the reasons behind the answer provided.

Based on the respondents' answers, current features for China's STI Performance are driven to larger extent by societal needs and problems and market-driven research for economic growth rather than by the desire for basic/applied research. Some European respondents believed that Chinese STI tends to follow or copy promising technology Western with application to Chinese societal issues. Chinese respondents pointed out that China's technology innovation focuses more on quantity than on quality, and that the government cannot protect new technologies emanating from Chinese companies. In addition, the government appears to have more inputs on the policy concerning technology innovation, but in many cases they do not meet the social needs. Cooperation between universities and enterprises needs to be strengthened.

Policy evaluation

Figure 16 and Figure 17 below present areas in which respondents consider Chinese STI plans and programmes to be most successful. The answers suggest that the plans and programmes for the promotion of international collaboration, increasing patents submitted, and enhancement of innovation by enterprises have been more successful than those for mobilising human resources quickly, raising international awareness about the strengths of the Chinese S&T system and increasing the number of companies formed. It would of interest to examine the reasons behind this success or lack thereof.

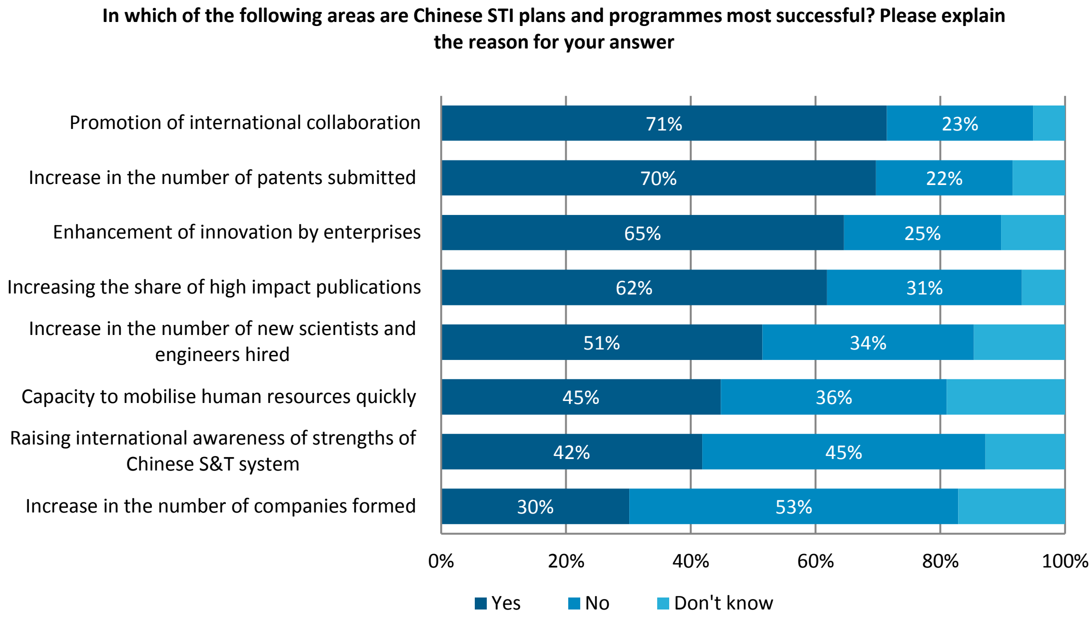

Figure 16. Most successful Chinese STI plans and programmes (Chinese)

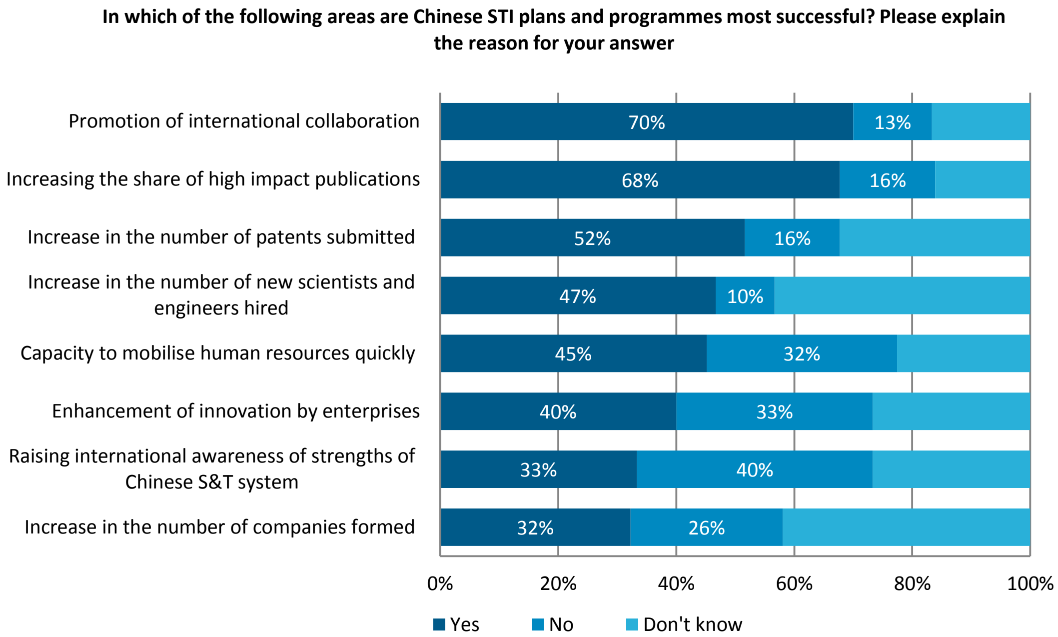

Figure 17 Most successful Chinese STI plans and programmes (European)

When asked about some less successful STI plans and programmes, as illustrated in Figure 18 and Figure 19, all except one of the possible areas included in the study were considered to be less successful by the majority of respondents. In particular, 82 % of the respondents agreed that the promotion of indigenous innovation was less successful. Such consensus suggests that there is general agreement about the lack of success in this area and it would be of interest to determine the reasons behind this. The area considered more successful was STI plans and programmes to increase employment opportunities. It is worth noting that the number of respondents selecting don't know for EU researchers was high for this question (between 19 and 33%), suggesting that EU researchers did not have sufficient knowledge of Chinese policies to comment.

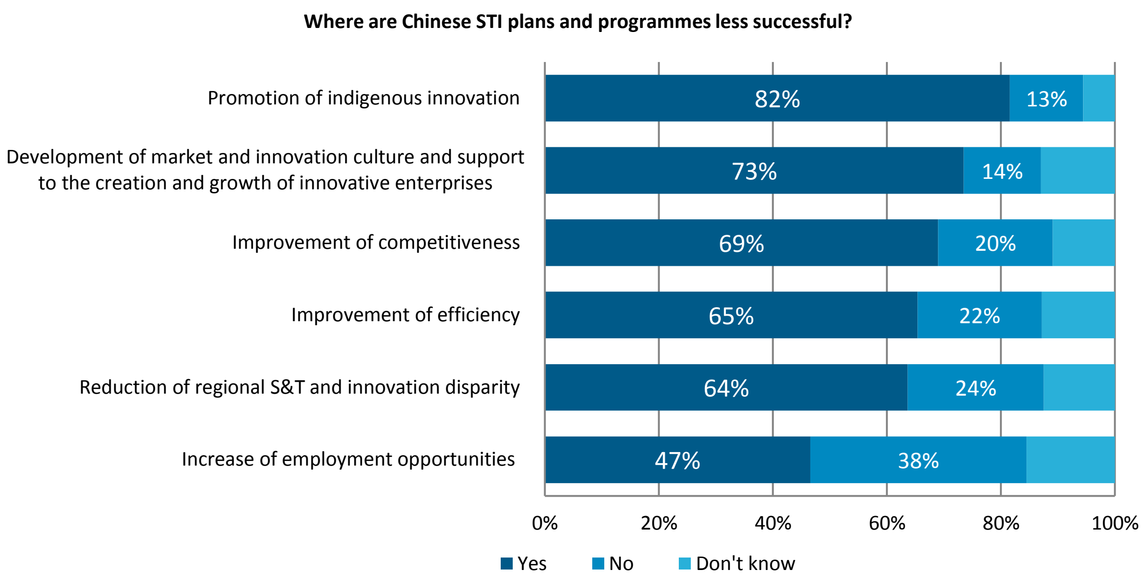

Figure 18 Less successful Chinese STI plans and programmes (Chinese)

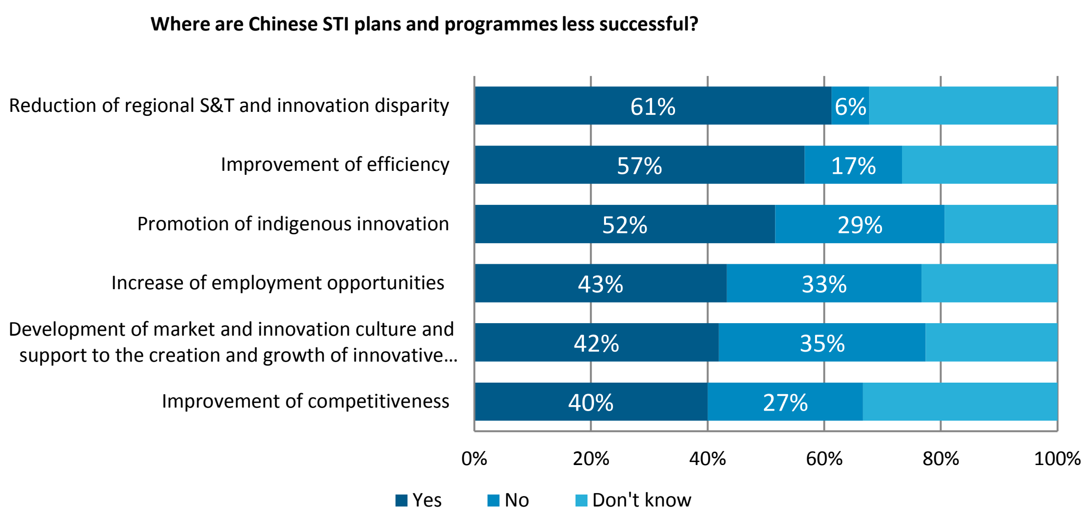

Figure 19 Less successful Chinese STI plans and programmes (European)

China has been expanding the strength of its scientific research, and its innovation plans and projects have effectively promoted innovation in enterprises and the visibility. However, the inputs of capital tend to concentrate on a few groups in certain locations, which are not effective to allocate highly skilled human capital. Some respondents stated that the most important is to improve the organization of innovation management in order to improve the core innovation team in state-owned enterprises. European respondents that commented on Chinese policies believed that they have succeeded in mobilizing enterprises and improving international cooperation, but that they remain mired in bureaucratic and patron-client networks which reduce their effectiveness. In addition, they mention that there is a lot of focus on publications and patents perhaps because it is easier to measure.

Other respondents noted that the gap of scientific research between Chinese and foreign countries is still large. By choosing highly qualified employees and making high quality technology outcomes, they can attract attention from international talent and increase the visibility of China's technology innovation plan. On the other hand, scientists and engineers are the core of innovation, so they can lead the process of promoting international cooperation and facilitate innovation in enterprises.

Some believed that Chinese government has already supported a large number of indigenous innovation related programmes, but not much has been done about increasing innovation efficiency. Moreover, a number of respondents mentioned that many ideas come from foreign countries. For example, some Chinese projects were announced as indigenous innovation, while in fact they were results taken from foreign countries. In general, respondents were of the opinion that although the level of China's technology innovation has been increasing, it is still far from its goal of competing with more developed economic regions such as the US and the EU. They felt that this is mainly due to the incomplete innovation culture and concept, and insufficiencies which exist in both innovation inputs and in support for enterprise innovation.

In regard to the less successful Chinese STI plans and programmes, one respondent mentioned that there are not enough jobs for all the graduates and higher degrees coming out of universities.

The survey respondents were asked what the future focus of STI funding should be in China. Figure 20 and Figure 21 below illustrate the answers provided, where the focus is ranked by importance including: "High importance", "Medium importance", "Low importance", "Not relevant" and "Don't know". In general, most survey respondents gave a high or medium importance to increasing the different aspects mentioned in the survey. Consensus was most evident for increasing support for research aiming at tackling societal challenges with 92% of the Chinese respondents and 97% of European respondents rating this as of high/medium importance. This percentage drops to 73% and 81% for “increasing support for high-risk research”, leading to the conclusion that this was seen as least important, in terms of future focus. These areas of interest, if corroborated by other evidence, could also be important in decisions about collaborative activities with the EU.

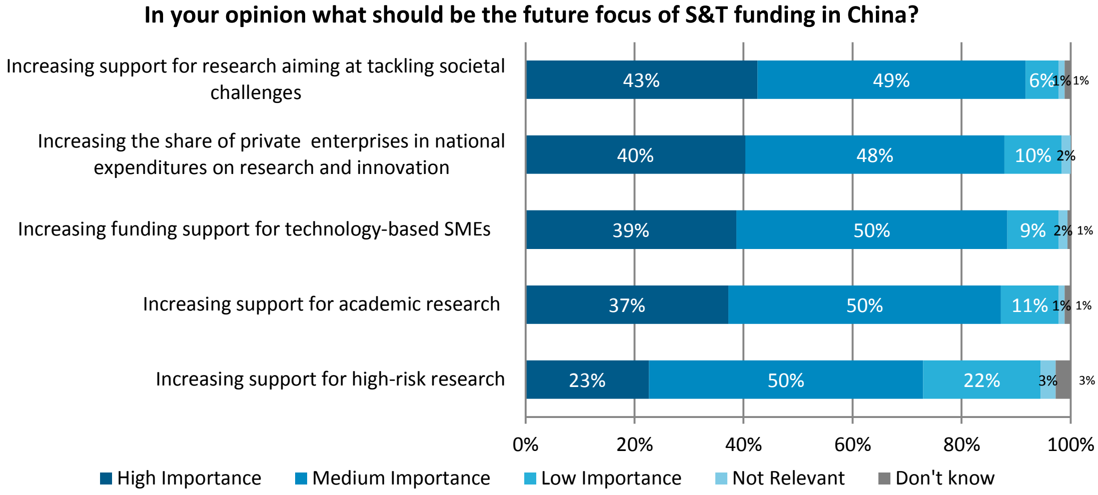

Figure 20 Future focus of S&T funding in China (Chinese)

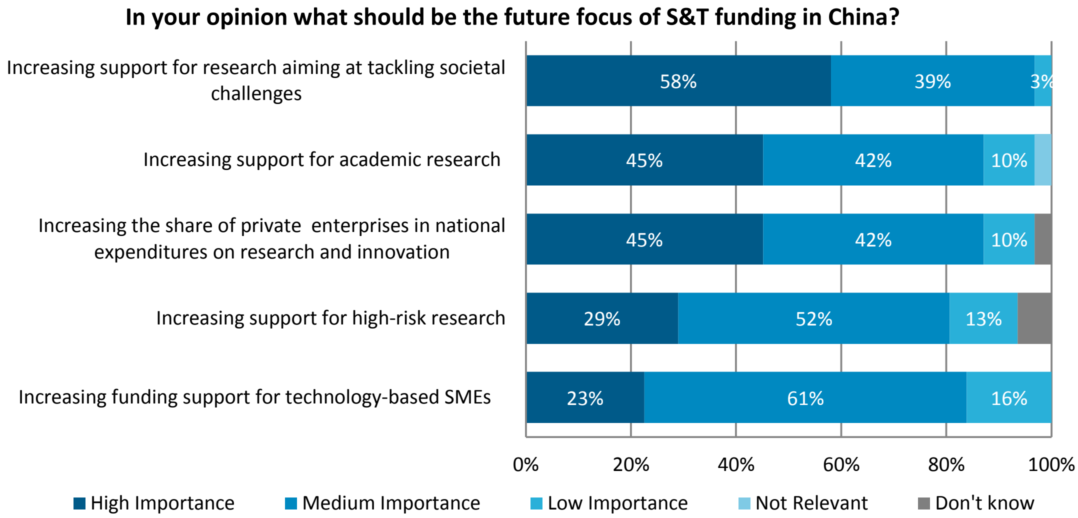

Figure 21 Future focus of S&T funding in China (European)

Chinese respondents considered that the most important focus should be increasing support for research aiming at tackling societal challenges. On the other hand, European respondents stated that the future focus of S&T funding in China should be the increasing share of private enterprises in national expenditures regarding research and innovation, increasing the support for academic research and aiming at tackling societal challenges. The importance is to have the system (not single elements as in the questions) working, i.e. interplay between the elements.

Some respondents stated that the government needs to support innovation by SMEs and other private enterprises, and to increase the efficiency of funding allocation. Compared to large enterprises and research institutes, the research activities by SMEs are considered to be more specific and active.

Respondents highlighted a desire to focus on international cooperation increasing the inputs on basic science and support to young researchers.

Patterns of international cooperation

The survey respondents were asked what has been the main function of international cooperation in developing China's STI capabilities. From Figure 22, it is possible to see that Chinese respondents mainly viewed international cooperation not from the perspective of any access to funding that it might provide, but rather from the perspective of helping in the identification of gaps/opportunities for improving STI capabilities, in the introduction of advanced technologies or in providing training and education of scientific personnel. However, from Figure 23, it is possible to see that 90% of European respondents stated that introduction of advanced technology has been the main function. It would be important to see how these views compare to other investigations about international collaboration with China, but if substantiated they may provide an indication of China's interests and thus influence the development of future collaborative activities in this sense.

Figure 22 Main function of international cooperation in developing China's STI capabilities (Chinese)

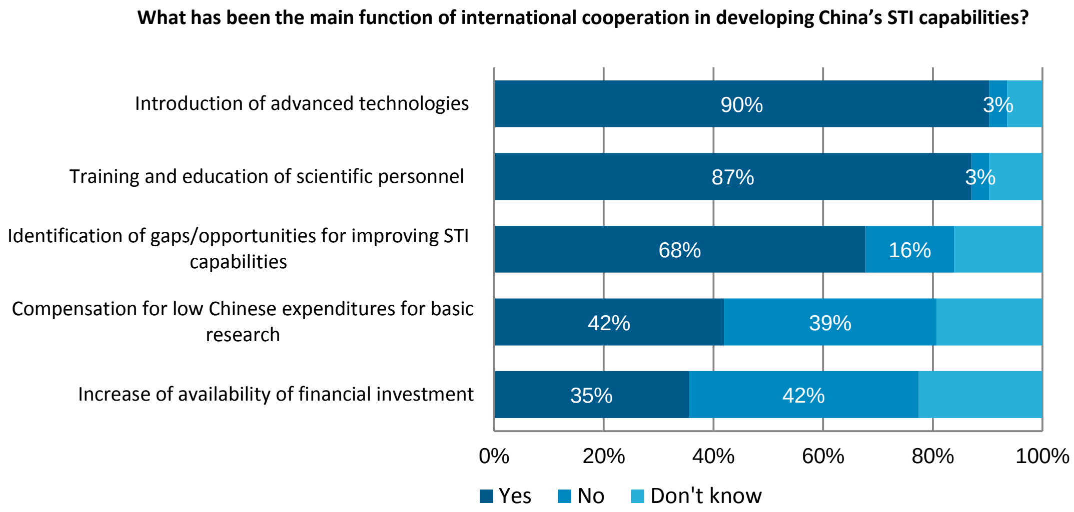

Figure 23 Main function of international cooperation in developing China's STI capabilities (European)

Figure 24 and Figure 25 display the opinions of respondents regarding the main forms of international research/innovation cooperation. For Chinese public stakeholders (public research organizations and firms). It shows evidence of two-way collaboration i.e. both the sending of personnel and the receiving of foreign researchers by Chinese public stakeholders. Both Chinese and European respondents have stated that sending of personnel has been the main form of international research cooperation than those that state hosting a foreign researcher as the main form. This aspect, if verified to be true, could be indication that there are greater opportunities/ or greater perceived benefits for Chinese researchers to go abroad than for their EU counterparts to go to China, or it could be that EU researchers don't access the opportunities available to them for one reason or another (whether because the opportunities are not viewed to be attractive or they have difficulties in accessing them, for example). Such aspects might deserve further investigation.

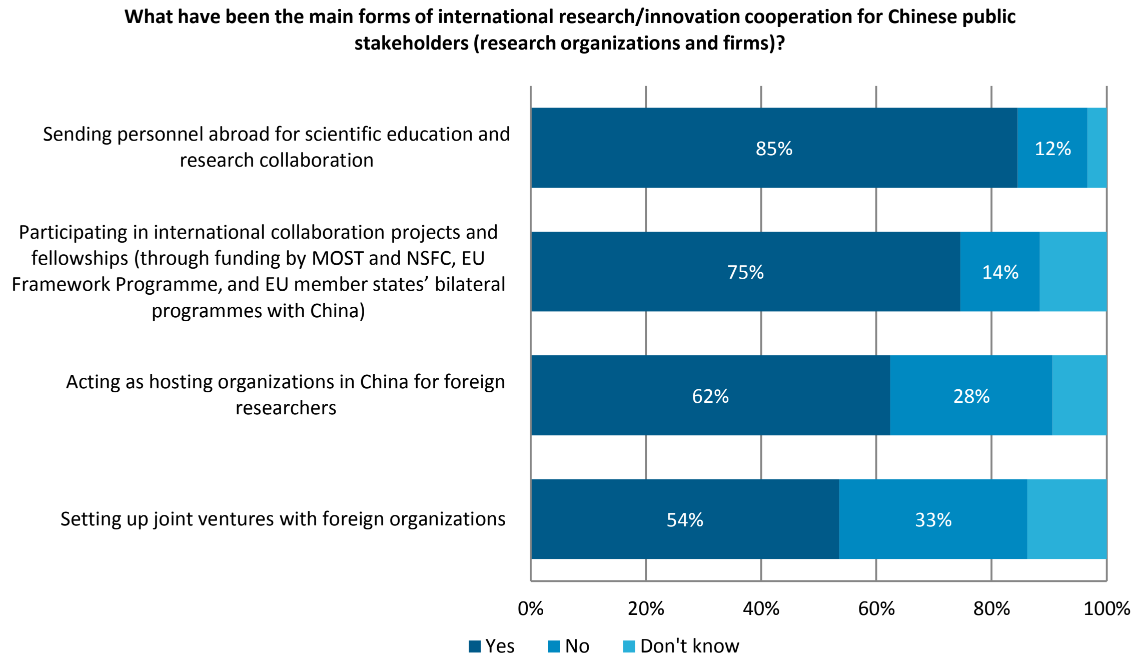

Figure 24 Main forms of international research/innovation cooperation for Chinese public stakeholders (Chinese)

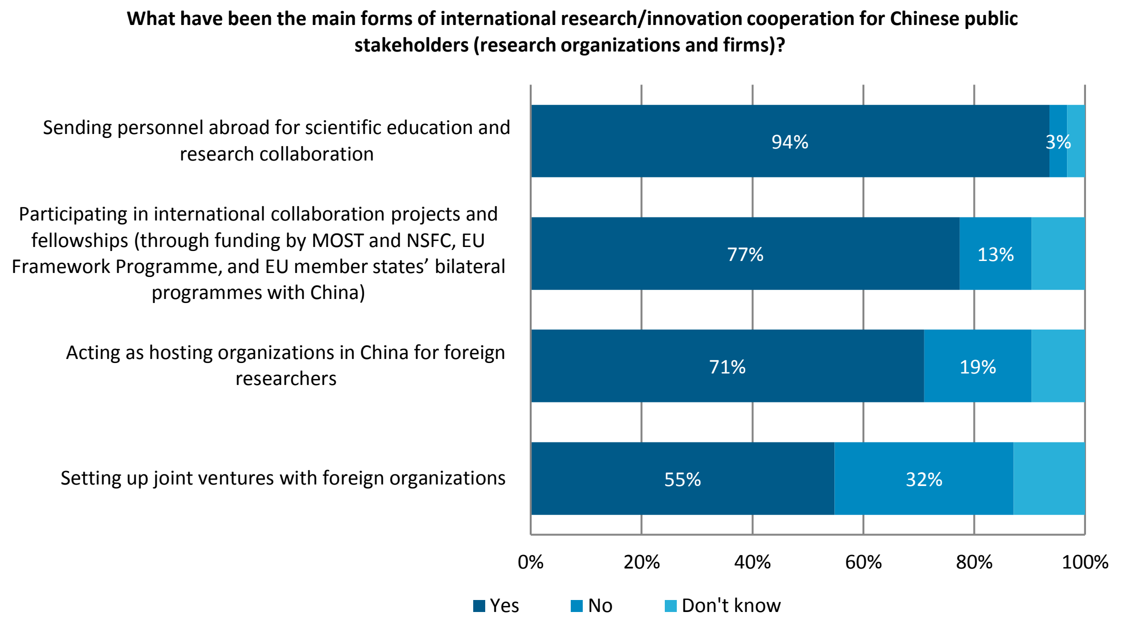

Figure 25 Main forms of international research/innovation cooperation for Chinese public stakeholders (European)

For Chinese public stakeholders, respondents indicated the main forms as below:

- Sending personnel abroad for scientific education and research collaboration;
- Participating in international collaboration projects and fellowship.

In addition to the answers above, some respondents had other opinions, including establishing international innovation cooperation projects, building research institutions overseas, and creating international cooperation platforms.

Questionnaire respondents were also asked what have been the main forms of international research/innovation cooperation for Chinese private stakeholders (private research organizations and firms) in China. The responses, illustrated in Figure 26 and Figure 27 below, again show evidence of two-way collaboration with sending of personnel abroad and the receiving of foreign researchers by Chinese private stakeholders being designated as main forms of international research /innovation cooperation and again it appears to be more common for Chinese personnel to go abroad than for foreign researchers to go to China. It would certainly be worth further examination of the reasons behind such a situation.

Of particular note, in the case of private stakeholders, is the major role of joint ventures, with 74 % of Chinese respondents considering this to be the main form of international research/innovation cooperation. It would be interesting to investigate further the reason why this the main form of collaboration, whether because it is perceived as most beneficial by both parties, whether is necessary for other reasons (e.g. to satisfy certain regulations), is the most flexible, has the least barriers or even just because there are more opportunities than say participating in international collaboration projects. For European respondents, joint ventures and sending personnel abroad are both considered by 58% of respondents.

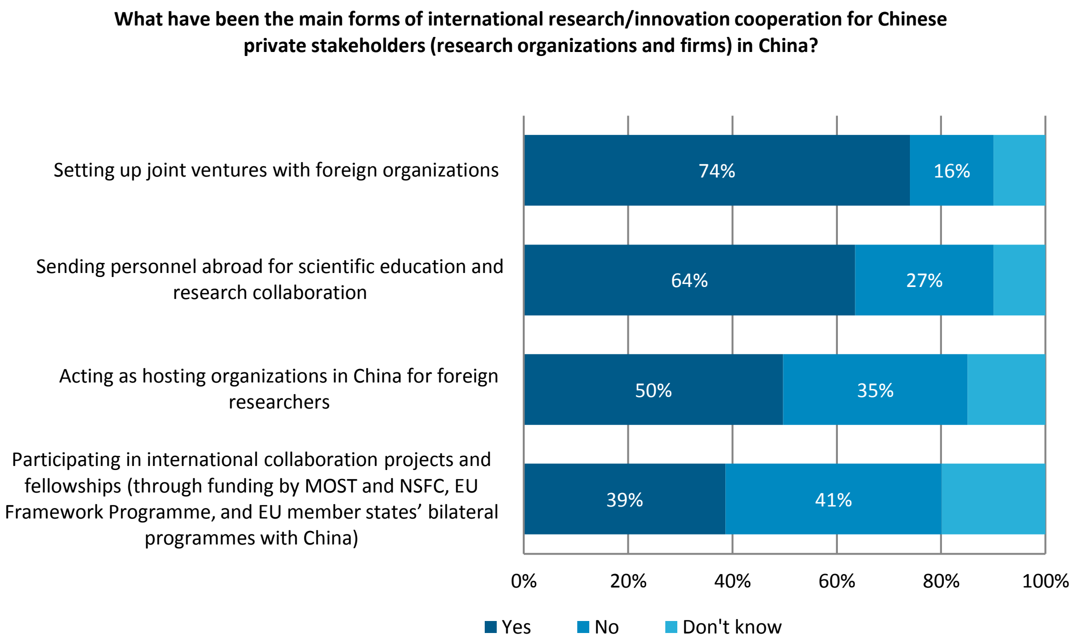

Figure 26 Main forms of international research/innovation cooperation for Chinese private stakeholders (Chinese)

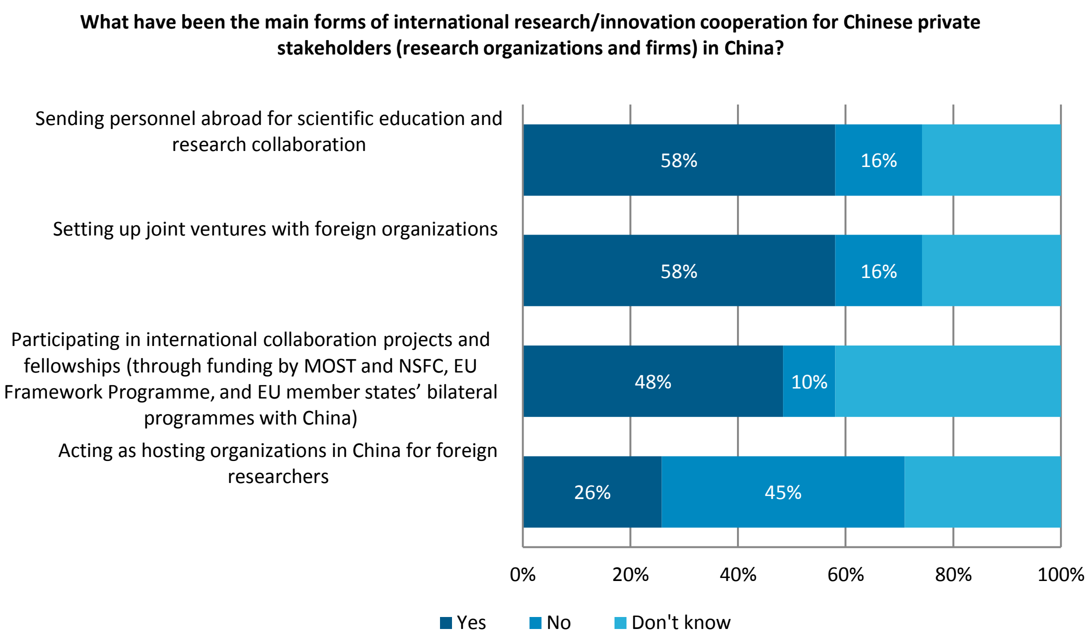

Figure 27 Main forms of international research/innovation cooperation for Chinese private stakeholders (European)

For Chinese private stakeholders, respondents indicated the main forms as below:

- Setting up joint ventures with foreign organizations;
- Sending personnel abroad for scientific education and research collaboration.

Other main forms of international research for private stakeholders include: hiring foreign employees, importing technologies and starting cooperation projects with foreign firms in China.

Human capital for innovation

Survey respondents were asked what has been the main impact of Chinese researchers' mobility in acquiring scientific and technological information. As illustrated in Figure 28 and Figure 29, all of the options seem to be considered as main impacts with at least 50% of the respondents giving positive results. Respondents appear to believe that researcher mobility is more important for gaining access to knowledge and connections to the international community than for raising awareness about Chinese S&T and improving language skills. Market aspects are also viewed as a significantly less important aspect, perhaps because respondent's experience of research mobility was more related to the academic domain and less linked to business opportunities.

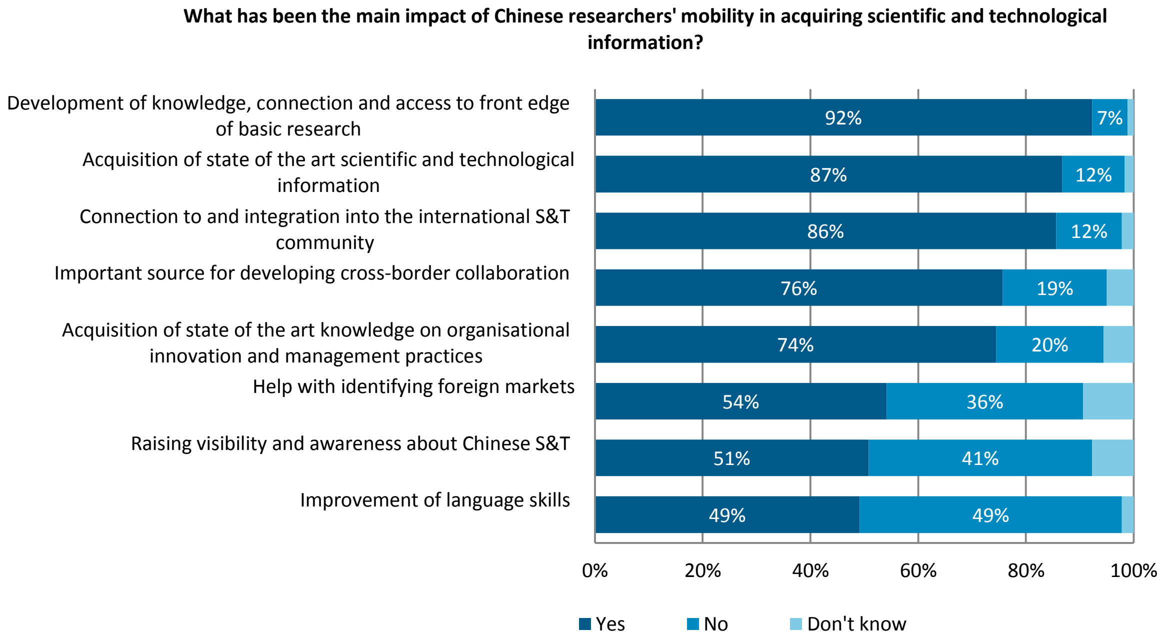

Figure 28 Main impact of Chinese researchers' mobility in acquiring scientific and technological information (Chinese)

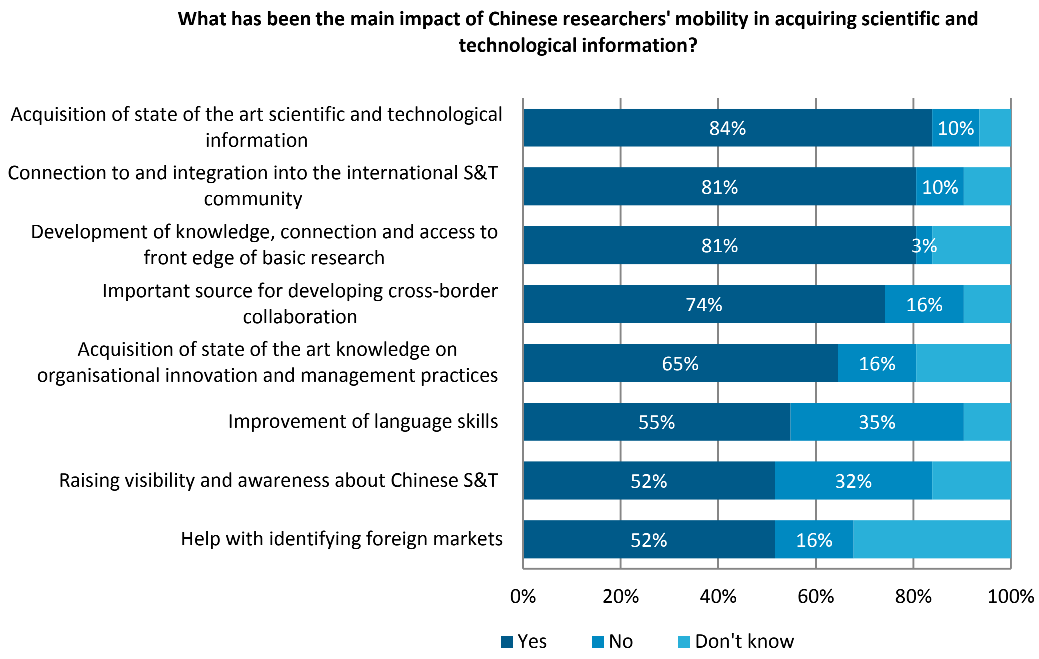

Figure 29 Main impact of Chinese researchers' mobility in acquiring scientific and technological information (European)

The following answers have been indicated by respondents as main impacts:

- Connection and access to front edge of basic research;
- Acquisition of state of the art scientific and technological information;
- Connection to and integration into the international S&T community.

Apart from the answers above, one more answer was indicated by European respondents as a main impact:

- Development of knowledge, connection and access to front edge of basic research.

Figure 30 and 31 below represent the main forms by which respondents believe Chinese research and technology infrastructure is opening to foreign researchers. It is clear from figures that respondents believe that the academic research environment is more open than the business environment for researchers. It would appear that the openness is considered to be more favourable for Chinese scientists with a foreign nationality due to the existence of specific programmes to attract these individuals.

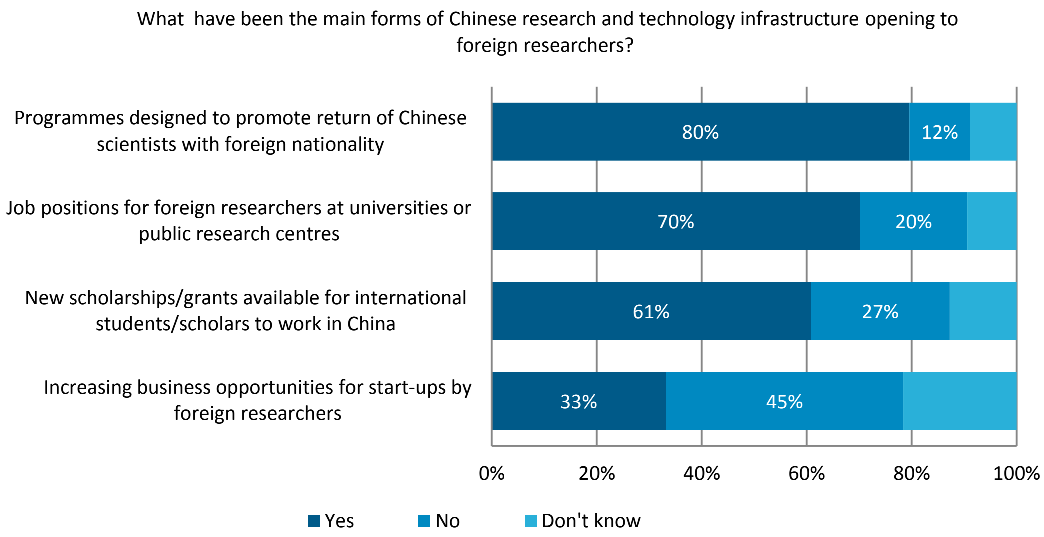

Figure 30 Main forms of Chinese research and technology infrastructure opening to foreign researchers (Chinese)

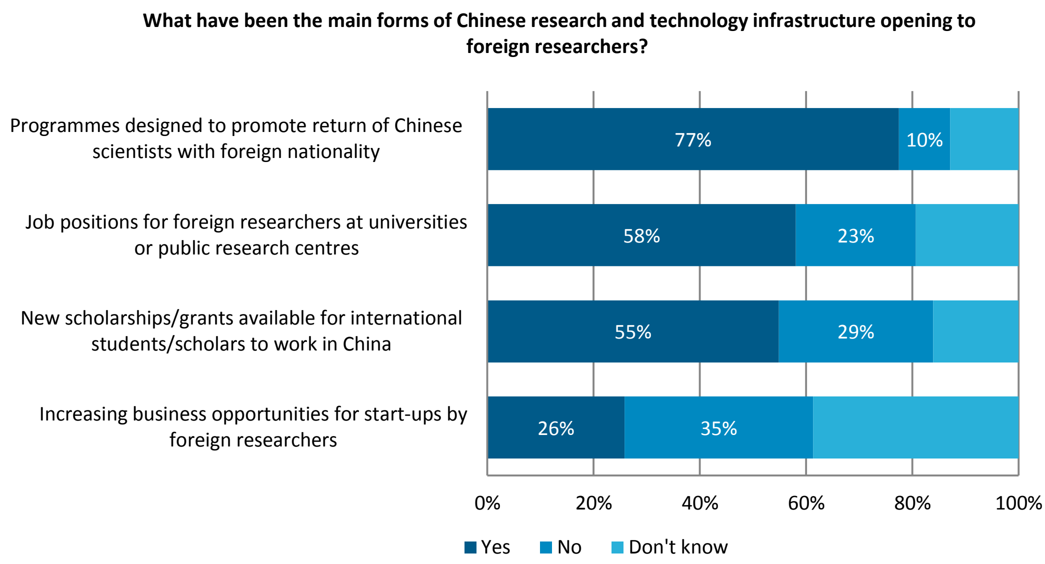

Figure 31 Main forms of Chinese research and technology infrastructure opening to foreign researchers (European)

The following have been indicated by respondents as main forms:

- Programmes designed to promote return of Chinese scientists with foreign nationality;
- Job positions for foreign researchers at universities or public research centres;
- New scholarships/grants available for international students/scholars to work in China.

Targeted Questions -Research Stakeholders

The survey respondents considered to be research stakeholders were asked the extent to which they believe that public R&D investment is being developed into high quality scientific results and innovation in China. Figure 32 below illustrates the answers, ranked by “Low”, “Very Low”, “Neutral”, “High”, “Don’t know”. One response “low” received many more responses than the others - 41% of respondents believed that there is little development of public R&D investment in to high quality scientific results and innovation in China, 19% of respondents considered that it is very low, while only 6% considers it as high. Such an agreement about the lack of conversion of investment into results, might lead one to question whether this had something to do with the way in which current investment is provided or how investment is linked to or intended to be converted into results.

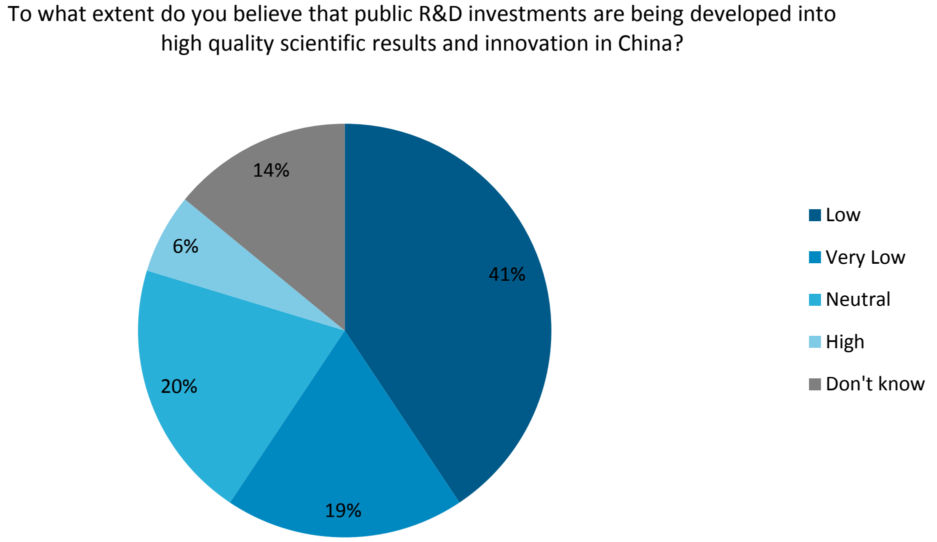

Figure 32 The extent of public R&D investment into high quality scientific results and innovation in China

The majority of research stakeholders considered to a low/very low extent that public R&D investments are being developed into high quality scientific results and innovation in China. Many believed that the current scientific research is focusing on paper work/report rather than practical social needs. In fact, some respondents stated that the goal of scientific research is to turn the research outcomes into industrial productivity, but few research institutes can use the investment of government appropriately. As a result, most research outcomes are not ready to be commercialized, and even the innovation ability in general is still weak among most industries.

When asked to what extent they believe that the research results are utilized by the business sector in China, although some indicated that China has tremendous demand of technology, and government is facilitating the transfer of scientific research outcomes to industries, the majority of the respondents considered that it is still low/very low. Most respondents believed that the research outcomes hardly meet enterprises' needs and cannot be commercialized as they are quite theoretical. Some mentioned the IPR protection schemes and the market itself is still immature. The form of cooperation between industry and research institution has been focused on improving manufacturing in industry, which solves part of mechanical issues but it is still not considered as innovation. It seems to be important to bridge the gap between research institution and industry so that both sides can understand what the needs are.

In the next question, the research stakeholder respondents were asked what the main avenues are for public R&D investment to be developed into scientific results and innovation in China. At least 50% of respondents agreed with all four avenues suggested in the survey. As Figure 33 and Figure 34 illustrate below, the two avenues, which most respondents agreed with (71% for Chinese respondents) were "funding earmarked for industry or academia" and "government projects by Ministry of Science and Technology (MOST) or National Science Foundation of China (NSFC)" suggesting that these two avenues are more successful/ or more commonly used for having a means of linking investment to results /or achieving the conversion of investment into results. The European researchers however thought that university-industry alliance for industrial innovation is the main avenue (59%), perhaps due to the perception that academia-industry links need strengthening.

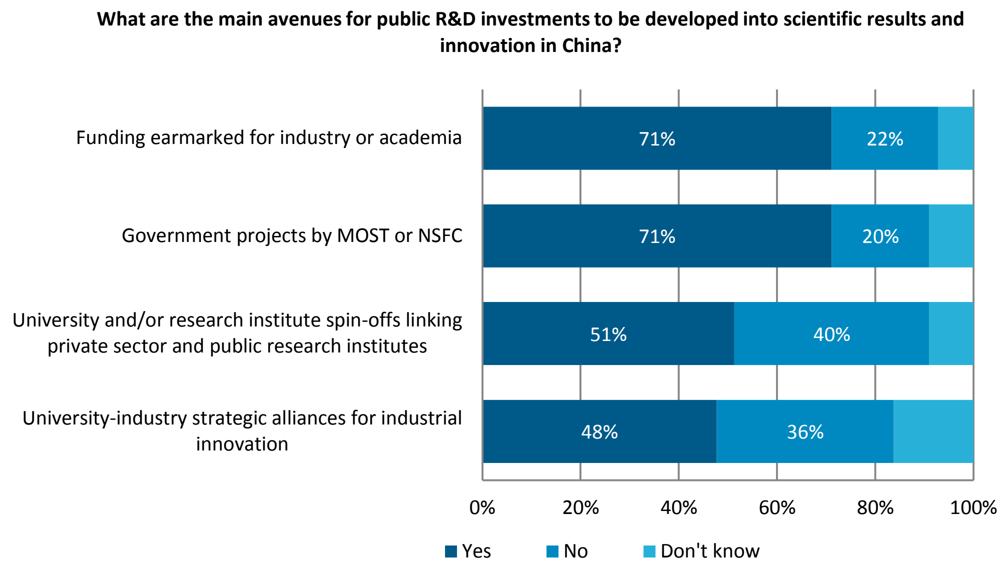

Figure 33 The main avenues for public R&D investments to be developed into scientific results and innovation in China (Chinese)

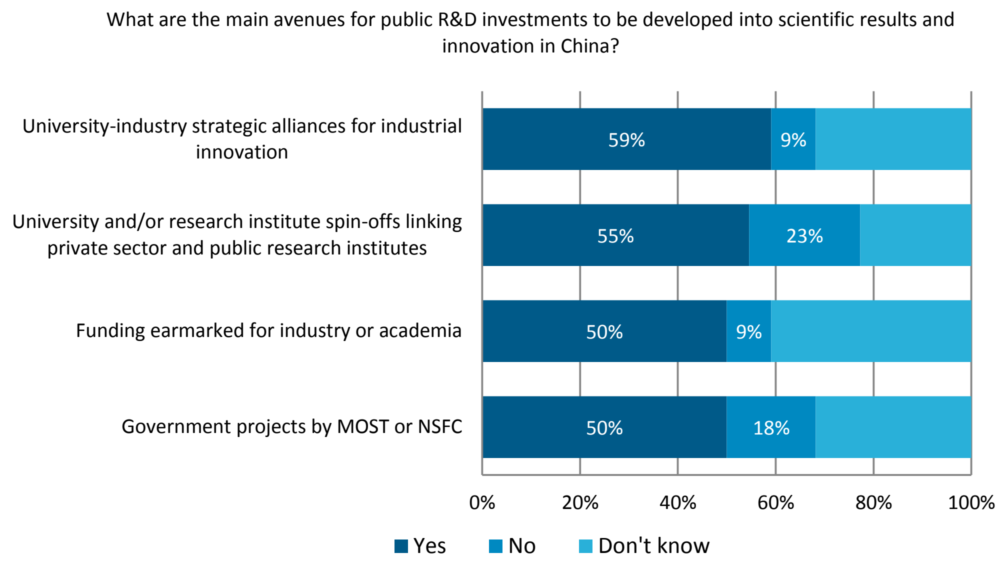

Figure 34 The main avenues for public R&D investments to be developed into scientific results and innovation in China (European)

When asked to what extent they believe that the research results are utilized by the business sector in China, some believed that the private sector benefits a lot from the 863 MOST programme, or incentives from the local government.

As illustrated in Figure 35, the research stakeholder respondents were asked to what extent they believe that the research results are utilized by the business sector in China. Basically, the majority of respondents considered that this use is still low/ very low. This opinion ties in with opinions expressed about the conversion of investment into high quality innovation or with the desire for increasing the expenditure of enterprises on research and innovation, reported earlier from this survey.

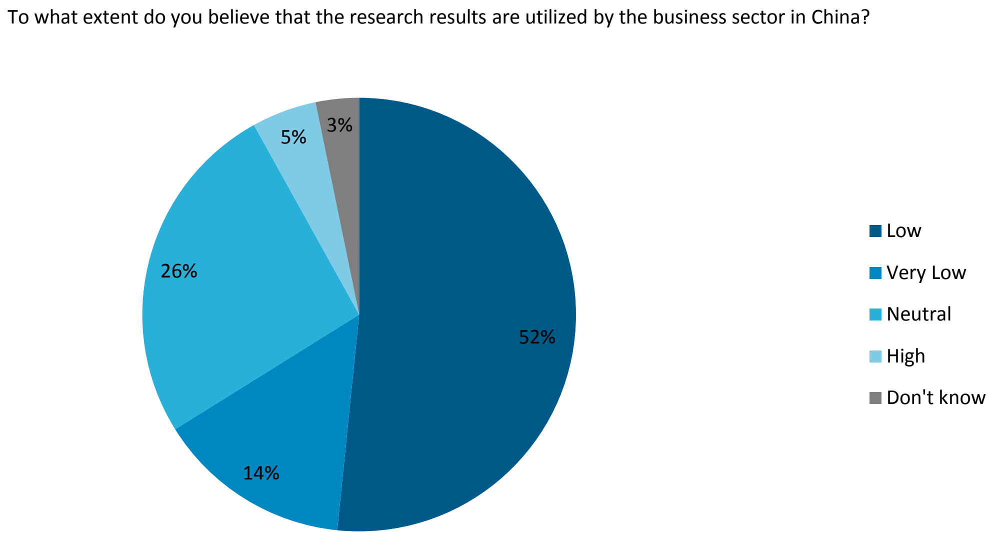

Figure 35 Utilization of research results by the business sector in China

Industrial innovation

<u>Targeted Questions - Industry Stakeholders</u>

Industry stakeholder respondents were asked how Chinese companies deal with STI. As illustrated in Figure 36 and Figure 37, a range of approaches are believed to exist. Most respondents agreed with the approach of cooperation with or outsourcing to universities/ institutes of CAS, suggesting that this is one of the most common means of dealing with this issue. It is also interesting to note that this cooperation would be particularly important for SMEs, since respondents reported that they do not have in-house R&D activities, whilst most believed that larger companies would have these, a factor that will have implications for STI policy. It would appear, according to these opinions, that State-owned enterprises do not contribute greatly to STI and that the main focus for Chinese companies for these activities is experimental development. It turns out that the major difference between Chinese and European respondents is the focus on experimental development; European respondents didn't think that focusing on experimental development was an important way of dealing with STI for Chinese companies.

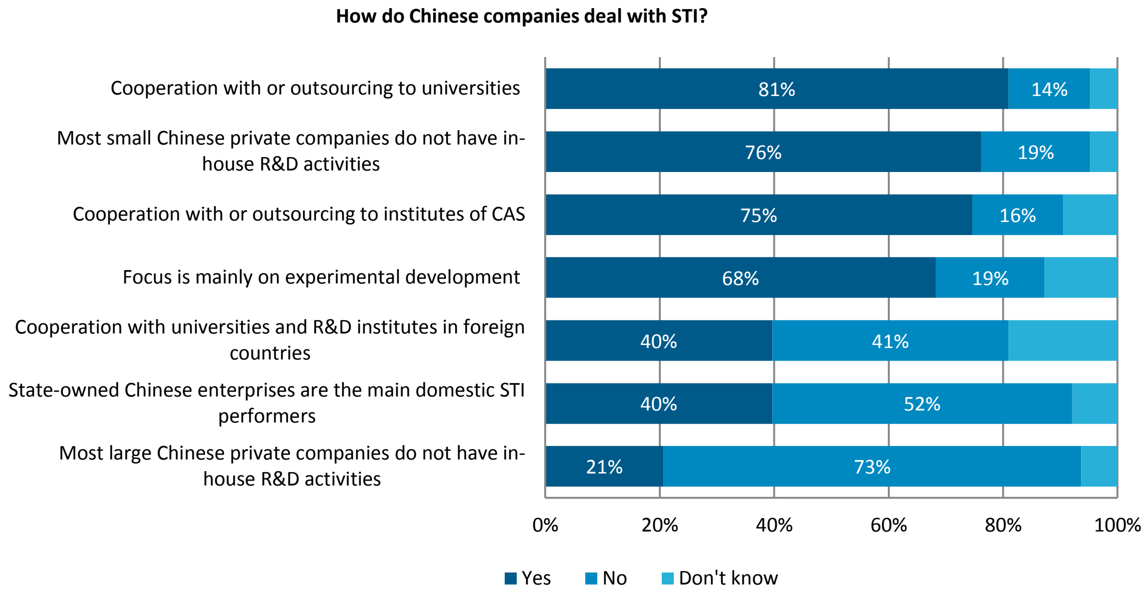

Figure 36 How do Chinese companies deal with STI (Chinese)

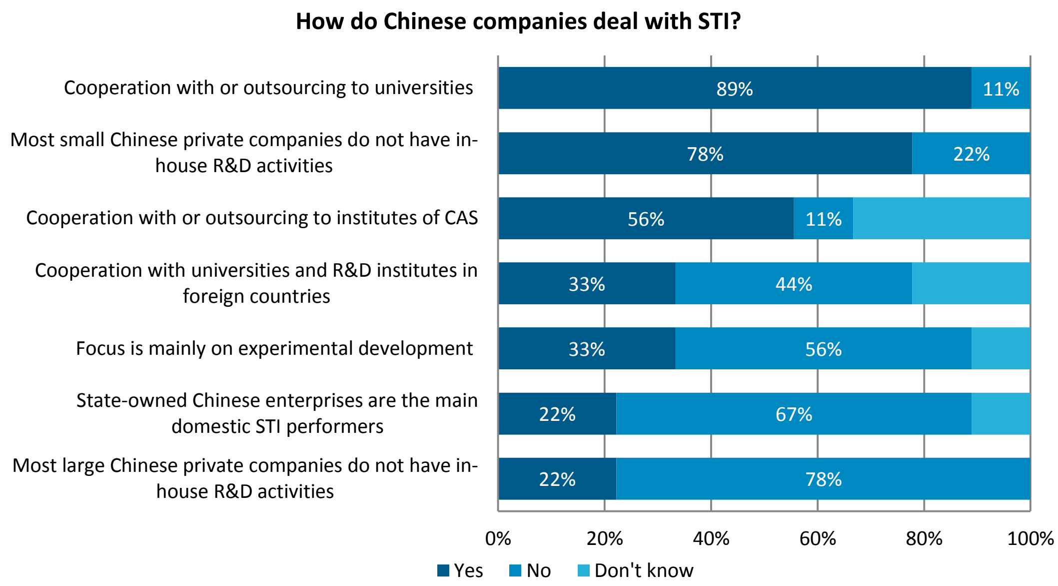

Figure 37 How do Chinese companies deal with STI (European)

The following answers indicated how Chinese companies deal with STI:

- Cooperation with or outsourcing to universities;
- Most small Chinese private companies do not have in-house R&D activities;
- Cooperation with or outsourcing to institutes of CAS.

As Figure 38 and Figure 39 show, industry stakeholder respondents were asked what the main mode is for technology acquisition for Chinese companies. Importing technology from abroad was thought to be a main mode by the greatest number of respondents (82% and 89%), suggesting that this is the most common method used by Chinese companies. In-house development, joint venture with foreign companies and acquisition of Chinese technology are also considered by more than 50% of respondents as main modes.

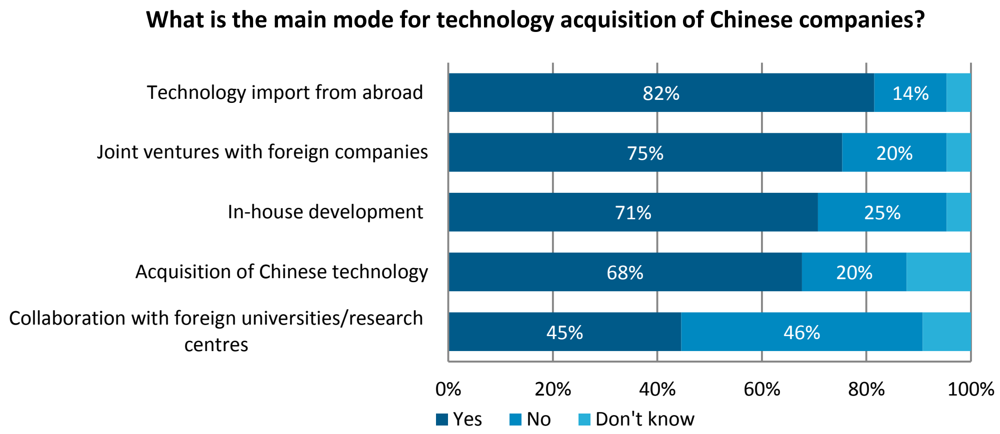

Figure 38 Main mode for technology acquisition of Chinese companies (Chinese)

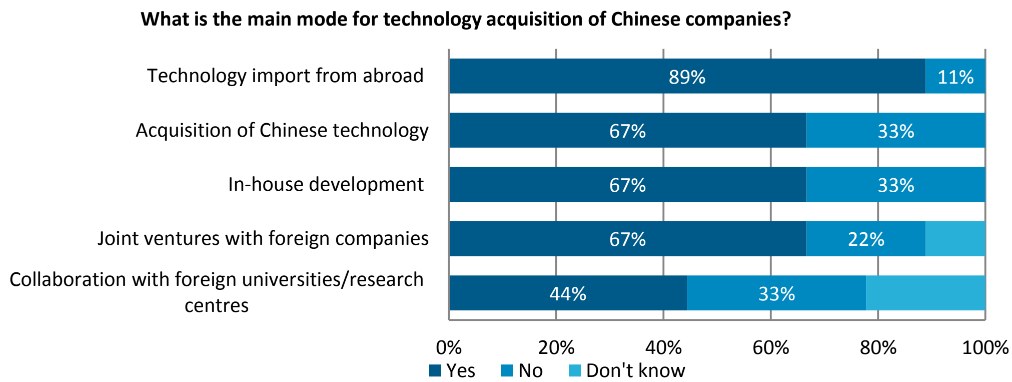

Figure 39 Main mode for technology acquisition of Chinese companies (European)

The main modes for technology acquisition of Chinese companies are indicated below:

- Technology import from abroad;
- In-house development;
- Joint venture with foreign companies;
- Acquisition of Chinese technology.

Respondents explained that Chinese industries mainly acquire the technology from other countries, which lose their original creativity. Government policies, especially for IPR protection, have not been well organized, which has resulted in piracy and counterfeiting among the industries. They believed Chinese enterprises should be supported and encouraged to foster innovation not only by funding and policy but also by a better IPR protection environment - only then enterprises can put more efforts on innovation.

Industry stakeholder respondents were asked what the main barriers are for Chinese SMEs in developing STI. The respondents felt that there are many significant barriers. The responses – illustrated in Figure 40 and Figure 41 below, indicated that the high cost of innovation is the main barrier, accounting for 85% of Chinese respondents. In contrast, European respondents stated that it is not only the high cost of innovation but that a lack of qualified personnel is also one of the main barriers. Insufficient funds, uncertain demand for innovative goods or services, and lack of qualified personnel are considered to be less important barriers.

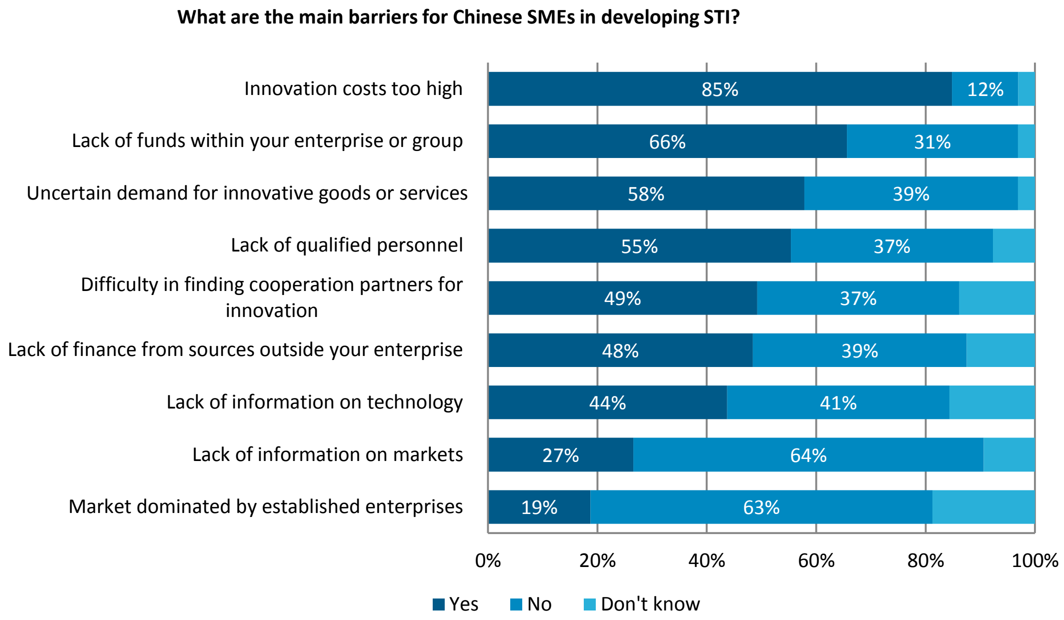

Figure 40 The main barriers for Chinese SMEs in developing STI (Chinese)

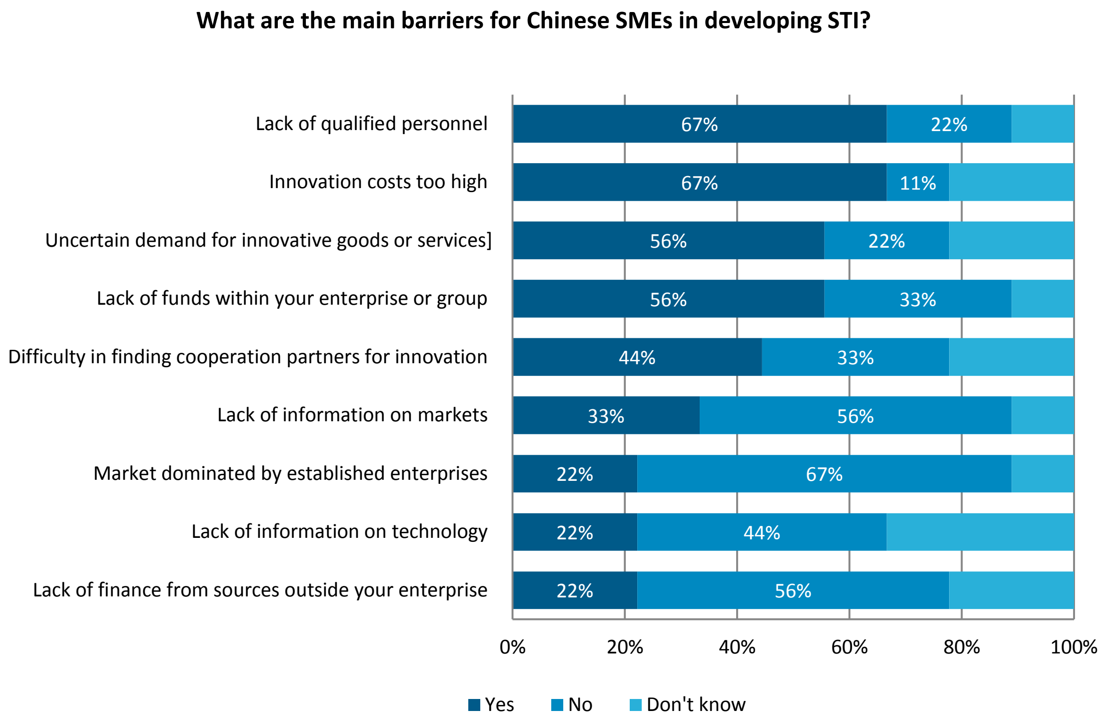

Figure 41 The main barriers for Chinese SMEs in developing STI (European)

Regarding the main barriers for Chinese SMEs in developing STI, the respondents mentioned the following:

- High cost of innovation;
- Insufficient funds;
- Uncertain demand for innovative goods or services;
- Lack of qualified personnel.

For European, the respondents mentioned that finding cooperation partners for innovation is the main barrier for Chinese SMEs in developing STI.

Industry stakeholder respondents were asked how large companies use newly acquired dimension for STI development. As illustrated in Figure 42, 88% of Chinese respondents mentioned increasing in-house spending on STI and 91% of respondents mentioned cooperating with higher education and public research organizations. This ties in with the research stakeholders claim that companies commonly cooperate with or outsource to universities to deal with STI. Similarly, the European respondents (Figure 43) also pointed out increasing in-house spending on STI and cooperating with higher education and public research organizations are the main dimension for STI development.

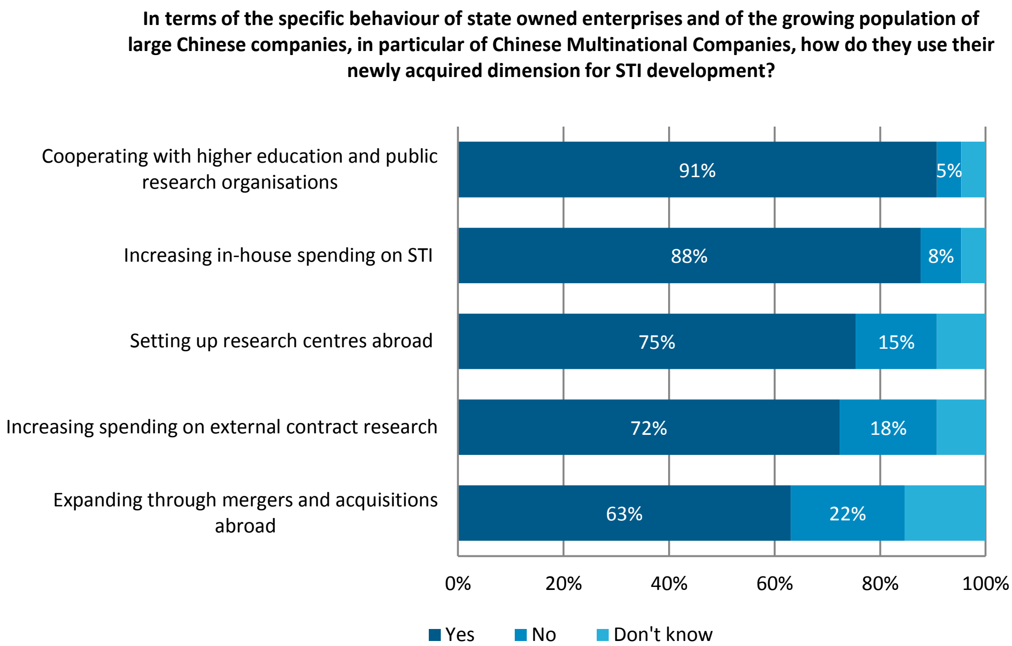

Figure 42 The use of newly acquired dimension for STI development (Chinese)

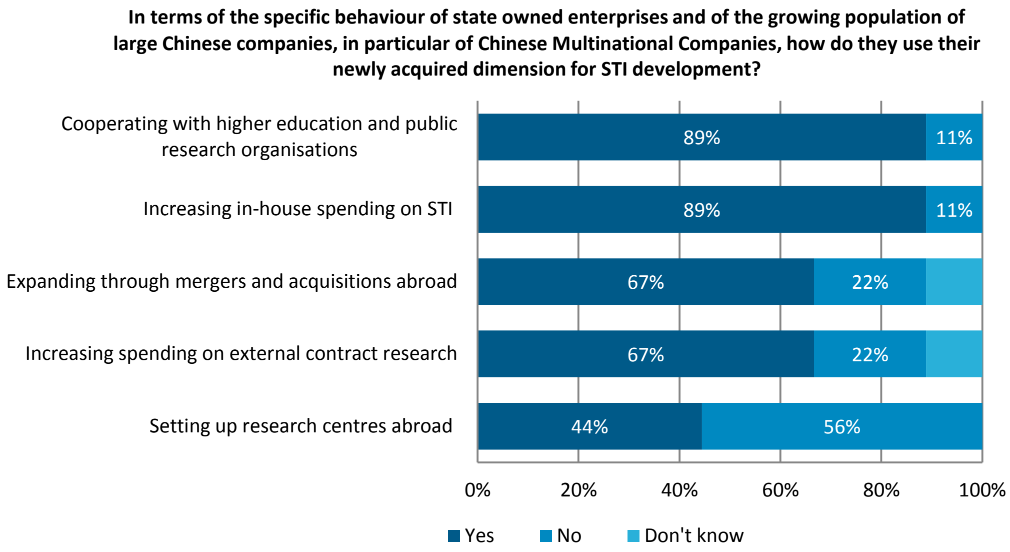

Figure 43 The use of newly acquired dimension for STI development (European)

Regarding the use of newly acquired dimension for STI development, the respondents mentioned the following:

- Increasing in-house spending on STI;
- Cooperating with higher education and public research organizations;
- Setting up research centres abroad;
- Increasing spending on external contract research;
- Expanding through mergers and acquisitions abroad.

The European respondents mentioned the following:

- Increasing in-house spending on STI;
- Increasing spending on external contract research;
- Cooperating with higher education and public research organisations.

Indigenous innovation and its impact on foreign firms

Industry stakeholder respondents were also asked about the negative consequences of the indigenous innovation strategy for foreign firms. This was the strategy that respondents appeared to suggest was the least successful among the existing STI plans and programme, according to results from this survey presented previously. As seen in Figure 44, a large proportion of stakeholders replied "don't know" in regard to the options provided for this question, suggesting that they didn't have knowledge about the experience of foreign companies. From those that responded, there was a high level of agreement among respondents about the consequences of the indigenous innovation strategy. It appears that access to public procurement is more difficult for them (this was highlighted by the greatest number of industrial stakeholder respondents – 75%). In the same way, half of the respondents think that the consequences include creating barriers to market entry with the development of Chinese certification and standards, being a preferential treatment of domestic entities and of national indigenous innovation products, as well as creating higher risk of IPR infringement for foreign firms with Chinese certification requiring disclosure of foreign proprietary technologies.

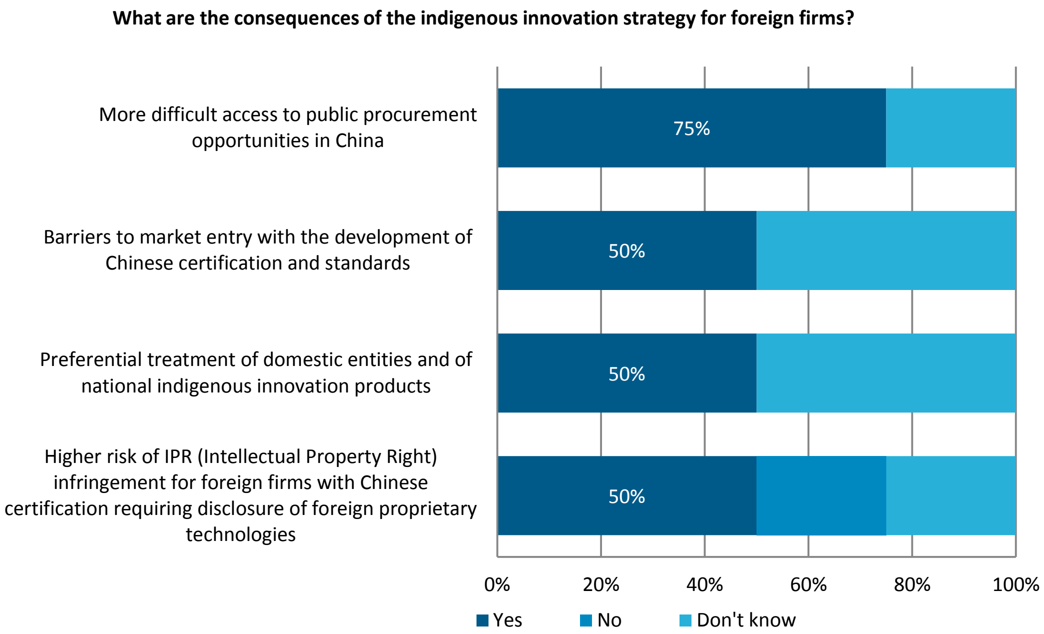

Figure 44 The consequences of the indigenous innovation strategy for foreign firms (European)

The consequences of the indigenous innovation strategy for foreign firms are indicated below:

- More difficult to access public procurement opportunities in China;
- Barriers to market entry with the development of Chinese certification and standards;
- Preferential treatment of domestic entities and of national indigenous innovation products;
- Higher risk of IPR infringement for foreign firms with Chinese certification requiring disclosure of foreign proprietary technologies