A Comparative Study on the Biotechnology Patents of CAS, China

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Abstract

The purpose of this article is to compare the biotechnology patent filing statistics of CAS to CNRS, MIT and MPI in DII covering a time period of 1985-2005 by scientometrics methods. The analysis was classified based on applications numbers, technical fields, times cited, countries, group intensity and associative intensity. This paper also introduced the Relative Intensity (RI) indicator to visualize the relative intensity of times cited, family members, inventors and associative intensity between assignees among the four institutions. As a result of this paper, although CAS had the largest number of patents applications among the four institutions, the strength of intellectual property protection of CAS was weaker than that of the other three institutions. Firstly, compared to CNRS, MIT and MPI, CAS had mainly paid its attention to its native land protection for its intellectual property but less in overseas. Although CAS had also applied the biotechnology patents in 24 countries, CAS's average numbers per family was only 1.12, which was much lower than other three institutions. Secondly, the RI (ANA/N) indicated that the associative activity of CAS was worse than the other three institutions. These characters also had been found in the indicators of group intensity and times cited. We hope this paper could be effective for the CAS to make powerful measures to prompt its biotechnology innovations capabilities and broaden its global protection strength.

Introduction

Biotechnology is becoming increasingly valuable in today's society, many corporations and institutions are developing R&D in the field of biotechnology because of its widely use in many industrial sectors, such as food, drink, pharmaceuticals, textiles, energy, agriculture and chemicals. Especially, just as Global Biotechnology Center (2007) reported that there is no question that biotechnology is now the engine of innovation of the drug development industry.

Chinese technological activity grew rapidly in recent years, so did the number of patent applications from the whole country since its first patent law came into force on April 1, 1985 (Shen, 1997). Chen, Yang, Fang, *et al.* (2008) had reported that the annual growth rate of patent applications was 48.7% and the quantity was 221,388 during the period 1999-2004. The Chinese Academy of Sciences (CAS) is one of the leaders in Chinese science & technology organizations. Biotechnology is also an important researching field of CAS, and CAS has many institutes engaged in biotechnology researching works.

As patent is an important indicator of technology innovation capability, there are many organizations use patents as indicators to evaluate the technology innovation capabilities in defferent levels of countries, regions or institutions. For example, OECD has developed new indicators, notably on patent families, citations, to map aspects of the innovative performance and technological progress of countries, regions or certain specific domains and technology fields (OECD, 2009). And ipIQ Inc helped NSF to do the research on Science and Engineering Indicators (SEI) for some years, in which patents had been analyzed carefully (ipIQ & NSF, 2009). At the same time, the advance of patent databases has greatly enhanced the possibilities for systematic data retrieval on a large scale (Dou & Bai 2007). Some studies on the biotechnology had been made by some researchers. For instance, OECE (2006) had made a definition of biotechnology technology by IPCs and made a comparative study on biotechnology technology of 25 countries. And Patel (2003) from University of Sussex had used the wealth of US patent documents to compare the UK with G7 countries in 10 fields of biotechnology over the period 1986 to 2000. Moreira, Muller & Pereira (2006), Ramani, El-Aroui, Carrere, *et al.* (2008) and Rosell & Agrawal (2009) had analyzed the biotechnology

Proceedings of ISSI 2009, pages 528–537.
Edited by B. Larsen and J. Leta.

innovations of industry or in university by patents. However, there was hardly a comparative study on biotechnology patents of different institutions from different countries.

All the above reasons prompted us to make a rapid analysis on the biotechnology patents of CAS compared with three important institutions from other countries. This article depicts the biotechnology innovation capabilities of CAS by analyzed the application activities of patents covering a time period of 1985-2005. In order to draw the relative status of CAS in the world, we select National Center for Scientific Research (CNRS), Massachusetts Institute of Technology (MIT) and The Max Planck Society (MPI) as the comparisons. All these three institutions are the important biotechnology institutions in the world. Both CNRS and MPI are national wide research organizations similar to CAS. And MIT is a top institute in US which has a different organization structure (university) to the other three organizations. The reason that we selected this research strategy is to make a deep comparison through poly-way and to find the differences between CAS and other national wide organizations and university.

Data Source & Methods

We used ISI Derwent Innovations Index^{SM} (DII) to collect all the biotechnology patents applied by the CAS, CNRS, MIT and MPI by the application year. The patents of CAS had been collected by the names of its institutes. The patents of CNRS, MIT and MPI had been collected respectively by its assignee code given by DII. And the biotechnology patents had been collected according to the OECD definition of biotechnology patents (OECD, 2006). Since the publication date of a patent publication is generally 18 months later than the application date, in order to make exact original data, we had just downloaded the data until 2005 filing year. And there is another reason that China enacted its first patent law in 1984, which came into force on April 1, 1985, so this paper analyzed the data covering 1985-2005 filing years, which was used to make the comparisons. In this paper we calculate, analyze or visualize the biotechnology patents mainly by the tools of Thomson Data Analyzer (TDA) and MS EXCEL. The scientometrics indicators include numbers, citing, country, patent family, technical fields, relative intensity, group intensity and associative intensity.

Biotechnology Patents Comparative Analysis

The objectives of this section were to collect statistical data on the four institutions' patent applications from 1985 to 2005, to explore the different of different institutions at the level of applications numbers, technical fields, times cited, countries, group intensity and associative intensity to provide a better understanding of the patent activities in this four institutions.

Applications Numbers in the four institutions

Data revealed that the total numbers of biotechnology patent applications from the CAS (1541) were larger than the other three institutions, which were CNRS (1033), MIT (499) and MPI (588). The biotechnology patents of the four institutions occupied respectively 10.4%, 32.7%, 16.9% and 46.8% of their total patents applications (Table 1). It suggested that biotechnology was actually an important research field for all these four institutions.

Table 1. Patent applications: 1985-2005

	CAS	CNRS	MIT	MPI
Number of total patents	14751	3161	2954	1257
Number of biotechnology patents	1541	1033	499	588
Percentage of total patents (%)	10.4	32.7	16.9	46.8
Average annual growth rate of biotech patents (%)	37.6	9.8	15.1	10.9

Figure 1 showed the every three years' growth of the biotechnology patents of the four institutions. From the figure we could see the rapid increase of CAS's biotechnology patents in the last 21 years with the highest average annual growth rate of 37.6% (Table 1). MIT held the second highest annual growth rate of 15.1%. It is expected that MIT's patent applications will exceed those from MPI and then CNRS in coming years for the latter two institutions only had that rates of 10.9% and 9.8%.
The biotechnology patent applications of CAS had exceeded all the three institutions in 2000 and had enlarged the advantage year by year. One major reason may be that China's patent law came into force in 1985, which was later than America, France and Germany, and the will to seek for patent protect had also been worse than the other three countries before recent years. Until the recent about ten years the patent applications increased rapidly in China, so did it from CAS. And another reason should be that the CAS brought the Knowledge Innovation Project into effect in 1998, the purpose of which was to accelerate the development of CAS's technology innovation capabilities, it has greatly accelerated the development of CAS's technology innovation capabilities. Many institutes of CAS had paid more and more attentions to patent applications. Therefore, we can estimate that the biotechnology patents number of CAS would rank first in the coming decades of years.

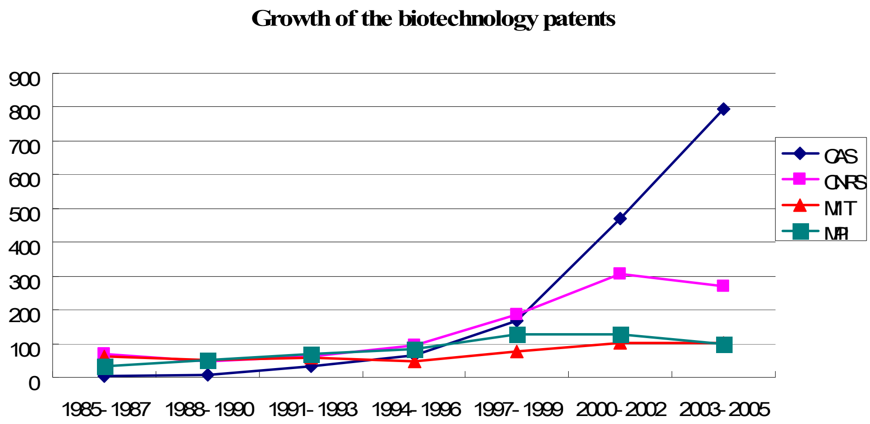

Figure 1. Growth of the biotechnology patents of the four institutions by every three years

Technical field

The distributing pattern of patents' technical fields reflects the institution's technological innovation. In this section we look at evidence for the technological field development paths pursued by each of the four institutions. In this paper we used IPC to give the information on the field of research and application. According to the OECD definition of biotechnology patents, all the biotechnology patents distribute in 11 Main IPCs (4 digits) (A01H, A61K, C02F, C07G, C07K, C12M, C12N, C12P, C12Q, C12S and G01N). We listed the patents number in each IPC of the four institutions in Table 2 from 1985 to 2005.
From the Table 2 we found that most patents of all the four institutions were distributed in the following six subjects: A61K, C07K, C12N, C12Q, C12P and G01N. In these preponderant subjects, CNRS ranked top 1 in four of them, which were A61K, C07K, C12Q and G01N, and CAS ranked top 1 in the other two subjects, C12N and C12P.
The four institutions had relatively less patents output in A01H, C02F, C07G, C12M and C12S. CAS had the unconditional quantitative advantage in four of these five subjects except C07G, in which there were only 6 patents totally from the four institutions.
These data indicated that CAS has the similar research points to the other three institutions and has the relative amount advantage in 6 Main IPCs.

Table 2. Main IPC (4 digits) of the four institutions, 1985-2005

Technical field \ maim IPC (4 digits)	CAS	CNRS	MIT	MPI
A01H (new plants or processes for obtaining them; plant reproduction by tissue culture techniques)	244	49	2	81
A61K (preparations for medical, dental, or toilet purposes)	280	549	213	272
C02F (treatment of water, waste water, sewage, or sludge)	43	12	0	1
C07G (compounds of unknown constitution)	2	2	2	0
C07K (peptides)	323	487	138	242
C12M (apparatus for enzymology or microbiology)	83	53	46	26
C12N (micro-organisms or enzymes; compositions thereof)	872	665	302	381
C12P (using processes to synthesise a desired chemical compound or composition or to separate optical isomers from a racemic mixture)	316	271	128	131
C12Q (measuring or testing processes involving enzymes or micro-organisms; compositions or test papers therefor; processes of preparing such compositions; condition-responsive control in microbiological or enzymological processes)	299	431	177	218
C12S (processes using enzymes or micro-organisms to liberate, separate or purify a pre-existing compound or composition; processes using enzymes or micro-organisms to treat textiles or to clean solid surfaces of materials)	23	2	1	0
G01N (investigating or analysing materials by determining their chemical or physical properties)	216	459	138	225

Cited index analysis

Based on the data in Table 3, we use an indicator of Relative Intensity (RI) to visualize the difference of the four institutions. The average ratio of cited patents of the four institutions was signed as $\overline{A/N} = \sum_{i=1}^{4} A_i \Big/ \sum_{i=1}^{4} N_i$, and each institutions' Relative Intensity (A/N) was signed as $(RI_{A/N})_i = [(A/N)_i - \overline{A/N}] \Big/ \overline{A/N}$.

Table 3. Cited index of the four institutions

i		**Number of biotechnology patents**			**Percentage of cited patents (A/N, %)**	**Accumulated times cited (D)**	**Average times citing per patents (D/N)**
		Times cited >0 (A)	Times cited =0 (B)	Total (N)			
1	CAS	71	1470	1541	4.6	121	0.08
2	CNRS	574	459	1033	55.6	3042	2.94
3	MIT	385	114	499	77.2	5820	11.66
4	MPI	383	205	588	65.1	2537	4.31

Using the same method we could get the Relative Cited Intensity (D/N). Fig 4 had showed the relative differences among the four institutions. As showed in Table 3 and Figure 2, no matter the percentage of cited patents or the average times citing per patent, CAS had the lowest value and had a big gap to the other three institutions. Here must highlight that MIT's average times citing per patent ranked top in these four institutions with a strong advantage.

However, these citation results had to be used carefully because of some reasons as followed. Firstly, although recent studies have shown that patent citations can be used as a proxy for knowledge flows (Criscuolo & Verspagen, 2008), there were some criticisms that the use of patent citations as an indicator of spillovers (Jaffe, Fogarty & Banks, 1998). Secondly, as Alcacer & Gittelman (2006) stress, USPTO and EPO patent examiner practices differ substantially. This has a strong effect on the relative number of citations included by the inventor. The different legal requirements of the USPTO and EPO also imply that there are significant differences in the number of citations in the patents. As pointed out by Michel & Bettels (2001), the US patent office cites 3 times as many patents as the EPO. Lastly, it was found that both in the US and Europe citing occurs more frequently between inventors located close to one another (Criscuolo & Verspagen, 2008).

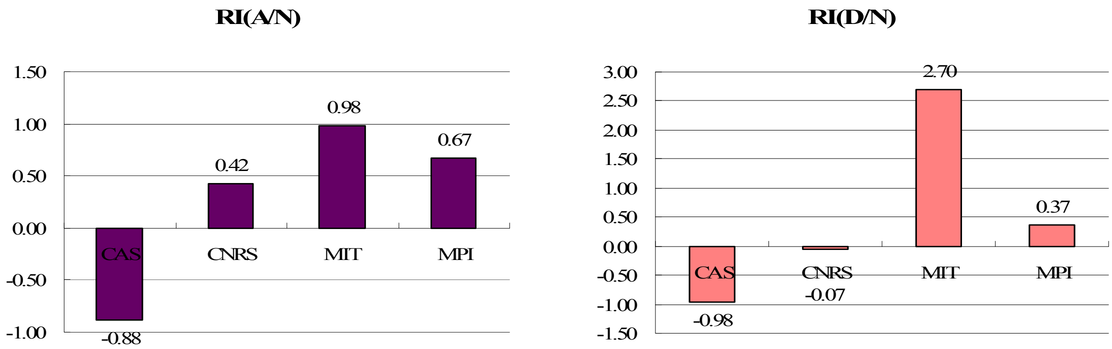

Figure 2. Relative Intensity (RI) for Percentage of cited patents (A/N) & Average times citing per patents (D/N)

Map the patent countries

For more and more firms and institutes are filing patents in foreign countries, so this paper compared the patent family members of each institution. Table 4 showed the patent family member countries and average numbers per family. Some findings from the table were given below: Family member countries numbers of CAS were as same as that of MIT, which were 24, and less than that of CNRS and MPI, which were 31 and 32. It seemed like that the latter two European institutions had larger patent protection scales than CAS and MIT.

Table 4. Patent family member countries and average numbers per family

	CAS	CNRS	MIT	MPI
Family member countries numbers	24	31	24	32
Family numbers (N)	1541	1033	499	588
Family member numbers (F)	1719	4725	1517	2229
Average numbers per family (F/N)	1.12	4.57	3.04	3.79

Nevertheless, although CAS had also applied the biotechnology patents in 24 countries as many as that of MIT, CAS's Average numbers per family only was 1.12, which was much lower than other three institutions. The Average numbers per family of CNRS, MIT and MPI were 4.57, 3.04 and 3.79. Figure 3 also gave an obvious deficiency of average number per family for CAS counted by relative intensity for average number per family. These data suggested that the strength of intellectual property protection of CAS was weaker than that of the other three institutions.

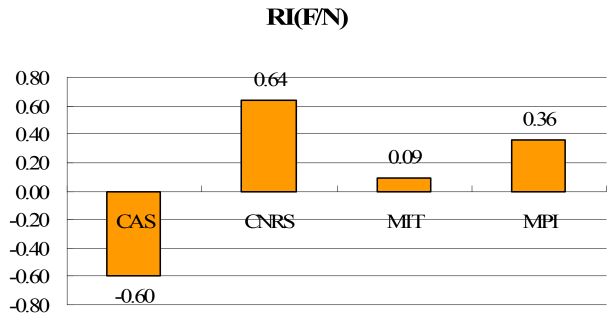

Figure 3. Relative Intensity (RI) for Average numbers per family

Figure 4 gave the family member countries distributing maps of the four institutions. As is vividly betrayed in the pie charts, the patents layouts of CNRS, MIT and MPI were better than that of CAS. All the former three institutions had applied much more patents in overseas than CAS. CNRS held most of its family members in WO、EP、US、AU、JP and DE besides in its native land (FR, 16%). MIT held most of its family members in WO、EP、AU、JP and DE besides in its native land (US, 28%). MPI held most of its family members in WO、EP、AU、US and JP besides in its native land (DE, 14%). The family member ratios in CN of these three institutions were 1% (CNRS), 1% (MIT) and 2% (MPI). While CAS held most of its family members in its native land (CN) the ratio of that was 90%.

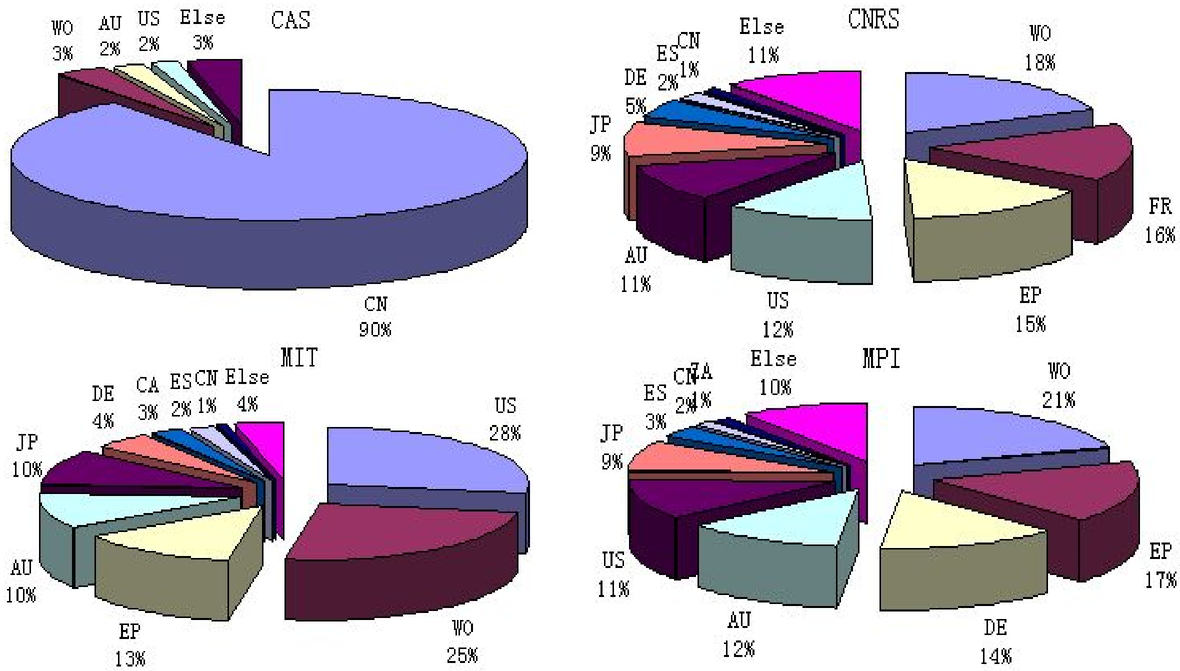

Figure 4. Family member countries distributing maps (Country codes: AU-Australia; CA-Canada; CN-China; DE-Germany; EP-European Patent Office; ES-Spain; FR-France; JP-Japan; US-United State of America; WO-WIPO; ZA-South Africa)

The above data obviously showed that CAS had mainly paid its attention to its native land protection for its intellectual property while CNRS, MIT and MPI had focused on the overseas protection during the last about 20 years.

Japan-US-Europe trilateral patents of the four institutions

According to METI (2008), the number of patent applications filed in 2006 worldwide rose to about 1.76 million, about 1.7 times as many as ten years ago. Of the number, about 0.97 million were filed with the trilateral patent offices of Japan, United States and Europe, about 0.24 million of them with two or more of the three patent offices. In additional, the report named *Key figures of Science, Technology and Innovation 2007*, published by European Commission (2007), had showed that The EU is the world's largest producer of scientific output, accounting for 38% compared with 33% for the US, 9% for Japan and 6% for China. Therefore, Japan, US and Europe trilateral patents had often been used in some reports by some famous analyzing organizations as one of the important indicators for analyzing the innovation capabilities. At the same time, the assignees from all over the world would like to apply patents in these three countries/organizations to assure their own benefits. In this paper, when we analyzed the Japan-US-Europe trilateral patents of the four institutions, China patents had also been introduced as a comparison, which would be helpful to analyze the difference distribution of CAS compared with the other three institutions.

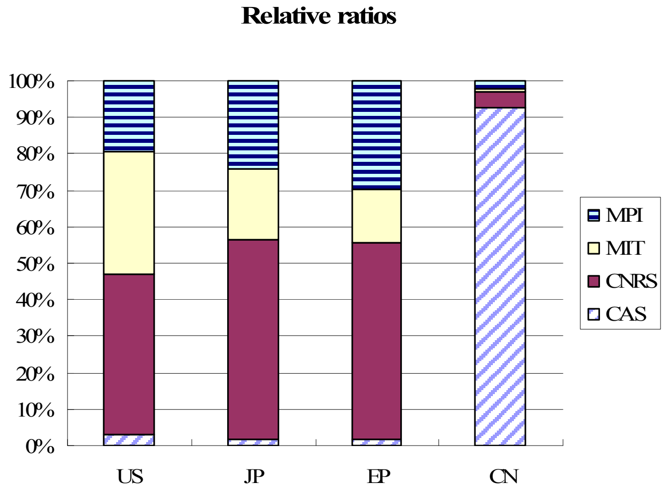

Figure 5. Relative ratios of the four institutions' biotechnology patents applied in Japan, US, Europe and China

When the total number of the four institutions' biotechnology patents applied in each one of Japan, US, Europe and China had been named as 100% as is it shown in figure 5. The figure showed that:

Compared to MIT, MPI and CAS, CNRS had the largest ration in US, Japan and Europe patents. Although its ratio was much lower than CAS in China patents, it is higher than MIT and MPI. So CNRS must be an assignee that had the highest protection level of the four institutions.

Most of the patents of CAS had been filed only in China, few of which were filed with the trilateral patent offices of Japan, United States and Europe. Comparing to the other three institutions, CAS hold only 3.1% of US, 1.8% of JP and 1.8% of EP.

Group Intensity (numbers of inventors / patent)

Whitfield (2008) reported that there were several researches on folkways of science depicted the clearer picture of science's increasingly collaborative nature, and of the factors that determine a team's success. Therefore, this paper attempt to conclude the group scales of each institution by the indicator of group intensity, which means the numbers of inventors per patent. This index reflects the group scale in technology innovation activities.

Table 5. Group intensity

	CAS	CNRS	MIT	MPI
Total accumulation numbers (accounted by inventors)(ANI)	4851	4918	2069	2503
Patents applications number (N)	1541	1033	499	588
Group intensity (ANI/N)	3.1	4.8	4.1	4.3

Table 5 and Figure 6 tell us that CAS had the least group numbers counted by inventors, each patent filing had only 3.1 inventors, while that number of CNRS was highest of 4.8. MIT and MPI were 4.1 and 4.3 respectively. The RI (ANI/N) indicated that CAS's group intensity was worse than the other three institutions. Given that science's increasingly collaborative nature would in faith determine a teams' success, probably we could draw a conclusion that the success possibilities of CAS's team were less than the other three institutions. This may be reflected as the less number of patents by a team or the worse qualities of a team's patents. While the number of inventors may simply reflect cultural patterns and was no importance to teams' success or patents' quality. Therefore, the actual relations between group intensity and its innovation capability are expected for further analysis.

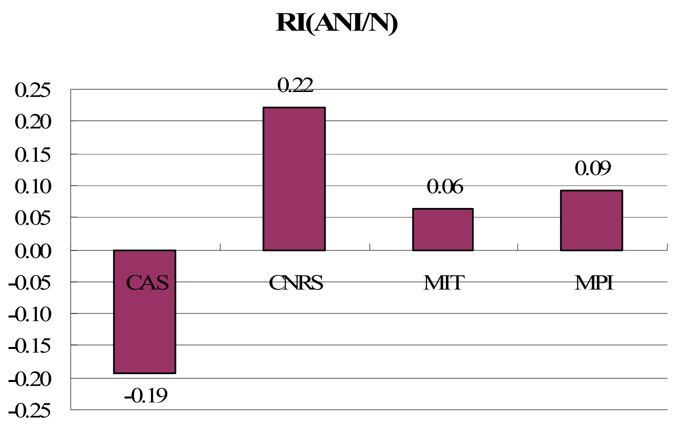

Figure 6. Relative Intensity (RI) for Group intensity

Associative Intensity (co-assignees numbers / patent)

In order to disclose an assignee's association with other assignee (s), this paper bring a concept of Associative Intensity, which means the numbers of co-assignees per patent. The co-assignees include the co-applicants and the new assignees get the patent right by patent and technology transfer. This index reflects the collaborative strength in technology innovation or technology transfer activities. Table 6 and Figure 7 tell us that CAS had the worst associative intensity, each patent filing had only 0.1 co-assignee, while that number of CNRS was highest of 2.2. MIT and MPI were 1.4 and 1.0 respectively. The RI (ANA/N) indicated that although CAS had the largest number of biotechnology patents, the associative activities was worse than the other three institutions. Therefore, CAS has to strengthen the power to collaborate with other outstanding research institutions or corporations to carry out R&D activities and accelerate the technology transfer of its patents.

Table 6. Associative intensity

	CAS	CNRS	MIT	MPI
Total accumulation numbers (accounted by co-assignee)(ANA)	126	2275	700	590
Patents applications number (N)	1541	1033	499	588
Associative Intensity (ANA/N)	0.1	2.2	1.4	1.0

（Note: Patent cooperation between institutes of CAS is not accounted. That is, all co-assignee orgazinations of CAS patents are NON-CAS organizations. So is CNRS, MIT and MPI）

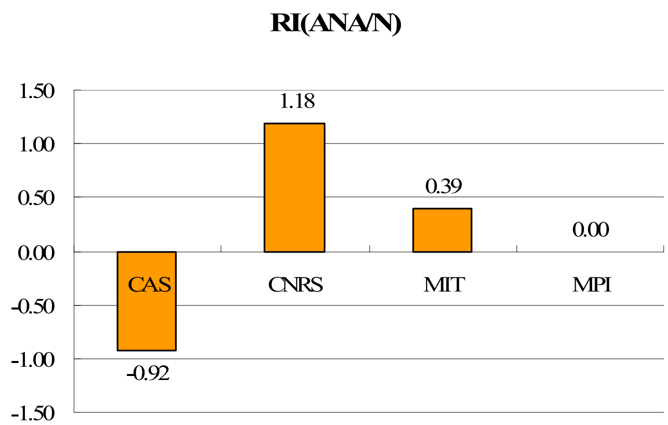

Figure 7. Relative Intensity (RI) for Associative intensity

Conclusions

The goal of the present paper is to show readers that the biotechnology innovation status compared with CNRS, MIT and MPI in biotechnology patents from 1985-2005 filing year. Our research has provided results of CAS, CNRS, MIT and MPI in Section 3 using the DII patents by some indicators of applications numbers, technical fields, time cited, countries, group intensity and associative intensity. Although for the publication delays that we had just compared the data until 2005 filing year, the findings of this paper together with further studies must be valuable for CAS to deal with its intellectual strategy and actions.

Data revealed that biotechnology was actually an important research field for all these four institutions, and the results of the study indicated a relatively larger number of patents of CAS. The CAS biotechnology patent applications had exceeded all the other three institutions in 2000 and had enlarged the advantage year by year as a result of the rapid increase in the last 21 years with the highest average annual growth rate of 37.6%.

However, although CAS had the largest number of patents applications, the strength of intellectual property protection of CAS was weaker than that of the other three institutions. CAS had mainly paid its attention to its native land protection for its intellectual property but less in overseas, while CNRS, MIT and MPI had focused on the overseas protection during the last about 20 years. Although CAS had also applied the biotechnology patents in 24 countries as many as that of MIT, CAS's average numbers per family only was 1.12, which was much lower than other three institutions.

Moreover, the RI (ANA/N) indicated that although CAS had the largest number of biotechnology patents, the associative activities was worse than the other three institutions. Therefore, CAS has to strengthen the power to collaborate with other outstanding research institutions or corporations to carry out R&D activities and accelerate the technology transfer of its patents. These characters also had been found in the indicators of group intensity and times cited.

The present study leads to a necessary thinking that what had made the above characters that CAS had the largest patents number but was weak in family members, associative intensity, group intensity and times cited. For patent information must be and will ultimately become an importance to policy and decision makers in governments, institutions and corporations, certainly including the CAS. Hence, we hope the results showed in this paper could be effective for the leaders or governors to make powerful measures to prompt its biotechnology innovations capabilities and broaden its global protection strength.

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