Observatoire des Sciences et des Techniques

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SCIENCE AND TECHNOLOGY

Indicators

China

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ECONOMICA

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http://www.obs-ost.fr

Table 1
China: framework data – population, labor force, surface area, GDP, GERD/GDP (2001)

China	2001
Population (millions)	1,276
Labor force (millions)	730
Area (thousand km²)	9,571
GDP (billion of euros)	5,872
GERD (billion of euros)	64
GERD/GDP (%)	1.09

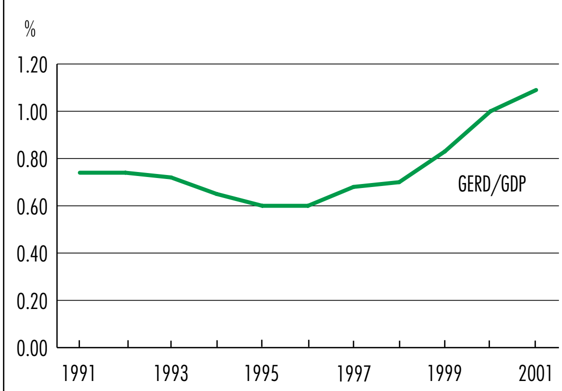
OECD data (Main S&T Indicators), OST treatments and estimations *OST report-2004*

- *data are in billion of current euro in purchasing power parity*
- *GERD: Gross domestic expenditure on research and development*
- *GDP: Gross domestic product*

1. Framework Data

China as an emerging giant is moving rapidly toward a central place on the international scientific and technical scene. Its research financing effort, or GERD, as a percentage of GDP remained steady at 0.7% until 1998 when it reached a level of 1%. In 2001 it attained 1.1% ***(Figure 1 and Table 1)***. This advance is all the more remarkable in light of the steep growth in GDP recorded over this same period.

Figure 1
Change in the ratio GERD/GDP for China (1996 to 2001)



OECD data (Main S&T Indicators), OST treatments and estimations *OST report-2004*

Table 2
China: domestic expenditure for R&D – spending by type of institution in terms of volume, GERD share, and percentage of GDP (2001)

	China		
	GERD expenditures (2001)		
Institutions	Volume (G€)	Repartition (%)	As percentage of GDP (%)
Public research institutions	**25**	**39.6**	**0.43**
Basic research	6	9.8	0.11
Oriented research	19	29.7	0.32
Private institutions	**39**	**60.4**	**0.66**
Total	**64**	**100.0**	**1.09**

OECD data (Main S&T Indicators), OST treatments and estimations — *OST report-2004*

- *data are in billion of current euro in purchasing power parity*
- *GERD: Gross domestic expenditure on research and development*
- *GDP : Gross domestic product*

2. R&D Expenditure

In 2001 domestic expenditure on research and development by China amounted to 64 billion euros (G€), in purchasing power parity, which as a share of total GDP for that year was 1.1%.

The major role played by the private sector in this effort is easy to spot; in 2001 the apparent percentage of all R&D spending which was attributable to private institutions was 60%. What is less apparent, however, is that a good deal of industrial end-research in China, like many countries with a communist tradition, is carried out in “research branches” of the Ministry of Industry, and public/private boundaries are still difficult to discern clearly ***(Table 2).***

University research, by contrast, accounts for a very modest portion of overall R&D expenditure. In 2001, 6 G€ were allocated to this branch of research, while 30% of all GERD was spent by public institutions of oriented research. The percentage of this latter volume of expenditure that was devoted to defence R&D, although not known with certainty, is thought to be sizable (on the order of 15%).

The change of attitude on the part of China's central leadership toward science and technology has been remarkable. Before 1949 China could barely be said to have a scientific or academic infrastructure, with the first Chinese university founded in only 1898, and the 1950's saw very little progress made. The Great Leap Forward (1958-1976) only made matters worse, and it was not until 1978 that higher education lost its unfavourable status.

Up until that date the Chinese research system had remained closely modelled on the Soviet example, with research activity concentrated in a few State institutions including the preponderant Chinese Academy of Sciences (CAS), which overshadowed the universities. A number of Soviet engineers and scientists were involved in the establishment of this system until 1960.

Starting in the early 1980's a much different and more "Western" system of research and innovation arose alongside this older structure. The State Science and Technology Commission (SSTC) was created and charged with the task of defining a research policy for the country, reporting directly to the State Council, the supreme political body in China. Gradually a sizable number of research institutes emerged, for the most part tied to universities, and served as counterweight to the dominance of the CAS. A major turning point occurred in 1986 when the SSTC established the National Natural Science Foundation of China (NSFC), conceived along very similar lines to the NSF in the US as a project funding agency that issues calls to tender and awards grants. The objective of the NSFC was to reduce ministerial compartmentalisation while encouraging international cooperation, and it marked the first time in China that research is funded on a competitive basis, through the use of incentive programmes.

These changes have shifted the overall research mechanism toward the direction of applied research and technological development. In 2001, for instance, only 10% of GERD in China went to fundamental research, despite the government's decision to increase fundamental research expenditure throughout the 1990's, essentially through the NSFC. With concurrently strong growth in finalised research spending, the marked imbalance in favor of the latter continues to typify the Chinese research effort.

See OST's country study on China (www.obs-ost.fr)

Table 3
China: students in higher education – number and percentage of total population (2001)

	Chinese students in higher education (2001)	
	Total	with doctorate degree
Number (thousands)	12,144	86
Number per capita (‰)	9.52	0.07

OECD data "Education at a Glance", OST treatments *OST report-2004*

• doctorate degree corresponds to ISCED 6 level in the international standard classification for education

3. Scientific and technical potential, and the stock of young researchers

Even with a considerable increase in their numbers over recent years, in 2001 China counted 12 million university students, all disciplines taken together, a figure which is comparable to the total number for university students in the 15 member States of the European Union. In China, there are only 10 students for every 1,000 of population, and only 1 doctoral student for every 10,000 ***(Table 3)***.

Table 4
China: research personnel – number (in full-time equivalents), percentage of labor force, distribution in public or private sector research (2001), and change over time (1996 to 2001)

	China					
	R&D researchers (fte)					
	2001			2001/1996 changes (%)		
Sector	Number (thousands)	Ratio to labor force (‰)	Repartition (%)	Number	Ratio to labor force	Repartition
Public sector	**234**	**0.32**	**35.2**	**- 25**	**- 29**	**- 40**
Government	34	0.05	5.1	- 81	- 82	- 85
Higher education	200	0.27	30.1	+ 52	+ 43	+ 23
Private sector	**431**	**0.58**	**64.8**	**+ 93**	**+ 81**	**+ 55**
Total	**665**	**0.90**	**100.0**	**+ 24**	**+ 17**	**0**

OECD data (Main S&T Indicators), OST treatments and estimations *OST report-2004*

• *fte: full-time equivalent*

In 2001 there were 665,000 research scientists in China, which amounts to a very low density compared to the labor force overall (less than one researcher for every 1,000 working individuals). Accordingly, China has roughly the same number of researchers as Japan (about 740,000 researchers) but their portion of the labor force is ten times less. The research population grew by nearly 25% between 1996 and 2001. The balance between public and what is labelled as private research underwent a major shift; private sector researchers nearly doubled while public sector researchers dropped in number. Most of this decrease was accounted for by a shift into university research, where the number of researchers rose by more than 50% ***(Table 4)***.

Table 5

China: scientific publications – share of world publications and impact index by discipline, and for all disciplines taken together (1996, 2001)

	China					
	World shares (%) in scientific publications			Relative impact		
Discipline	1996	2001	2001/1996 (%) changes	1996	2001	2001/1996 (%) changes
Fundamental biology	0.7	1.4	+ 107	0.26	0.35	+ 34
Biomedical research	0.7	1.0	+ 53	0.49	0.58	+ 19
Applied biology-ecology	0.7	1.6	+ 132	0.66	0.52	- 21
Chemistry	3.9	8.3	+ 110	0.44	0.51	+ 16
Physics	3.8	6.1	+ 60	0.45	0.48	+ 6
Sciences of the universe	1.2	3.0	+ 149	0.46	0.42	- 10
Engineering	2.6	4.9	+ 90	0.64	0.68	+ 6
Mathematics	3.8	6.1	+ 61	0.48	0.72	+ 50
Total	**1.9**	**3.5**	**+ 84**	**0.36**	**0.40**	**+ 12**

ISI data, OST treatments *OST report-2004*

• *the number of publications for China was 11,000 in 1996, and 24,000 in 2001 (fractional count)*

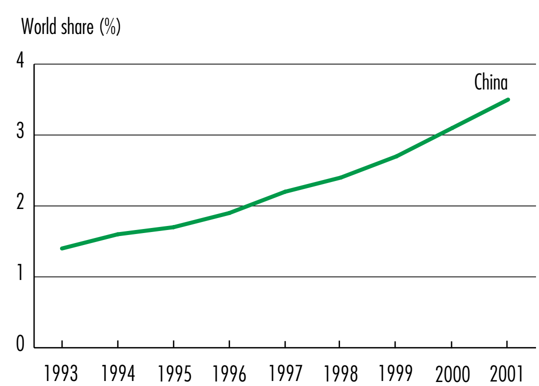
4. Scientific output measured by publications

The rapid expansion in overall scientific activity has been mirrored by a large increase in scientific publications. With a world publications share of 3.5% in 2001, China became the world's seventh largest scientific producer, a remarkable achievement. Between 1996 and 2001 China's share of world production increased by 84% ***(Table 5)***.

This increase in scientific output can be noted in every discipline, to varying degrees. China's strongest field, chemistry (+110%), accounted for over 8% of world publication by 2001. The next two strongest disciplines, physics and mathematics, saw their world share rise by more than 60%. In these two fields, China accounts for more than 6% of world production.

Figure 2

Change in world share of scientific publications of China (1993-2001)



OECD data (Main S&T Indicators), OST treatments and estimations *OST report-2004*

China's dynamic growth in output is just as noteworthy in fields where its world share was virtually nonexistent in 1996. In sciences of the universe, for instance, world share increased by 150%, giving China 3% of world production by 2001. In fundamental biology and applied biology/ecology, China more than doubled its share of world output over the same period. Biomedical research also showed a significant, if less sharp, increase (+53%).

With this strong growth in what were its weaker disciplines, China has succeeded in narrowing the traditional gap between sciences of matter on one hand, and biomedical research, life sciences and sciences of the universe on the other.

One aspect, however, of China's increased scientific production mitigates the dynamic picture presented by this growth; when article citations are studied instead of volume of production, much remains to be done in improving the impact of Chinese production has on world science. The impact index that measures the ratio between citation share and publication share was in 2001 still only 0.40 for all Chinese disciplines taken together (world average equals 1). This impact index nonetheless showed significant progress between 1996 and 2001 (+12%) after having been stable throughout the previous decade. This would seem to indicate, roughly, that the large increase in Chinese publication at first had little impact but is now entering a second stage as Chinese science opens up to international research networks.

In mathematics, for example, the impact index increased by 50% between 1996 and 2001, to reach a level of more than 0.70. Fundamental biology and biomedical research show noticeable increases in impact, which suggests that even if still weak in terms of absolute output (especially for fundamental biology), the growth accomplished in these fields has been able to find an audience. Applied biology/ecology and sciences of the universe, however, show production growth without citation increase, and their impact index dropped 20% and 10% respectively.

Table 6
China: scientific publication – shares of China's top ten partners in China's international copublication (1996, 2001)

	International co-publications shares (%) of China			
	1996		2001	
Rank	Country	%	Country	%
1	United States	35.8	United States	34.6
2	Japan	14.1	Japan	16.6
3	United Kingdom	12.2	Germany	10.3
4	Germany	10.3	United Kingdom	10.0
5	Canada	8.5	Canada	6.3
6	France	5.6	Australia	5.8
7	Australia	5.0	France	4.7
8	Italy	4.4	Singapore	4.0
9	Sweden	2.8	Italy	3.1
10	Netherlands	2.2	Chinese Taipei	2.8

ISI data, OST treatments *OST report-2004*

- *total may add up to more than 100% because copublication are calculated using an integer distinct count*
- *the number of China's copublications was about 3,600 in 1996 and 6,800 in 2001*

In 2001 the US retained its position as far and away China's strongest scientific partner, accounting for about 35% of China's international co-publications, followed by Japan at 17%, Germany and the UK at 10%. Australia and Canada hold fifth and sixth place. France, in seventh place, accounted for less than 5% of Chinese international co-publication ***(Table 6)***.

The clearest trend to be noted over the period 1996-2001 is the rise of newly industrialised Asian nations as Chinese partners with the appearance of Singapore and Taiwan among China's top ten scientific partners. Japan also gained 2.5 percentage points in China's international copublication, as the latter turns increasingly towards its Asian neighbours.

Table 7

China: technological production – world share of European and American patents, by technological field, and all fields taken together (2001) and change over time (1996-2001)

	China			
	European patent world share (%)		American patent world share (%)	
Technological Field	2001	2001/1996 (%) changes	2001	2001/1996 (%) changes
Electronics-electricity	0.33	+ 81	0.22	+ 44
Instrumentation	0.24	+ 89	0.14	+ 37
Materials-chemistry	0.32	+ 202	0.20	+ 145
Pharmaceuticals-biotechnologies	2.64	+ 1,469	0.21	+ 16
Processes	0.30	+ 170	0.23	+ 83
Machines-mechanics-transport	0.35	+ 67	0.23	+ 46
Consumer goods-construction	0.80	+ 117	0.86	+ 59
Total	**0.59**	**+ 246**	**0.25**	**+ 56**

INPI, EPO and USPTO data, OST and CHI-Research treatments *OST report-2004*

- *patents filed with the European Patent Office and via the Patent Cooperation Treaty designating European countries are considered as European patents*
- *patents are calculated according to the address of the inventor*
- *european patents amounted to about 700 in 2001, while American patents were about 350*

5. Technological production as measured by patents

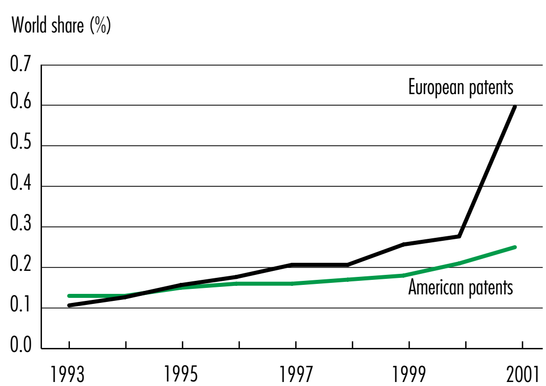
Although when measured in terms of world share China's technological production remains modest, the increase in its applications for patents overseas brought Chinese applications to 0.59% of all applications for European patents and 0.25% for US patents ***(Table 7)***.

The advances made by China in both European and American patents came from across all technological fields. The most dramatic increase can be seen in applications for European patents in pharmaceutical/biotechnological technologies, but this spike is essentially due to a Chinese biotechnologies firm which applies for European patents via the PCT in the area of genomics.

In both patent systems, American and European, China has more than doubled its share in the field of materials/chemistry. Noticeable progress has also been made in industrial processes with an increase of 170% in its share by nation of European patents and of 83% of American patents. Finally, in the field of consumer goods/construction China's world share in both European and American patents rose to over 0.8% in 2001.

Figure 3

Change in China's world share of European and American patents (1993 to 2001)



INPI, EPO and USPTO data, OST and CHI-Research treatments *OST report-2004*