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Intellectual Property Rights and Innovation Activities in China: Evidence from Patents and Publications

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List of Abbreviations

CAS	Chinese Academy of Sciences
EPO	European Patent Office
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on Research and Development
ICT	Information and Communication Technology
IP	Intellectual Property
IPO	Intellectual Property Office
IPR	Intellectual Property Rights
PCT	Patent Cooperation Treaty
R&D	Research and Development
SAIC	State General Administration for Industry and Commerce
SCI	Science Citation Index
SEC	State Economics Commission
SIPO	State Intellectual Property Office
SSCI	Social Science Citation Index
SSTC	State Science and Technology Commission
TRIPS	Trade Related Aspects of Intellectual Property Rights
USPTO	United States Patent and Trademark Office
USSR	Union of Soviet Socialist Republics
WIPO	World Intellectual Property Organisation
WTO	World Trade Organisation

1 Introduction

The Chinese innovation system is one of the most dynamic in the world. The annual growth of GDP per capita of over 7-8% on average in the years 1993-2003 (OECD 2005: 32), respectively the total R&D expenditure (GERD) of 18.6% on average during the years 2001-2003 (Ministry of Science and Technology (China) 2006: 44) are evidence of this development. However – and this must also be underlined – China still lags behind the developed industrial nations with regard to the absolute amount as well as the level of the single indicators, but was able to catch up considerably in the recent past. Thus the share of R&D expenditure in GDP (R&D intensity) amounted to 1.3% in 2003, which means an outstanding position among the developing countries, but still a clear gap compared to the EU-25 with 1.8% or to Germany with ca. 2.5%. Other countries like the USA, Japan, Finland or Sweden are even beyond the threshold of 3%. If the GDP is not measured in purchasing power parities but in market prices, then it can be calculated that the per capita income in China amounts to approx. 4% of the per capita income on average of all OECD countries. The demand for raw materials and finished goods has increased greatly in the past years. The exports from China to Europe, as well as China's imports from Europe have made this gigantic country into one of the most important trading partners for example for the whole of Europe. In 2003, China imported goods and raw materials to the value of ca. US $ 413 billion and exported goods to the value of US $ 438 billion (Statistisches Bundesamt 2004). The most important trading partners were other Asiatic countries, in particular Japan and Korea, as well as Hong Kong[1] and Taiwan. The USA is the largest market for Chinese goods, while conversely China's imports from the USA clearly lag behind. Germany's balance of trade with China was (still) positive in 2003 and reached a share of 5.9% in China's imports and 4% in the exports.

China's population amounts to about 1.3 billion and it covers an area of 9.5 m square kilometres (Statistisches Bundesamt 2004). China however is not in the least homogeneous. Besides the numerous tribes and the geographically and topologically vastly differing regions in this country, it is primarily the economic differences within China which lead to marked heterogeneity. So the east coast with the two metropolises Beijing and Shanghai but also other provinces, are clearly further developed than numerous other areas in this huge territorial state. The Chinese also speak of "four worlds". As far as economic power is concerned, the first world in the east has reached a level similar to many developed states in the world. However, only approx. 2.2% of the Chinese population lives here (Hu 2005). The further westward one goes, the less economically developed the provinces are, and ca. 50% of the population lives in the fourth world, i.e. with a per capita income below that of the average developing countries. For this reason the central government in Beijing has set the goal to let China's less developed regions participate in economic growth and overall development.

To sum up, China is on a fast and steep path of development and several indicators are at hand for the analysis and monitoring of these changes. The general indicators to describe economic or technological trends and in particular to analyse the innovation system all underline the significant dynamic of this country, although the level frequently lags behind that of western industrial nations. Of special interest in this latter context are patents and scientific publications which cover the technological and scientific achievements of innovation systems. This paper tries to track the science and technology development in China in the past twenty years, particularly innovation activity, which is measured with patent indicators. Patents not only reflect the success of an innovation process, but also the potential for the appli-

cation in products or processes that may be offered on economic markets. So patents are, on the one hand, an output indicator that can be related to R&D investment and, on the other hand, an input indicator to future technology production (Frietsch, Schmoch 2006; Grupp 1998).

But as with any indicator, a deep understanding and knowledge of the underlying forces that guide the actors in the system has to be reached, before a proper and sophisticated interpretation of the outcome of the patent analysis can be given. Also scholars who are only interested in the statistical analysis – based on patents – have to have a sound knowledge on the underlying formal/legal and informal framework conditions of the system. As patents are still only granted on a national level and as the national systems differ – sometimes enormously – in their formal and informal framework, the knowledge of one system cannot directly be transferred to another system. Therefore, in a first step, we have to learn something about the legal cornerstones and the actual effects of the system, before we can make comparisons of the statistical outcome to any other system.

Correspondingly, the paper starts – after a short description of the recent situation of intellectual property rights in China – with a review of the evolution of intellectual property law, with a focus on patent legislations. Together, the paper discusses the enforcement of these IP regulations and its impact on innovation and patenting activity. The second part of the paper presents the scientific and technological profile of China through publication and patent analysis, both in China and abroad. Our work is based on desk research, database analyses and interviews with several experts, both in China and Germany.

2 Describing the Formal Situation of IPR in China – the Evolution of IPR Legislation[2]

2.1 Initiation of IPR Legislation (1950s-1970s)

After being founded in 1949, PR China followed the USSR in establishing the country system, including intellectual property institutions.[3] In August 1950, the central government initiated *Provisional Regulations on the Protection of Inventions Rights and Patent Rights*. Under this regulation, the state owned the patents and the inventors were awarded with certificates for inventions made in the course of employment, and in the case of inventions made outside of work, the inventors were granted the ownership. In terms of trademark, the *Provisional Regulations on Trademark Registration* set up a new registration-based trademark system after invalidating the registration in the former Guomindang government. So far, no comparable regulation concerning copyrights was set up, but issues of payments for publication were addressed without the force of law. Authors were entitled to a certain amount of fixed basic payments and had the right to stop unauthorized alteration of their work.

In 1960s, several social movements were undergoing, which brought the appropriateness of material incentives for creative activities into attention. In this context, the regulations on IPR were amended to reduce the property rights and material incentives. In 1963, the *Regulations to Encourage Inventions* and the *Regulations to Encourage Improvements in Technology* were promulgated, which emphasised that inventions and improvements in technology were exclusively the property of the state. The system of certificates of inventions was

terminated. In the same time, the *Provisional Regulations on Trademark Registration* was replaced with *Regulations Governing the Control of Trademark*, which was issued solely for quality control purpose, with no mention of rights. In parallel, although no copyright regulations to be revised, the payments for publication were reduced intensively.

However, none of these restrictions of IPR was comparable to the 10-year Cultural Revolution started in 1966. In this 10-year period, almost all scientific work was turned down and knowledge was ignored. The revised regulations of 1963 were abandoned. There was no payment and no protection for invention or publication. No one was willing to claim the credit in inventive activity.

When the Cultural Revolution was over, China's new leadership realised the importance of science and technology, and launched a series of programmes to motivate intellectuals back to scientific work. As part of this, the legal framework of intellectual property regulations was restored. In 1978, the 1963 invention regulation and trademark regulation were reissued. In terms of copyright, the *Trial Circular Concerning Basic and Supplemental Payments for News Publications* was announced in 1977, which brought the payment back to the level in early 1960s. It was soon replaced by the *Provisional Regulations on Basic Payments for Books*, where authors were entitled with the payment at the level of 1950s.

2.2 Reconstruction of IPR Legislation (1980s-1990s)

Different entities took over the tasks of constructing laws and regulations to protect intellectual work. The State Science and Technology Commission reestablished in 1978 to oversee science and technology policy, was responsible for developing policies related with inventions. The newly reconstituted State General Administration for Industry and Commerce (SAIC) was in charge of trademarks starting from 1979. In 1980, a special copyright committee was established.

A hot debate was undergoing in terms of the drafting of a patent law. The opponents argued that the patent system was against the socialist principles by giving a few individuals ownership of important technologies, and it might stifle the development of domestic industries and increase the dependence on foreign technologies. On the other hand, the proponents believed that material incentives specified in the patent law would promote innovation activity, and disclosure could foster information exchange among scientists. In the meantime, a patent system could assure foreign investors of the intellectual property protection and encourage international technology transfer. It could also enhance China's image in the world and get better protection abroad for Chinese technology. The debate was undergoing until Deng Xiaoping, late leader of China, made the decision that China should adopt a patent law. After spending 5 years on studying patent laws in different countries, the drafting committee came up with the first Patent Law, which was approved in the National People's Congress on March 12, 1984.

According to Alford (1995), the first patent law was structured in a way to make individuals difficult to secure rights through which they might extract monopoly rents, but with the promise of material rewards to stimulate innovation. For instance, individuals were not allowed to apply for patents for inventions made related to one's job, using materials from work, or within one year of leaving one's job, but they could receive a money prize from their work unit. Foreign applicants were faced with some additional disadvantages. They suffered more

from the exclusion of chemical, pharmaceutical, alimentary or process inventions from patent coverage because these fields were much more advanced in other countries and were relatively easy to reverse engineered, which made it more important to have legal protection. Mertha (2005) suggests that the exclusion of chemical and pharmaceutical patents from the original patent law was due to the concern of the Chinese leaders to avoid indispensable reliance on foreign patent holders for products of maintaining public health.

These issues were addressed in subsequent two revisions of Patent Law in 1992 and 2000 respectively. In the first revision, the duration of invention patent protection is extended from 15 to 20 years and the duration of utility model and design patents is extended from 5 to 10 years; food, beverages, flavoring, pharmaceutical products, and substances obtained by means of chemical processes are also covered by the patent protection. In the second revision, state and non-state owned enterprises are treated as equal in obtaining patent rights; individuals are allowed to own patents for inventions made during work time if there is an agreement between individuals and employers. In 2005, the State Intellectual Property Office (SIPO) initiated the preparatory study for the third revision for the Patent Law and its implementation regulations.[4]

Parallel with the development of the Patent Law, the first Trademark Law was issued in 1982 and the first Copyright Law was promulgated in 1990. Both Trademark Law and Copyright Law experienced the same discussion and concern as in drafting the Patent Law. These laws were based on international treaties and conventions: the Patent Law was based on the *Paris Convention*, the Trademark Law on the *Madrid Convention*, and the Copyright Law on the *Universal Copyright Convention* (Yang and Clarke, 2005).

2.3 Enhancement of IPR Legislation (1990s-2000s)

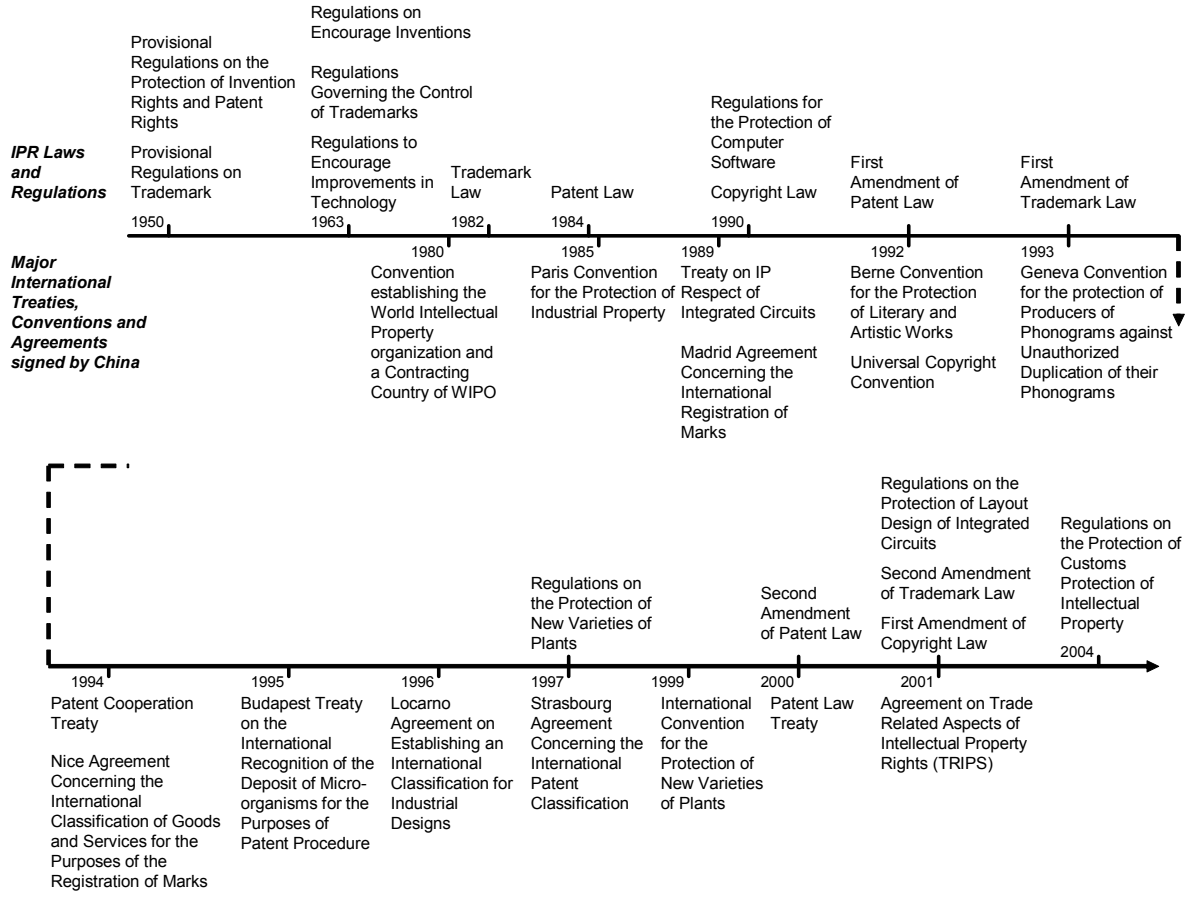
If we described the intellectual property system in the first forty years from 1949 to 1990 as being shaped by domestic political events, starting from 1990s the intellectual property regime is under mixed pressure from internal and external forces.

The first IPR negotiation between China and the U.S. took place in 1979 during the *U.S.-China Bilateral Trade Agreement*, where China committed to protect foreign patents, copyright and trademarks. Since then, China has made extensive progress in establishing IPR laws and joining international IPR conventions. However, disputes over IPRs between the U.S. and China have been recurring in the following decades. In 1991, China was identified as a priority foreign country under Special 301[5] that failed to protect U.S. intellectual property. The U.S. again pressured China to improve IPR enforcement regime by threatening to impose trade sanctions. After several rounds of heated bilateral negotiations, these two countries reached an agreement in 1992, the *Sino-U.S. Memorandum of Understanding on the Protection of Intellectual Property*. In this agreement, China agreed to update intellectual property protection and join major international conventions (La Croix and Konan, 2002). For example, chemical inventions were included in patent protection; and patent protection term was extended from 15 to 20 years for foreign patents. These amendments led to the first revision of Patent Law and the promulgation of the *Implementation Rules for International Copyright Treaties* in 1992. (Mertha, 2005)

In 1993, China was complained for violating U.S. copyrights on a variety of goods such as computer software and CDs. Since then, the focus was shifted from legal measures to

enforcement of IPR. New rounds of negotiations were held from 1993 until 1995. An enforcement-based *Action Plan* was reached to strengthen the enforcement and dissemination of IPRs. In 1996, an additional agreement, *Report on Chinese Enforcement Actions under the 1995 IPR Agreement*, was signed, which was particularly focused on the copyright issues. In 1997, an *Article 216* was added to the Criminal Law, which provides criminal penalty for patent counterfeiting. The Copyright Law and Trademark Law were amended in 2001 to revise the sections against the World Trade Organisation (WTO) rules (Yang and Clarke, 2005). Figure 1 highlights the important events in the evolution of intellectual property regimes in China.

Figure 1: Timeliness of Major National and International IPR Laws and Regulations



Source: Alford (1995); Yang and Clarke (2005); La Croix and Konan (2002); Ministry of Commerce of PR China, Depart of Treaty and Law, website: http://tfs.mofcom.gov.cn/aarticle/cj/200503/20050300029076.html; Ministry of Commerce of PR China, Depart of Treaty and Law, website: http://tfs.mofcom.gov.cn/aarticle/cj/200503/20050300030517.html

3 Describing the Effective Situation of IPR in China – Some Flashlights

Since China joined the WTO in 2001 and signed the *Agreement on Trade-Related Aspects of Intellectual Property Rights* (TRIPS Agreement)[6], the Chinese patent system – after the introduction in 1985 and two revisions in 1992 and 2001 – corresponds formally to international

standards and conventions. Applications to the SIPO have clearly picked up speed since then. The Chinese officials appear to have expanded their efforts on protecting intellectual property rights in the recent past, with some success. The European Chamber of Commerce (2005) confirmed this in a recently published expertise, as well as several German firms which spoke in interviews of a positive development. Nevertheless, the situation is far from satisfactory, and the protection of intellectual property rights is still the subject of frequent complaints or is criticised as inadequate, often by representatives of large international enterprises or by innovative companies active in China in particular. Copying technologies without paying royalties, unauthorized trademarks, and infringement in publications occurred frequently. Foreign firms are hence reluctant to transfer technology, export goods to or produce them in China (Maskus and Dougherty, 1998). For instance, most foreign-owned R&D centres in China apply patents initially in their home countries, and some of them do not file applications in China (Walsh, 2003).

3.1 IPR Infringement in China

According to company reports, the patent system as such is very dependable and in the meantime patent infringements stay within limits or "one can live with it". Patent infringements are reported and heard in court. In China – similar to other countries – there are specialised law courts, which the enterprises can choose according to the subject concerned. What remains problematic, however, are infringements of some intellectual property rights, above all copyright and trademark protection. Here in general less technical input is necessary on the part of the "pirates", so that infringement is easier and therefore more frequent. Well-known examples of such infringements are cinema films on DVD, and also the DVD standard itself, which was used by Chinese producers without procuring a licence. Handling the situation in China was rather problematic for a long time. In 2003 a company exported DVDs to Europe, where protection of intellectual property of the DVD technology exists. The import was refused and the Chinese company was sentenced to a fine (Hong 2006). After that, the Chinese began to develop their own standard for DVDs. This is at the same time an example that imitation strategies can lay the foundations for own innovations. Japan acted in a similar fashion in the 1960s and 1970s and Korea in the 1980s and 1990s, and both were successful.

Product piracy especially, i.e., partly exact and partly less accurate copies of products, and generally of lesser quality, still takes place in China, especially infringement of trademark applications of individual enterprises. Figure 2 shows one example. This involves a pesticide called "Regent", which is sold by Bayer on the Asian market in the package illustrated in the right hand picture. On the left and in the middle are the copies which a chemical factory in Hunan Province distributed.

Figure 2: Original (right) and Copies of a Pesticide Produced by Bayer

Source: http://www.bayercropscience.com.cn/communication/communication02_13.htm

Another problem still existing for many firms in the Chinese innovation system is re-engineering, i.e. buying single pieces and imitating the technologies, to copy the products on the one hand. On the other hand, learning effects are achieved and Chinese firms are in a position to produce own innovations in a medium-term perspective, which can either replace the product or develop technologies complementing it, which then also restrict the ability of the original innovating company to act. However, this applies in similar form for enterprises in all markets of the world. The publication of the technical properties – and this is what happens with a patent application[7] – codifies the knowledge and makes it accessible to others. Given sufficiently attractive markets for these technologies, competing firms try to substitute the technologies or to develop further aspects of the technology line and capture their own market niche. According to the licensing and product policy of the technology leaders, competing enterprises will be tempted to different degrees to invent alternative technologies ("patenting around"). In general, this phenomenon is not a specific problem of the Chinese or Asian market. However, the form it takes or the vehemence with which this strategy is pursued is extremely pronounced. On the one hand, this may lie in the absolute will of the Chinese government to catch up with the leading technological nations.[8] On the other hand, it may lie in the large numbers of qualified human capital who can be employed for relatively low wages.

3.2 Behind IPR Infringement

With the rather sophisticated intellectual property regulations in place, the frequent infringement activities need to be understood from another angle. As one of the respondents in our interviews pointed out, “there are very good intellectual property laws, but the implementation is a different story”. We will discuss this problem from two perspectives: why some people disrespect other’s intellectual property and why IP laws do not effectively deter infringing behaviour.

3.2.1 Public Awareness of IPR

The first question could be understood in the context of the public awareness of intellectual property. China has long been under the influence of Confucianism and Socialism, where the former considers learning taking place by copying, and imitation is a form of flattery[9] (Bosworth and Yang, 2000), and the latter believes that “in inventing or creating, individuals were engaged in social activities that drew on a repository of knowledge that belonged to all members of society” (Alford, 1995). Knowledge was transferred from academia to industry for free until 1980s, during which period universities and research institutes were responsible for R&D, while enterprises had solely the function of production. With this tradition, it has been taken for granted that knowledge is public good and everyone can use it for free. The concept of knowledge as private property embedded in IPR was rather new to China, given the large ignorance on intellectual property rights, education and propaganda.

3.2.2 Enforcement Systems of IPR Regulations

The second question lies in the fact that how well the IPR regulations are enforced. There are two parallel enforcement systems in China, judicial approach and administrative

approach. Complaints of IP infringement can be either filed in the court or in the administrative authorities.

3.2.2.1 Judicial Approach

A Special People's Court System was established in 1992 to handle IPR protection issues and disputes. In 2005, courts at all levels accepted 16583 IPR civil cases in total and 13424 cases were of the first instance. Among these first instance cases, there were 6096 copyright cases with an increase of 43% from 2004, 2947 patent cases with an increase of 15.6%, and 1782 trademark cases with an increase of 34.5%. Infringement and ownership disputes accounted for the majority of all the IPR-related civil cases (SIPO, 2005b).

However, judicial approach is not the first choice when dealing with infringement cases because the procedure is costly and complicated. Individuals and small firms are also concerned about the requirement that a proportion of the claimed damages need to be posted as a bond if they go to the IPR court (La Croix and Konan, 2002). Around two-third patent infringement cases, 95% trademark cases and most copyright cases are not filed in court (Bosworth and Yang, 2000).

3.2.2.2 Administrative Approach

Administrative approach is by contrast more preferred by injured companies and individuals. The government in China was in charge of all aspects of the country including jurisdictions before the legal system established in late 1970s. People are strongly dependent on government and tend to seek administrative settlement instead of going to a court (Yang and Clarke, 2005). Even now with all the laws and regulations in place, the government administration is still playing an important role in solving disputes, including IPR related ones. The unit that deals with IPR related disputes is Intellectual Property Office (IPO) at different levels. After receiving the case, IPO staff conducts investigations and helps to coordinate between the two parties. If a fine is issued, the infringers are required to pay it into a special account in the bank. Otherwise, the enforcement units of the courts will follow up.

However, as Mertha (2005) pointed out, IPOs lack its own independent power and authority, which often affects the effectiveness of enforcement. Since the Patent Bureau founded in early 1980s, it has been transferred frequently from one host administrative unit to another, such as the State Science and Technology Commission (SSTC), the State Economics Commission (SEC) and the State Council. In 1998, the China patent Bureau was reorganised and renamed as the State Intellectual Property Office (SIPO), which also incorporated copyright and trademark units, although Mertha (2005) suggests that the consolidation is more symbolic than substantive, since copyright and trademark are still under the control of their previous host organisations. As a result, the political base of the IPOs is rather shaky. The political power and administrative effectiveness of IPOs depends on the relationship between these offices and local government and the priorities of local government, which largely affects how intellectual properties are protected and enforced in that region (Mertha, 2005).

3.2.2.3 Problems with Enforcement

Given the problems embedded in each system, both juridical decisions and administrative decisions are difficult to enforce due to the lack of appropriate infrastructure and mechanisms. Currently, a fail to follow a court order is not regarded as a crime, and few penalties exist for non-enforcement.[10] Hence, even when the courts reach a clear decision, it might not be enforced (Bosworth and Yang, 2000). The courts simply don't have enough man power to track each case and enforce their decisions. Injured companies have to keep pushing the court or authorities if they really want to get the infringer punished, which requires certain amount of time and money. It is often not worthwhile pursuing every single case, as the damages amount to only some ten thousand euros. As well, the injured company cannot count on receiving a fair amount of compensation, even if they are successful. Besides, the pirates pursue the tactic of frequently closing down a "busted firm" to immediately open a new "firm" which continues in the same vein.

Generally, these infringement cases are not categorised as relevant, so that the international multinational concerns are not restricted or endangered by them. In sum, however, the problem of the "little pinpricks" is definitely relevant, especially as the plagiarists or the violating parties often cannot be traced or brought to court (European Union Chamber of Commerce in China 2005). To deal with this problem, some Chinese and foreign firms are self-organised into associations and building networks with local authorities, to undertake additional private enforcement and push government to continue enforcement efforts (La Croix and Konan, 2002). According to the European Chamber of Commerce, and information from several representatives of German companies and institutions in China, criminal prosecution has improved greatly[11] and the officials pursue the reported cases with greater vigour. Tsinghua University – one of the largest applicants in China[12] – prosecutes in each case with all possible means. This underpins at least the generally expressed expectation that with the transition to own "genuine" innovations, the benefits and the acceptance of intellectual property rights in China will increase, driven by the needs of their own innovators.

3.3 Value of IPR Protection

One thing has to be emphasised at this point: Patents are a vested right for the applicant to secure a temporary monopoly on a certain technology. Companies have no interest in the disclosure of their technological inventions – next to some strategic interests. They accept this fact due to the securing of their rights. The argument for the public provision of private monopoly rights is that otherwise the total economic or social investment in the production of new technologies is below the optimum and the reason for this is very simple. Modern high-technologies afford massive investments into research and development. If the temporary monopoly is not granted, the interest of the individual company is close to zero as the free-riders – or pirates – could use their intellectual achievements and properties without any restriction. The R&D expenditure would be gone without being compensated and by this inventors are kept away from the investment as they cannot expect that their efforts will ever pay. Free-riders do not invest into the creation of new and advanced technological knowledge.

This means, if anyone can use any technology, no one will invest into the production of these technologies. The effect of this is a sub-optimal or even no investment into the creation of

new knowledge, no progress is made and any innovation is nipped in the bud. This damages the innovation system, because genuine innovators lose interest and motivation. It is therefore expected that when China becomes increasingly innovation-oriented for its own inventions – the transition from imitation to innovation – this problem will be recognised and appropriate counter measures taken. Though patents may give a private monopoly they are still in the interest of the public (Cohen et al. 2000; Frietsch, Schmoch 2006; Kash, Kingston 2001; Kingston 2001; Mazzoleni, Nelson 1998).[13] Cultural and social changes are necessary for this, which cannot take place overnight. There are however already examples heading in this direction. For instance, the SIPO has already conducted a campaign to diffuse information on IPR (SIPO 2005b).

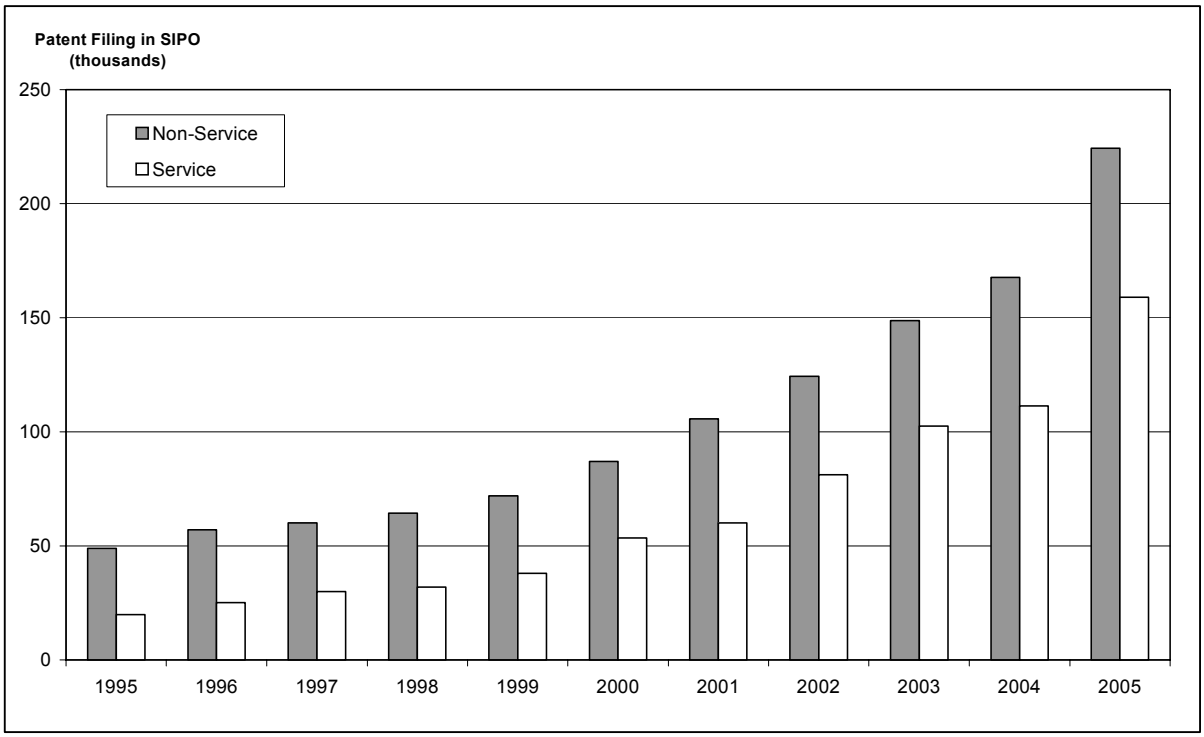
4 Innovation Activities in China – a General Perspective

Patenting activity in China started in mid 1980s after the approval of patent law. Compared with only five certificates of invention and four patents issued between 1950 and 1963 (Bosworth and Yang, 2000), the number of patent grants has increased dramatically in recent twenty years and reached 214,003 in 2005. The patent application number grows even more significantly, with an average annual growth rate of 19% in past ten years.

4.1 Patent Categories in China's Patent System

In current China's patent system, there are two types of patents: service patents and non-service patents. Service patents are those with applicant or assignee as organisations; and non-service patents are those made by individual entrepreneurs or individuals outside their work, which generally involve lower-level technology and minor changes. In the first version of Patent Law, only the work unit, not the individual, was allowed to apply for patents for inventions made in work or within inventor's one-year leave from work, which means only service patents could be generated from inventions in work. This was changed during the second revision of Patent Law in 2000, where individuals can also own patents for inventions made during work time as long as they have agreement with the employer. More than 60% of Chinese applications filed in 2005 were for non-service patents, while the number of foreign applicants for non-service inventions was only 4.7% (Figure 3).

Figure 3: Patent Applications (including three kinds) at the SIPO from Domestic Applicants



Source: SIPO Annual Report (2000-2005).

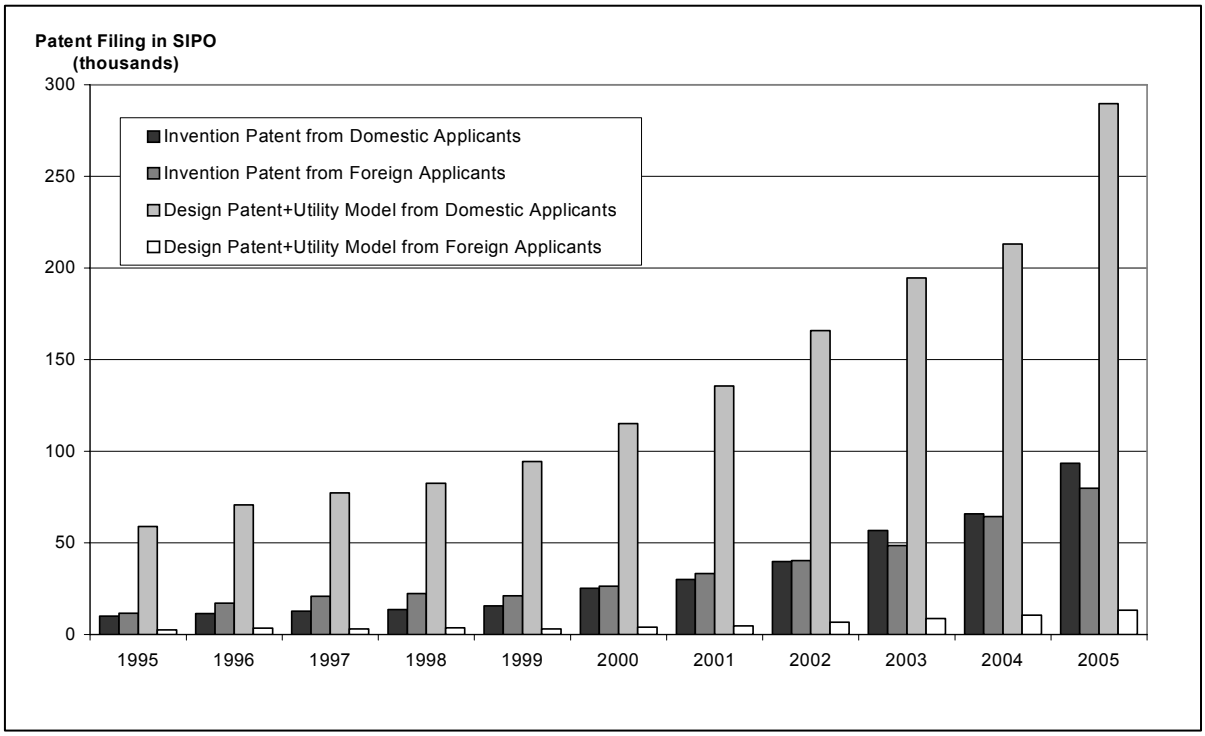
Independently of these two types, there are three kinds of patents: invention patent, utility model and industrial design. Invention patents refer to new technical solutions related to a product and process; utility model means new technical solutions related to the shape or structure of a product; and industrial design represents new design of the shape or pattern of a product. Invention patents are the highest formal requirements – corresponding to international convention – and must fulfil the criteria novelty, inventive step – sometimes also called non-obviousness – and economic applicability. Novelty means that the same content must not be filed at any other patent office worldwide or used in any product or published in any journal or book anywhere in the world. Inventive step means primarily that the content of the patent, which is of an exclusively technical nature, must exceed the already known state of the art. By contrast, the formal requirements of utility and design patents are less strict, so that trivial alterations can be applied for and technological advance is not necessarily a precondition.

4.2 Profile of Patent Application at the SIPO

In 2005, the number of total applications to SIPO amounted to ca. 476,000 and the great majority, 64% of total, were utility and design patents (Figure 4). The invention patent applications merely came to ca. 173,000 (SIPO 2005), which means about 50% more applications than at the European Patent Office (EPO) and about 50% as much application as at the United States Patent and Trademark Office (USPTO) (EPO 2005; WIPO 2006). Similar with the lion's share (98%) of domestic applicants in non-service patent applications, 97% of utility and design patents are applied for by Chinese applicants, which means that the Chinese inventors focus primarily on incremental or less technologically oriented innovations, which

appear less attractive for the international concerns, and they are still relatively at a disadvantage with new technologies against the foreign inventors and applicants. However, the invention patent application is catching up, with the proportion in total domestic applications increasing from 15% in 1995 to 24% in 2005, and for the first time surpassed the ones from foreign applicants in 2003. We will limit ourselves to invention patents in the following analyses, as they better depict technical advances, the evaluation criteria are more unambiguous and thus the quality to judge the inventions are higher, as well as making an international comparison of technological performance possible. The term patent refers to invention patent in the rest of paper if not otherwise indicated.

Figure 4: Patent Applications at the SIPO Received from Home and Abroad



Source: SIPO Annual Report (2000-2005).

5 Chinese Patent Activities – a Differentiated Perspective

5.1 Methodological Clarifications

5.1.1 The Use of Applications Instead of Grants

Some methodological clarifications need to be made before presenting the data. Applications are used instead of grants as this perspective allows the interpretation of patents as R&D output indicator, whereas grants may be closer to the market or at least to the usage of the technology for the business of the applicant. However, there are several reasons for an applicant not to pursue the process of patent granting to the end (Frietsch, Schmoch 2006). R&D output – of course – is also restricted to a set of technologically relevant inventions, to areas where patenting is a meaningful tool for the protection of intellectual property and

where other means are not in opposition, e.g. secrecy. To sum up, as an R&D output indicator, patents only reflect the technological part of the inventions and the propensity to patent may vary from technology to technology or from sector to sector (Gallini et al. 2001; Grupp 1998; Malerba 2004; Pavitt 1984).

5.1.2 The Use of Inventor Country Instead of Applicant Country

Furthermore, whereas SIPO and other official patent data are based on applicant country and year of application to the SIPO, we follow a slightly different approach here. Inventor instead of applicant country is used as criteria for the assessment of the origin of the patented innovation. The applicant country better reflects the ownership structures, which however is of subordinate significance here. It is of minor importance for the technological and inventive capabilities of a country who owns the patent. Instead, it is of high importance who has invented it and where the research and development activities took place.

5.1.3 The Use of Priority Year Instead of Application Year

Priority year is used instead of application year as this date is closest to the act of invention being the earliest date when the content of the patent was first filed at any office around the world, creating a priority, which is – based on the *Paris Convention of 1883* – the date of first filing after which the filing party has up to one year for the application at any other office around the globe without hurting the novelty criteria in its own. The focus on priority instead of application or even publication year restricts the timeliness of the analysis to about two years before the point of time when the data is gathered. This stems from the fact of an 18 month phase before the applications are published. Furthermore, international applicants often use the route of the Patent Cooperation Treaty (PCT), hosted by WIPO, to apply for patents in other countries. Also China signed this treaty and therefore it is possible – and in fact often used – to apply for a patent under this application procedure. A preliminary search report may extend the phase before a PCT-application enters the regional phase – also the case at the SIPO – so that the effective number of filings to the Chinese office for two more priority years is not known. And this effect is clearly biased between residents and non-residents so that compensation is necessary. Fortunately, the PCT-applications are also published after an 18 month phase so that estimations of filings entering the regional phase at SIPO are possible based on the total numbers of PCT-filings. This procedure is applied in this report to get a complete picture of the patent applications up to the priority year 2004.

5.1.4 A "Fictitious" Patent Office

For the analysis of international patent filings of Chinese inventors, a "fictitious" patent office is generated by summing up the direct filings to the EPO and the filings via the PCT-procedure of the WIPO. This was done, on the one hand, to overcome the problem of home advantage or home disadvantage. This means that applicants or inventors from the region/nation of the patent office have a higher propensity and probability to file patents at this regional/national office. To be precise, European countries have a home advantage at the EPO, because this covers their home market, where most of the companies are active exclusively. This is why the WIPO patents are included, which account for large shares of total filings a certain offices. At the EPO, for example, more than 50% of all filings are applied for

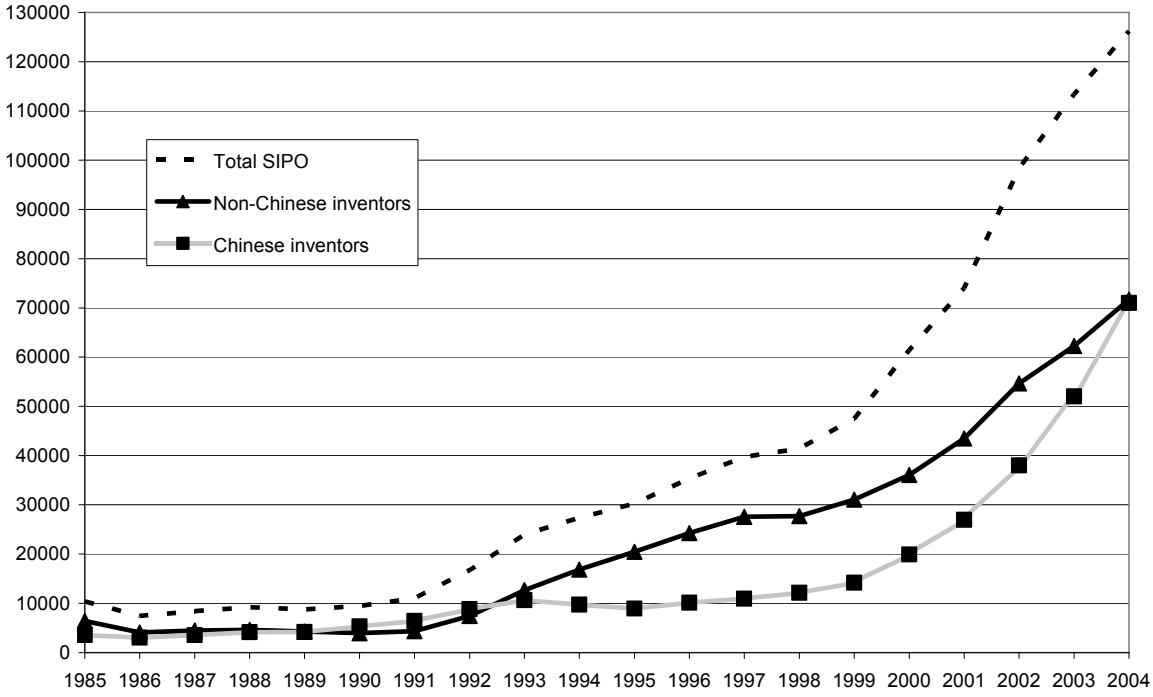
via this route. On the other hand it was necessary to keep the system constant, covering applications by priority date and inventor country. This all is possible with EPO and WIPO data, whereas – for example – the inclusion of US-American patent filings would make it necessary to change the perspective, as the USPTO only publishes granted patents, which is not only a subset of all patent applications, but also leads to a substantial time delay of patent data. The exclusive use of the PCT-filings would have been problematic for the whole period under observation as the shift towards this way of filings patents started very late and therefore the growth rates are too high in general. To put it in other words, in the early stages the numbers of patent filings at the WIPO have been too low as this system was accepted by the applicants with a certain delay. By using the "fictitious" patent office by summing up the numbers at EPO and WIPO, it is possible to overcome or at least reduce the disadvantages of exclusively analysing one data set. The data used should be able to cover the structures and trends of international activities of most countries and also of China.

5.2 Patent Applications in China

Since the beginning of the 1990s, the applications at the SIPO developed very dynamically, achieving an average annual growth rate between 1993 and 1999 of ca. 12%. In this period it was primarily the foreign applicants who were responsible for the strong growth. Approximately since the year 2000 – with China's membership of the WTO and signature of the TRIPS Agreement in 2001, together with further political reforms[14] – Chinese inventors have been driving the development of the total numbers and the average annual growth has soared to about 20% between 2000 and 2004. Figure 5 contains the total numbers of applications at the SIPO as well as the applications of Chinese and non-Chinese inventors. As the SIPO only publishes 18 months from the priority date, data were only available in generally accessible databases up to the year 2004 at the time this study was conducted (2006). If the figures from the *State Intellectual Property Office Annual Report* are taken as a basis (2005), which already contains further information, then the sharp increase continued in the following year up to 2005 and now the number of Chinese applicants has definitely increased more than the international applicants, so that the ratios appear balanced in the meantime.[15]

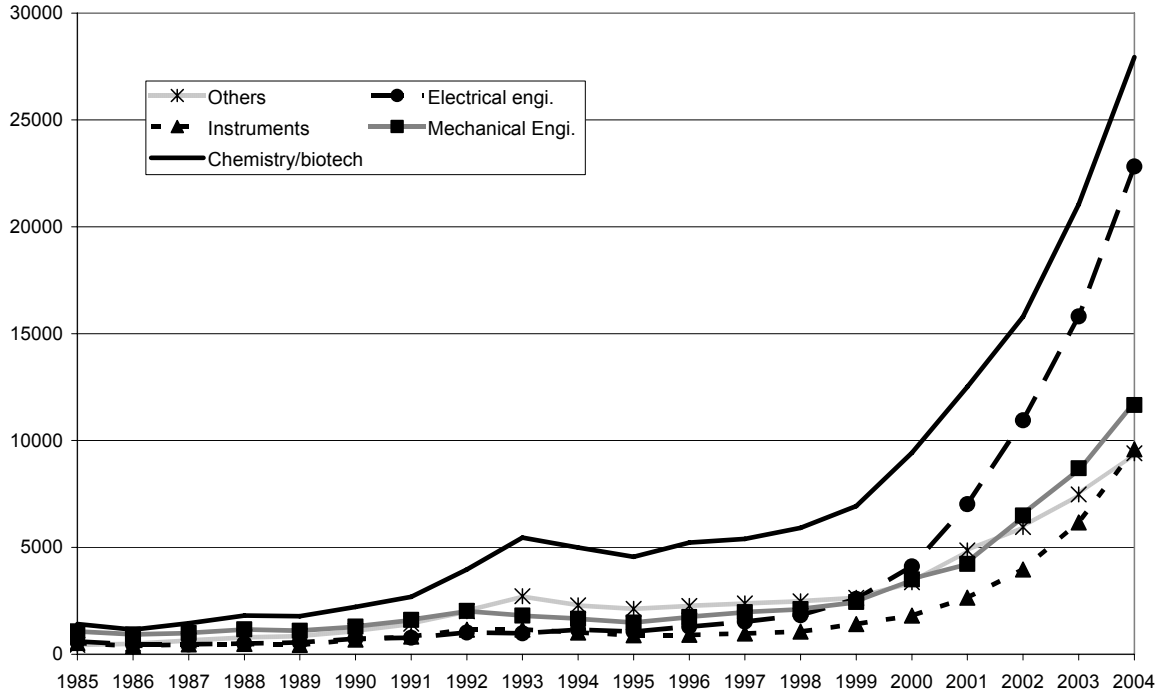
The majority of the applications in China are in the fields of chemistry/biotech/pharmaceutical (see Figure 6). Electronics/electrical engineering follow after a considerable gap of about 5,000 filings by Chinese inventors in 2004, whereby this area has been leading as regards growth in recent years, followed by measurement/control/regulation (instruments), the smallest of the fields observed here to date. Mechanical engineering reaches a medium position in absolute terms, also reaching a considerable growth rate in the recent past.

Figure 5: SIPO Invention Patent Applications by Inventors, 1985-2004



Source: INPADOC, STN.

Figure 6: SIPO Invention Patent Application of Chinese Inventors in Selected Technological Fields, 1985-2004

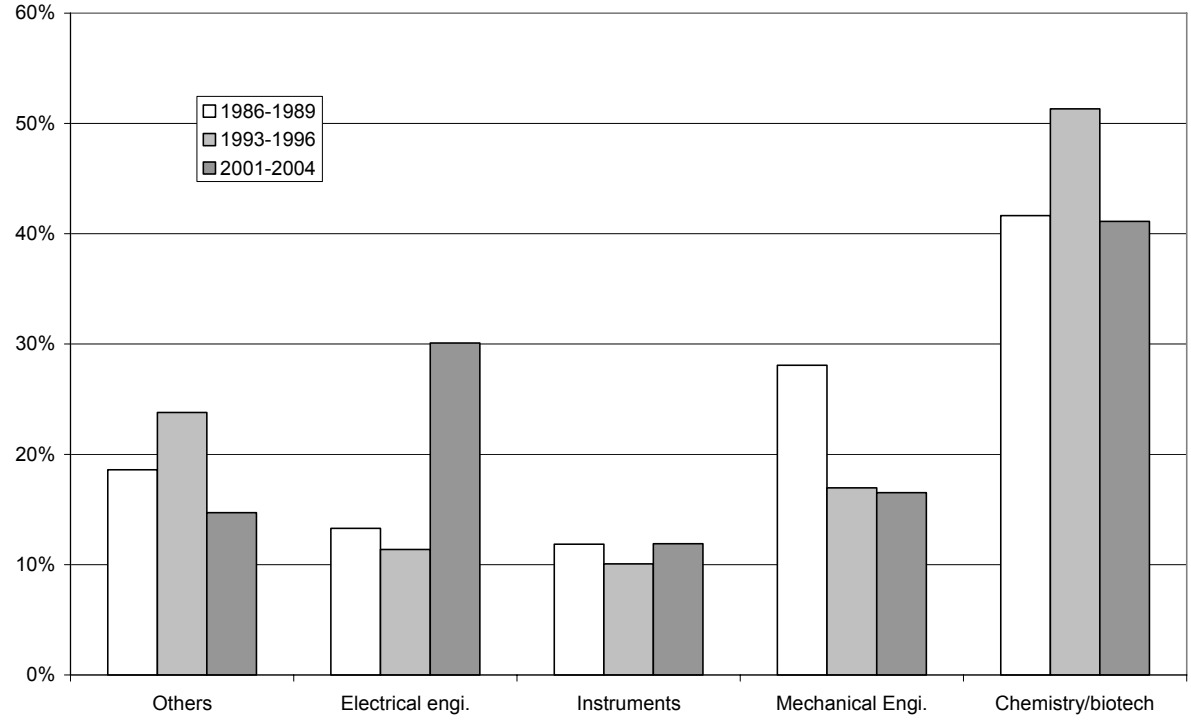


Source: INPADOC, STN.

Figure 7 summarises the shares of the technological fields and their change over time. Especially patents in electrical engineering have more than doubled their shares within the recent four years. About 30% of all patent applications of Chinese inventors to SIPO are in the

area of electronics and electrical engineering, playing the main part in the recent successes. On the other hand, chemistry lost ground, which was the main driver in the 1990s. Instruments and mechanical engineering have been able to keep their shares in relation to the 1990s, which proves that they have been able to follow the pace of the total patenting system.

Figure 7: SIPO Invention Patents in Selected Technological Fields in Relation to Total Patent Filings of Chinese Inventors, 1985-2004



Source: INPADOC, STN.

5.3 Research Performers in China

The structure of applicants to the SIPO is extremely interesting, for in contrast to western industrial nations, in China primarily universities and institutes of the Chinese Academy of Sciences (CAS) are among the largest patent applicants in most technology fields. Apart from information and communication technologies or electronics and electrical engineering in general, where the vast majority of the patents stem from internationally known and active enterprises such as Lenovo or Huawei, public research dominates patenting in China. Therefore the big universities and institutes have their own departments, respectively facilities which deal with patent exploitation. They try to generate further funds for the university by means of licensing agreements or via own spin-offs. The supposed "gold-digger mood" which is to found everywhere has also seized publicly funded research. Perhaps this is even a necessary stage in China's development towards an innovative economy.

For Chinese enterprises – be they private or state-owned – frequently do not have either the means or the patience to lay the fundament of future success through (application-oriented) basic research or applied research. In many cases, they are far more interested in the short-term maximisation of utility and profit. In the wider sense, one can speak of development

activities. The same or similar can be stated for most of the international firms which conduct R&D in China. R&D is often limited exclusively to "D", i.e., adapting their products, services and technologies to the Asian or Chinese market respectively. This is confirmed by the relatively low number of patent applications at the SIPO in which a foreign company appears as co-applicant, together with inventors from China. Many foreign firms have only established production plants in China, to profit from the in part excellent qualifications of the workforce at favourable prices. Only few companies actually conduct research in China and the most frequently cited reason for this reserve is the fear of educating one's competitor and thus making the Chinese really fit for the future. This certainly reflects negatively once again on the already discussed "piracy" or the bad reputation of the officials in pursuing infringements of intellectual property rights. But here too there are the first harbingers of change; for example, Bayer recently built one of the largest laboratories outside Germany or Europe in the vicinity of Shanghai.

Research in China must be mainly conducted by public institutions, partly because the enterprises do not possess the experience, capacities, resources or simply the interest in research. It appears that the division of labour has not yet developed optimally in this respect. However, it should be remarked here that generalisations should always be treated with care, or it should not be basically assumed that the way of the western industrial countries is automatically the best, or indeed only way. The Chinese innovation system could follow a completely different and still successful path.

However, based on experiences in other countries, as well as on scientific findings in the analyses of innovation systems, it does not appear very practical if universities and public research institutes were also to undertake the production, marketing and distribution of their research results in the form of products or services, in addition to their original tasks of educating the younger generations and conducting basic research. Here and there, this may facilitate knowledge and technology transfer. And innovation research has shown that this can prove to be a bottleneck (März et al. 2006; Schmoch et al. 2000). This facilitation would however certainly be dearly paid for through frictional losses in other places. So they should orient themselves not exclusively to demand, and possibly re-direct their research accordingly. Universities would simply expand their set tasks too far and thus over-reach their competences.

One task is to observe how this trend continues to develop and whether a stable division of labour will emerge. If the total performance of the Chinese innovation system as described up to now is observed, then we can well conclude that the relative strength of the universities and research institutions can be traced back to a weakness in the enterprises and not to an especially exposed and excellent position of public research. The ICT branch in any case showed that other relationships are also possible in China between public and private R&D.

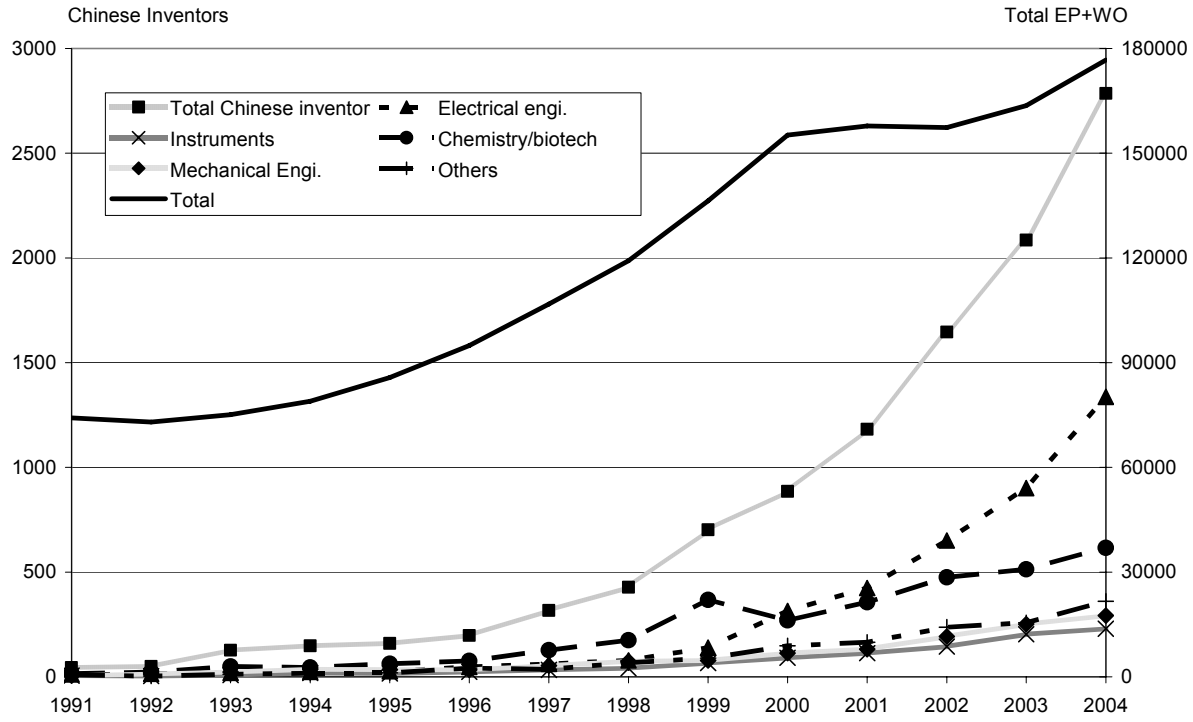
5.4 China's International Applications for Patents

If the invention patent applications of Chinese inventors are compared with the international activities – in this case the sum of European direct applications and PCT applications – then a clear dynamic is seen in recent years, but the total figures remain modest (Figure 8). Whereas more than 70,000 patent applications were made to the SIPO in 2004 by Chinese inventors, according to calculations made here only approx. 2,500 were international, i.e. ca. 3.9% of applications. If similar ratios were calculated for example for Germany, the shares

are 50% and more (Blind et al. 2003; DPMA 2005), which reflects a distinctly stronger international orientation, even taking a possible home advantage in the EPO into consideration. Even for the USA, the largest and most important market in the world, an internationalisation quota of approx. ¼ can be calculated. This leads us to the conclusion that the numerous applications at the SIPO admittedly illustrate an impressive dynamic. However, an international quality or a level which could survive in international markets on a broad front is not given at the present time.

These results complement the picture of the Chinese innovation system already sketched above, which grows rapidly and also produces a remarkable amount of output. Not only the fact of the low shares of patents of national origin – in relation to utility and design patents – but also the low shares of international applications, suggest that Chinese inventors do not research the most leading-edge technologies, or at least cannot yet offer solutions. This may be in part because the activities of Chinese firms abroad are still controlled or approved by the government. More and more companies are admittedly appearing in the international markets. But frequently they are not competitive or go abroad in order to learn. It appears that the government deliberately accepts that some firms will have to be sacrificed hereby (Zedtwitz 2005). Another reason for the low share of international applications is the lack of financial resources (OECD 2002). International patent application is more expensive than domestic patent application due to the low exchange rate of Chinese currency. Patent application fees at the SIPO are CNY 900 for invention patents, CNY 500 for utility models and industrial design while contrast, PCT application fee is around CNY 9000. In 1999, 60 international patent applications were withdrawn due to unaffordable application fees. Furthermore, next to the fees of the offices it is even more important to consider the general processing costs for international filings like patent attorneys and translation. These costs may sum up to 20,000-50,000 US$ for each application.

Figure 8: European Direct Applications and International Applications via the PCT Procedure of Chinese Inventors, 1985-2004



Source: EPFULL, STN.

It transpires that the development of the European direct applications or the applications via the PCT procedure from China do not run parallel to the general trend of total applications, but are definitely steeper. The numbers of patent filings have more than tripled in the period since 1999. This points to a catching-up process, i.e., the orientation towards this "fictitious" office grows more rapidly than technological development as a whole. And the total dynamic is also impressive, but is driven primarily by patents in the areas of electronics and electrical engineering, while the development at the SIPO was much more broadly based. In absolute figures, the applications in the fields of electronics and chemistry are the ones which clearly influence the total numbers. Ultimately, these are the technology fields in which Chinese enterprises are more likely to be competitive at an international level.

One idiosyncrasy can be observed in the PCT applications from China in the areas chemistry/biotech/pharma. In the years 1999 and in particular 2000, an extreme swing upwards, which stemmed from the applications of a single company (Shanghai BioWindow Gene Development Inc[16]) which filed almost 1,000 patent applications in this period. However, not a single application survived a short time later – i.e., all without exception were rejected or withdrawn. The application process was discontinued and no single patent was awarded. According to various experts and authorities on the Chinese patent system, this enterprise was "inspired" by the human genome project. What finally is at the root of it – whether own invention, adaptations of the intellectual property of others or applications with only a low inventive level – cannot be further clarified here. In any case, all applications were withdrawn or rejected shortly after publication (18 months after application). If even one single patent had been awarded, then the cost would have already been worthwhile for the company. However, obviously no countable inventions or innovations supported the applications and

this negatively influenced the time series, so we subtracted this company's applications from the statistics of Chinese applicants.

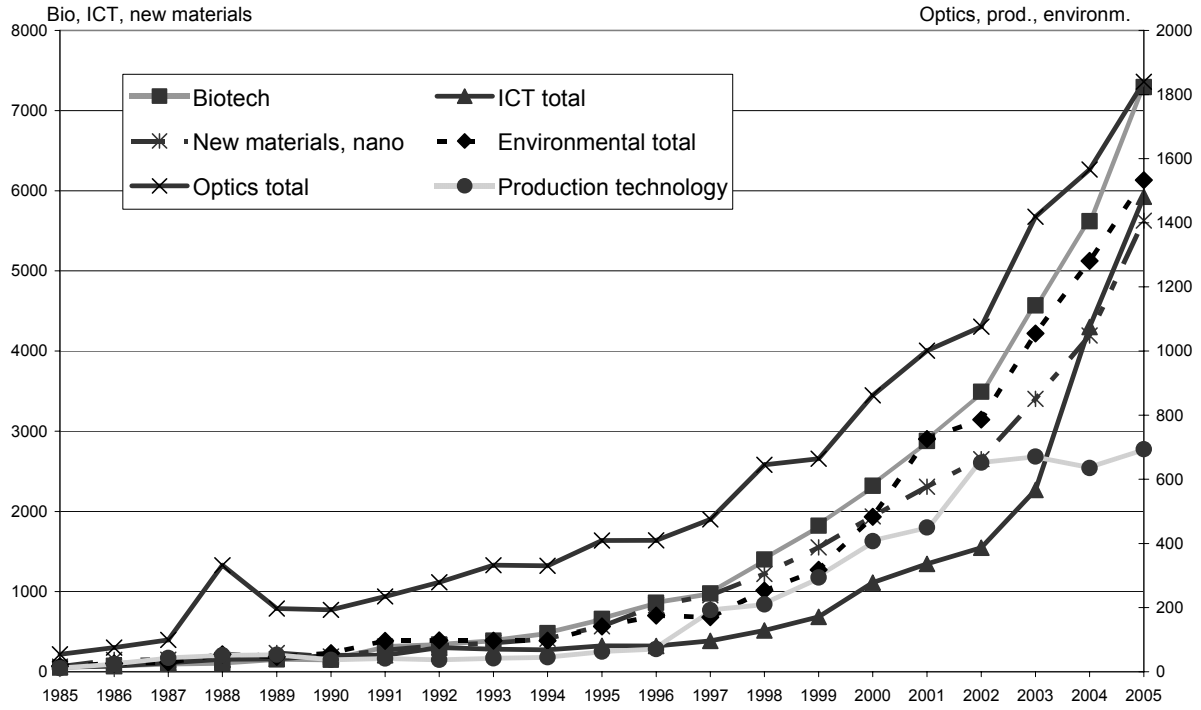
6 Internationally Relevant Publications

The Science Citation Index (SCI) contains the most significant internationally relevant journals from different scientific and technological fields. It is utilised in evaluations of institutes and research institutions, as well as to judge the performance of individual scientists. A journal is included in this data collection if articles from this journal are quoted with sufficient frequency in other articles. In the same manner, articles can be banned from the database if they do not meet the criteria. The fact that an article appears in a journal which is quoted in the SCI can thus be assessed as a "quality criterion" as such. However, the SCI has disadvantages, respectively does not adequately reflect some scientific areas – in particular the engineering sciences – in all aspects and facets (Schmoch 2004). Anyway, the SCI is frequently taken as a measuring stick in many cases and it forms the basis for assessing the international, scientific performance within the framework of this report.

The Chinese government and the Chinese scientific system have also recognised the significance of this database and utilise it to judge their national performance in an international comparison (Ministry of Science and Technology (China) 2006). The Chinese university system sets very powerful incentives for professors to apply for patents and to publish internationally. For instance, professors at universities and research institutes receive a bonus – which sometimes is roughly equivalent to a month's salary for an assistant professor – for each patent application and also for every SCI publication. For a social science publication in the SSCI (Social Science Citation Index) they sometimes even receive a larger amount of money. And this money is paid as a bonus to their salary and not allocated to the institute or research group as additional budget for the group. In addition, students of engineering, for example at Tsinghua University, can graduate on the strength of an awarded patent application, and students from other faculties can receive their degrees by producing evidence of having published in the SCI. This sets very clear signals on all levels, which are then also perceived by the participants. However, this can possibly also have negative effects, as these individual rewards tend to limit the interest and motivation to cooperate within the group somewhat. After all, one does not necessarily want to share one's results and one's bonus with too many other people.

Figure 9 shows the development of journal articles by Chinese authors in six selected scientific fields. China arrived at a share of 7.6% of all publications in the SCI in 2005. By comparison: Germany's share was 8.4%, but at the beginning of the new millennium the highest share of 9% was reached. Not last as a result of the expanding activities of the catch-up countries – with China at the head – the absolute number of publications was more than doubled between 2002 and 2005, while the total numbers in the SCI of all countries merely grew by ⅓.

Figure 9: SCI Publications of Chinese Authors in Selected Scientific Fields, 1985-2005



Source: SCISEARCH, STN.

Figure 9 proves that China places particular emphasis on the fields of biotechnology, information and communication technologies and also new materials or nanotechnology, and in the recent past was able to clearly improve its position therein. This means that in science – although similar to patents on a low level – the Chinese researchers have focused their attention on the new and modern technologies. "Catching-up" processes can also be noted here. By specialising and focussing on modern technologies, they may possibly be able to achieve considerable successes rapidly and catch up with the leading scientific nations in the near future. The quality of knowledge or technology achieved, respectively the proximity to application of them, cannot be derived from these statistics. According to experts who have been investigating the scientific system in China by means of bibliometric analyses for a long time, quality – in terms of reaching internationally reflected and acknowledged research – on a broad scale is indeed lacking (Jin, Rosseau 2004). Language barriers could be one hindrance, for English is the scientific language which many, in particular younger Chinese understand. This can however be a hurdle to realisation and use in articles for peer-reviewed journals. The Chinese government recognised this fact as well and supports numerous researchers and students by making stays abroad possible.

7 Summary

China is without a doubt an extremely dynamic and ambitious economy which has in the meantime assumed an outstanding position according to numerous indicators, compared with other catching-up countries. The growth rates of the gross domestic product, the R&D expenditures, foreign trade as well as the science and technology production are impressive.

However, the level in many cases – in particular when measured against the size of the country – is often low. This may stem primarily from the heterogeneity of this vast country, for some single regions and provinces have already arrived at a stage of development which is in no way inferior to that of western industrial nations.

However, there are still deficits, as this investigation substantiated. In research and development, especially, many activities are restricted to development and adaptation of existing products and technologies to market needs on the one hand. On the other hand, the R&D results are not yet sufficiently competitive for international markets. Besides, multinational enterprises which are active in China seldom conduct real research, but frequently only development. A reason for this may be product piracy and infringements of intellectual property rights. However, (large) enterprises have come to terms with these circumstances or rather, the patent system meets the international standards (TRIPS) in the meantime, at least in purely formal terms. The enforcement of IPR in general – and of trademarks and copyright in particular – is still a problem, but here too changes are on the way.

Patenting at the SIPO is increasing greatly, but has not reached the international standard on a broad scale. The large shares of universities and CAS institutes in technology production must be stressed. It can be expected that with increasing quality of the R&D results and growing international competitiveness, the division of labour will be changed. In the area of information and communication technologies, where some companies from China already operate alongside the top performers, this division of labour is already established. In this field, as in new technologies in general, scientific activities are specialised in the form of publications. A positive development can thus be expected here also, although the international level has not yet been reached on a broad scale. The success of the past years bodes well for the near future.

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Notes

[1] Hong Kong belongs once more to the Peoples' Republic of China since it was handed back by Great Britain in 1997, but still enjoys a special status.

2 The section is in part drawn from Alford (1995) and Mertha (2005)

3 The first patent law in China was promulgated by the Qing Dynasty in 1889. It was followed by the Republication Patent Law in 1912, and the Patent Law of Nationalists in 1944, which is still effective in Taiwan. (Source: Mertha, 2005)

4 See SIPO http://www.sipo.gov.cn/sipo_English/gjhz/zycf/t20060410_78991.htm

5 The "Special 301" provisions of the Trade Act of 1974 require United States Trade Representative (USTR) to identify foreign countries with inadequate IPR protection. Once the foreign countries are identified, they are assessed by USTR of whether being designated as priority foreign countries, which have the most adverse impact on the US products and are not making progress in addressing these problems. For details, see

http://www.ustr.gov/assets/Document_Library/Reports_Publications/2005/2005_Special_301/asset_upload_file223_7646.pdf

6 The TRIPS Agreement defines international "minimum rules", which should facilitate dealing with and especially the international "flows" of intellectual property. In sum, this agreement states that "… the agreement addresses the applicability of basic GATT principles and those of relevant international intellectual property agreements; the provision of adequate intellectual property rights; the provision of effective enforcement measures for those rights; multilateral dispute settlement; and transitional arrangements."

(http://www.wto.org/english/docs_e/legal_e/ursum_e.htm#nAgreement; 19.09.2006).

7 A patent application contains an exact technical description and thus enables every expert to comprehend the proposed technical solution and possibly even replicate it. One should not expect that a rationally acting enterprise is interested in explaining the technologies in exact detail to its competitors. The innovative companies accept this circumstance as the price for safeguarding their invention and extend or supplement the protection by utilising further intellectual property rights. The reliability of the system is thus crucial. In addition, some applicants pursue a deliberately "confusing tactic" in their patent application strategy, by describing the object as generally and in as broad terms as possible, or they make it extremely difficult for competitors to fully grasp the contents by skilful formulations. Several other procedures are also possible, e.g. applying for further patents around the actual invention or chopping up the actual technology into several applications. On the whole, the significance of IPR has increased and companies utilise IPR in the meantime for strategic purposes (Blind et al. 2006).

8 In a speech at the opening of the national Conference for Research and Technology, the Chinese President Hu Jintao announced in January 2006 that China wants to develop into an innovation-oriented country. Top priority will be given to energy and environmental technologies.

9 A Chinese proverb describes the mentality very well; the translation is approximately: "Stealing a book is not theft" or "To steal a book is an elegant offense" (Alford 1995). Poor students who want a book, but cannot afford it, steal it with the honourable goal of educating and further developing themselves. They have a high regard for the book, especially because of the theft. The same applies for intellectual property and the technical and technological solutions of other parties. The Chinese want to learn, and also esteem "theft" or copying objects. The difference between a "pirate" and the poor student is that with the infringement of intellectual property a financial benefit is sought and simultaneously the original innovator is harmed.

10 Punishment of infringement has increased, but punishment of non-enforcement of court order still doesn't receive enough attention. The court decision is often ignored, not only in IPR disputes, but also in other civil right cases.

11 Since 1997, patent counterfeiting is subject to criminal law with up to three years' imprison (Article 216), which adds some deterrence.

12 A study of the largest applicants for patents in China in six technology fields revealed that in a ranking according to the number of applications, Tsinghua University was among the first ten in all six fields, frequently even among the first three applicants.

13 The opponents of patenting argue the other way around: As the monopoly is granted on an individual level, this monopoly may be abused to gain higher royalty fees and the social costs are higher than the social gain. Furthermore, they claim that patents hinder technological progress as the monopolists keep other away from using their technology and thereby derivatives and further development is not possible. These opposites become most obvious in the software patent discussion {Blind, Software patents; McQueen, 2005 4397 /id}. The latter argumentation is followed up by the Open Source community.

14 In 1999 the Communist Party and parliament passed a decision ("Decision on Strengthening Technological Innovation and Developing High-Technology and Realizing Industrialization"), which made it easier for firms to carry out research and development (R&D) and in particular to market the research results {Liu Li, forthcoming}.

15 The Chinese Patent Office uses the applicant country exclusively to determine the origin, whereas in this study the country of invention is the basis because this better pictures the place where research activity took place. In this respect the numbers are only comparable to a limited degree. Only a slight deviation can be determined between these two counting methods, at least referring to the Chinese applicants and inventors. It can be derived on the one hand that until now Chinese companies carry out (practically) no research abroad, or that conversely foreign firms only conduct limited research with patent output in China.

16 Various variations on the name of this company which appeared in databases: Bode Gene and Bodao Gene.