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E/ nº 17 / 2004

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Organization, Program, and Structure: An Analysis of the Chinese Innovation Policy Framework*

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Abstract

The paper first identifies the stakeholders involved in the design and implementation of China's innovation policy and compares them with different government systems in selected Organization for Economic Co-operation and Development (OECD) countries. In order to disclose the relative strength and weaknesses inside China's innovation policy framework, we proceed to utilize policy practices in the OECD countries as a guideline to examine China's innovation policy in five categories: reform in the public S&T institutions, financial policy, business innovation support structure, human resource policy and legislative actions. Subsequently, several weak components of the Chinese innovation policy framework are identified and two of them are selected for further analysis: education and human resource policy, and protection of Intellectual Property Rights (IPR). Finally, the paper provides some priorities and possible actions for future innovation policy developments in China.

* Forthcoming in R*&D Management*. Special Edition "Managing R&D in China". Late 2004.

We would like to send our great thankfulness to the comment on the early version of this paper from Prof. Yanyun Zhao in Renmin University of China, Prof. Jon Sigurdson in Stockholm School of Economics, Prof. Eddy Szirmai in Eindhoven Center for Innovation Studies, Ms. Jiang Jiang in Chinese Academy of Social Science and other valuable opinion of the participants of *Conference on The Emergence of New Knowledge Systems in China and Their Global Interaction*, September 29th and 30th, 2003 in Lund, Sweden and Conference on *Innovation and Learning in a Globalised world, Experiences of Developing Countries*, October 10th, 2003 at Eindhoven Centre for Innovation Studies, Eindhoven, the Netherlands.

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1. Introduction

China began implementing its market-oriented reform in the late 1970's. The Chinese innovation policy has experienced complicated and diverse changes due to the Country's economic and political transition. In this transitional phase China intended to promote economic and social change and to strengthen competitiveness through a coordinated S&T and innovation policy. After a series of policy and administration changes, the following questions to be asked are: Which government bodies have become responsible for innovation policy at the national level? Which organizations can be considered important participants in the process of policy making? To what extent has China developed an innovation policy? In which area of the innovation policy does China do well, and where does it lag behind compared with international practices?

For the purpose of this paper, innovation policy is defined as a set of policy actions intended to raise the quantity and efficiency of innovative activities where 'innovative activities' refers to the creation, adaptation and adoption of new or improved products, processes, or services (European Commission, 2000). The innovation policy can be developed and implemented at different levels such as local, regional, and national. This paper, mainly addresses the national level, which is specifically established and executed by the Chinese central government. The "National Systems of Innovation" approach (Freeman, 1987; Lundvall, 1992; Nelson, 1993; Dodgson and Rothwell, 1994; Edquist, 1997) used in this paper underlines the influence of the policy on the interplay between business enterprises and S&T organizations and on the creation, transfer and absorption of technology, knowledge and skills.

The Organization for Economic Co-operation and Development (OECD) (1996) indicated that an efficient innovation policy strategy must combine a number of macroeconomic and structural policy actions and its success depends on the validity of the policy framework and the complementarities and mutual support among the different policy actions. The lack of coherent policy practices in certain aspects of national innovation systems will limit and even offset the effect of other well-functioned policies and harm the efficiency and effectiveness of the whole system.

To assess China's relative strengths and weaknesses, this paper will focus on examining components of China's innovation policy framework in comparison to the OECD countries' practices. Some OECD countries are regarded as the world's leading countries engaged in innovation policy frameworks.

The remaining parts of this paper are organized as follows: section 2 introduces the institution framework for innovation policy matters in China; section 3 describes the policy actions, the structure and the programs implemented by Chinese government; section 4 analyzes the Chinese practices in the OECD context and examines two selected weak points of China's innovation policy identified in the former analysis; and section 5 concludes the paper.

2. The Governance Models of Innovation Policy Matters in China and OECD

Countries

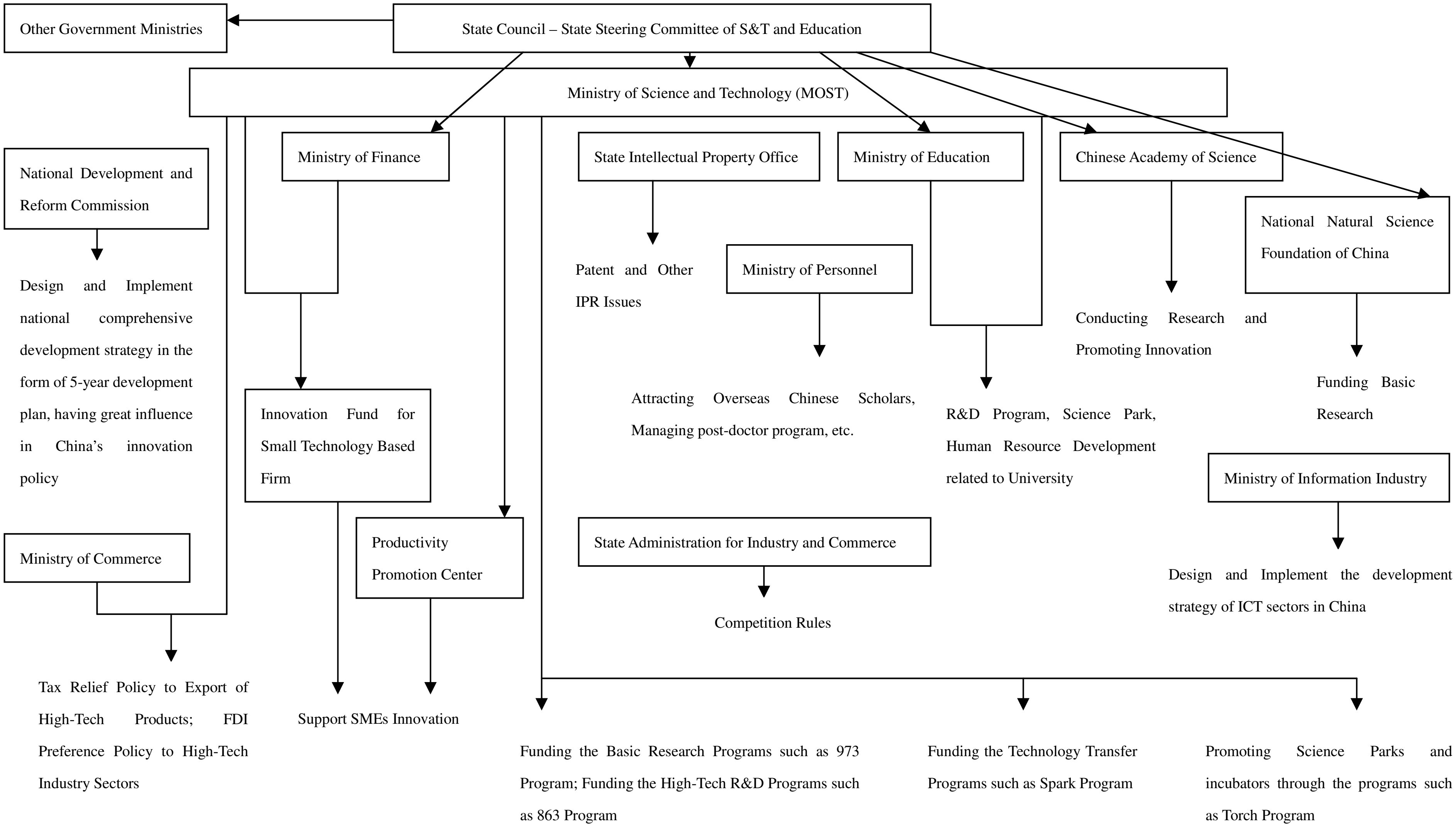
After 1978, basic principles of market-oriented economy were beginning to be introduced into China's S&T policy reform, experiencing a series of multi-level administration reforms in combination with shifts in administrative power within different government bodies and agencies (US Embassy Beijing, 2002; OECD, 2002; Sociedade Portuguesa de Inovacao, 2002). The main executive stakeholders with regard to the Chinese innovation policy framework are shown in Figure 1. In this section, the three important stakeholders are highlighted and compared with counterparts in some OECD countries.

There exists a coordination mechanism in the State Council, called the State (National) Steering Committee of S&T and Education (*Guo Wu Yuan Ke Ji Jiao Yu Ling Dao Xiao Zu*), founded in 1998, which is the highest ranked innovation policy coordination body in China. The State Council Premier carries out a role in the coordination of government policy as a decision maker for national strategy for S&T and education fields and coordinates the innovation policy in the ministry and local level. From June 2003, the group has been leading in designing and developing an outline document "2006-2020 Chinese National Science and Technology Development Plan". Compared with China, the similar co-ordination structure at ministerial level with the alike task can be found in the OECD countries, for example in Finland. The Finish Science & Technology Council, chaired by the Prime Minister is composed of seven Ministers and ten representative organizations (European Commission, 2001a).

In 1998 the State Science and Technology Commission changed its name to the Ministry of Science and Technology (MOST) and became a principal participant in China's technological endeavors. Now, MOST is regarded in China as having a high competence with regard to the design and implementation of innovation policy. Through its executive body, it implements several programs to fund basic and applied R&D, serve enterprises, especially SMEs to innovate, manage and promote the science parks and incubators throughout China and develop human resources in the S&T field.

Models of governance differ among the OECD countries. In some countries, there is no separation between the government departments that design policy and those that implement measures. For instance, in the UK, the Department of Trade and Industry is at the center of innovation governance system. It designs science policy and also "operate and/or funds a number of schemes for the promotion of innovation in companies"(European Commission, 2002a), which is very similar with China's governance system. Differently, in countries like Ireland, policy is framed by ministries but delivered by semi-autonomous agencies. There is a distinction between the responsibilities of the Department of Enterprise, Trade and Employment and Enterprise Ireland, which is the implementing agency (European Commission, 2002b). In Austria, Belgium, Germany, Spain, the countries with federal structure, innovation policy framework is more complex with the interaction of federal and

Figure 1 Chinese Innovation Policy Institutions



local governments (European Commission, 2002c).

The Chinese Academy of Science is another important stakeholder in the Chinese innovation policy framework. It has been an essential part of China's S&T system in the planned economy, founded in 1949 by following the ex-Soviet Union's experience. After the years' reform and restructuring, by the end of 2002 it still had a huge size, composed of 112 institutes, including 84 scientific research institutes, one university, one graduate school and 4 documentation and information centers and two media and publishing organizations (Chinese Academy of Science, 2002a).

Distributed over various parts of the country, the Chinese Academy of Science had a total staff of over 45,600 of whom 67.2% are scientific personnel (Chinese Academy of Science, 2002b). The statistical data shows that the Chinese Academy of Science is the major beneficiary of China's government funds for S&T. In 2002 it received 20% of total funding of National Nature Foundation of China, 12 of a total of 26 projects of Program 973; in 2001 and 2002, it received 14.1% of total funding of Program 863 (Chinese Academy of Science, 2002c). (The S&T programs in China are discussed in section 3.2.)

3. The Policy Actions Implemented in China for Promoting Innovation

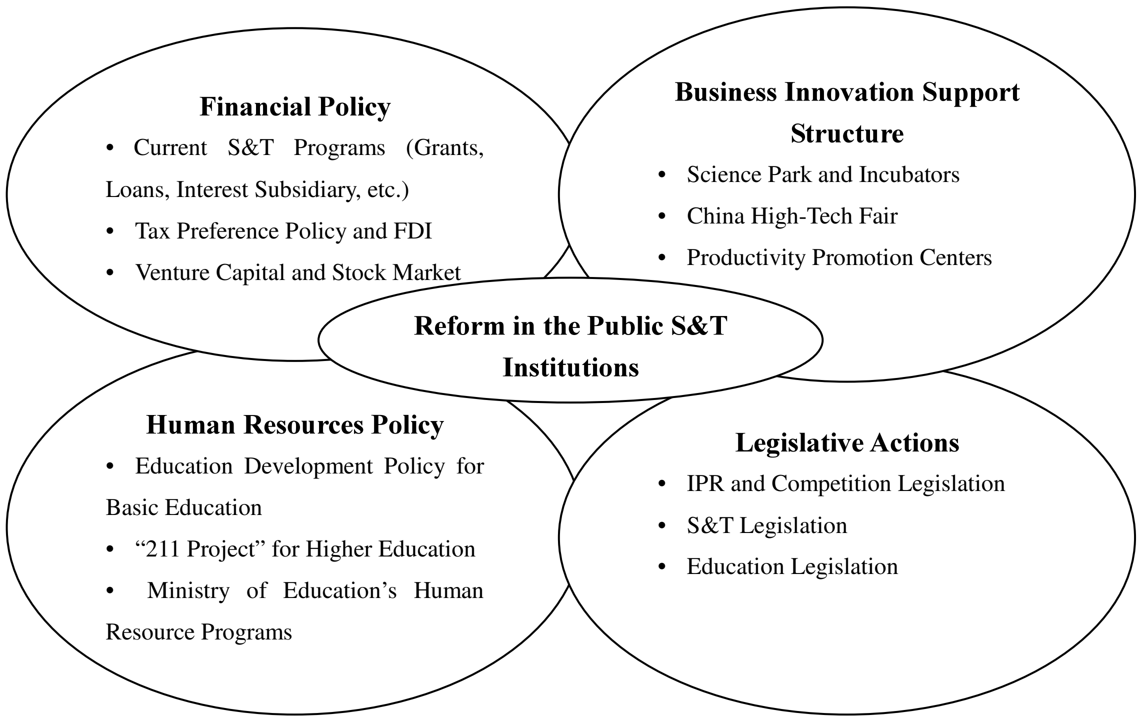
Since the emergence of the "National Innovation System" approach, some scholars endeavored to create a theoretical scheme to compare the different national innovation system in the diversified social and economic context (Nelson, 1993; Liu and White, 2000; Shyu et al., 2001; Chang and Shih, 2003). Edquist (1997) also probed into the function of the national innovation system, which could be utilized to implement a comparative study. However, in terms of our purpose of comparatively describing a transitional innovation policy framework like the Chinese, which misses some typical policy components in the countries with an established market economy and possesses the other ones inherited from planned economy, the collected literature does not elicit many scattered policies in China and gives us a comprehensive answer, especially for the question in which area the policy has been catching up and in which it is still weak. Therefore, we propose an analytical scheme, particularly for China's innovation policy framework as illustrated in Figure 2 and examine each policy category respectively.

3.1 Reform in the Public S&T Institutions

In the international context, the reform to public S&T systems in post-socialist countries also occurred in some central and eastern European countries (Dyker and Radosevic, 1999). The challenges facing the authorities in those countries and in China were similar, which is transforming the R&D system highly detached from industry and fostering the innovation capability of the enterprises that were not main innovation agents under the socialist planning economy.

Gokhberg (1999) summarized the policy chosen by the central and eastern European

Figure 2 Chinese Innovation Policy Framework



countries during the transitional period such as increasing government's funding for R&D, maintaining and developing the basic research and improving the collaboration between S&T institutions, universities and industry, etc., which also were embraced by China government's practices. Chinese government undoubtedly realized the reform of public S&T institutions constitutes a vital pillar of whole S&T and innovation system reform since the late 1970s.

Gu (1995) discussed intensively the policy reform for the S&T System in China by dividing the evolution of the reform policy into several phases. Recently, Suttmeier and Cao (1999), Liu and White (2001), Liu and Jiang (2001) and Cao (2002) extended the empirical observation of policy initiative after 1995. However, the analysis on the newest round reform since 1999, called "the transformation of the R&D institutes", is seldom seen in the published literature. In Table 1 and 2, we synthesize the above works and the result of the survey done by MOST in 2002 May on the 290 newly transformed R&D institutions, depicting a preliminary picture of China's latest reform in public S&T institutions after 1999.

3.2 Financial Policy

Since the 1980s, China's government intensively utilized a series of programs with the different priorities as a mechanism of funding S&T activities. The initial time, respective priority and characteristics of these programs are discussed in Table 3. The data of funding in recent years of those programs (Table 4) obviously shows that China's government continuously increased the direct support to S&T activities. Furthermore, the central government set up its strategy as attracting the financial input from local government and enterprises, evidenced by the funding structure of Spark Program. In 2004, the 863 Program, Key Technology R&D Program and 973 Program emerged as the biggest three funding programs led by MOST, holding 72% of the funding managed by MOST for R&D in the country. (National Natural Science Foundation of

China is independent from MOST and reports directly to State Council.)

The Chinese economic performance and the increase of the national innovation capability since 1978 can be partly attributed to foreign direct investment (FDI)(Liu and Wang, 2003; Buckley et al., 2002). China has welcomed foreign investors in ever increasing numbers, attracting them by providing physical and institutional infrastructures, as well as fiscal incentives. Due to this policy, the FDI inflow accelerated rapidly in the 1990s and China became the world's largest recipient of FDI in 2002, receiving nearly US$ 53 billion (OECD, 2003a). Chinese central government continuously implements tax advantage and deduction policies targeted towards foreign investors, but shifts the focus of preference fiscal policy from low-tech and labor-intensive industry to high-tech manufacture and service sectors. In July 2003 MOST and the Ministry of Commerce developed a list of high-tech products that China's government is going to attract FDI to produce in China.

Among China's goals is the establishment of a viable financial system, and particularly a venture capital system, to support technology-based SMEs. Currently in China, there does not exist a specific law to regulate venture capital development. Legislative framework for venture capital only consists of Company Law and a joint regulation of 7 ministries. Some legislative proposals for venture capital law have been submitted to the national legislation authority, and at the local level the Shenzhen, Chongqing, Shenyang municipal governments have enacted some local regulations to protect and promote venture capital development in their administrative areas.

Additionally, the Chinese stock market is acting in support of high technology companies listed on the market. By August 1999, the listed high technology companies accounted for 17.8% of all companies listed. These companies have raised nearly RMB 47.8 billion (US$ 5.76 billion). (In this paper, the exchange rate of US Dollars to RMB for 1996 to 2004 data is 1:8.3). Their average earnings per share and return on equity compared with the average of the ordinary listed companies are 64% and 45.5% higher respectively (Zhou, 1999). The debate of the feasibility of creation of "Chinese NASDAQ" has not concluded yet and recently it seemed that the favorable decision for the establishment of Chinese SME board has been made (Securities Times, 2004)

3.3 Business Innovation Support Structure

A dynamic innovation system is characterized by its capacity to generate new activities in existing firms, the creation of new firms, and also the emphasis placed on diffusion and absorption of knowledge in the innovation system.

In China, the internationally prevalent business support structures such as science parks and

Table 1: Chinese Reform Policy for Public S&T Institutions: 1978-2004

Period	Policy Actions Target	Policy Actions
Reformation of Planning Practice (1978-1984)	Recover and develop the R&D system and integrate it into the planned economic practices.	• Rehabilitation and improvement of R&D institutions after the damage during Culture Revolution (1966-1976). • Integration of R&D activities into the 6th National Five-Year Plan (1980-1985).
Performing the S&T activities in the "Market" (1985-1991)	Establish the horizontal and regular connection between S&T sector and enterprises.	• Replace the former S&T funding method that is mainly through planned appropriation by the program projects competition mechanism. • Diminish the government grants to force the R&D institution to establish cooperation with industry. • Create a "Technology Market" to legitimize paid transactions for technology and set up the agencies to support the transactions. • Promote the autonomy of R&D institutions and mobility of the S&T Personnel. • Attempt merging the R&D institutions into enterprises. • Support the spin-off enterprises.
Bridging S&T activities closely to " Socialist Market Economy" (1992-1998)	Run non-basic research R&D institutions as run enterprises.	• Endow the R&D institutions the comprehensive economic autonomy as the same hold by normal enterprises. • Encourage spin-off activities through promoting science park and incubators. • Continue the merging strategy.
Large Scale Transformation of R&D institutions (1999 till now)	Transform nearly all of the government owned R&D institutions.	• Transform the R&D institutions into enterprises, non-profit organizations, intermediary organizations or merged them into universities.

Source: Gu (1995); Suttmeier and Cao (1999); Liu and White (2001); Liu and Jiang (2001) ; Cao (2002).

Table 2: Transformation of Public R&D Institutions in China After 1999

<table>
<tr><th>Transformation Year</th><th>Number of Transformed R&D Institutions</th><th>Owners of the Transformed R&D Institutions</th><th>Status After Transformation</th><th>Preliminary Result
MOST Survey in 2002 May on 290 Transformed R&D Institutions</th></tr>
<tr><td>1999</td><td>242</td><td>Ex-State Economy and Trade Commission</td><td rowspan="3">Enterprises</td><td rowspan="3">• Revenue in 2001: 1.5 times of in 1999; Profit in 2001: 2.6 times of in 1999; Tax in 2001: 1.9 times of in 1999.
• R&D expenditure annual increase rate in 2001: 16.2%; in 2000: 6.84%.
• Patent application annual increase rate in 2001: 9.6%.
• Employee average salary in 2001: 142.6% of that in 1999.
• 92.6% of them set up enterprises accounting system; 88.65% entered the local unemployment insurance; over 10 of them went public in the stock market.</td></tr>
<tr><td>2000</td><td>134</td><td>11 Ministries: Ministry of Construction, etc.</td></tr>
<tr><td>1999 - 2002</td><td>660</td><td>Local Governments</td></tr>
<tr><td>2001</td><td>98</td><td>4 Ministries and Agencies: Ministry of Land and Resources, etc.</td><td rowspan="3">89 institutions: Non-profit Organizations
61 institutions: Enterprises
Others: Merged into universities, transformed into intermediary organizations</td><td rowspan="3">N/A</td></tr>
<tr><td>2002</td><td>107</td><td>9 Ministries and Agencies: Ministry of Agriculture, etc.</td></tr>
<tr><td>2004</td><td>43</td><td>5 Ministries and Agencies: Ministry of Health etc.</td></tr>
</table>

Source: Li, (2002).

Table3: China's current S&T programs

Program	Initiating Year	Objective	Program Characteristics
Key Technology R&D Program *(Gong Guan Ji Hua)*	1983	Concentrate resources on key and common technologies that direly needed by industrial upgrading and social sustainable development.	The program target set in 10^{th} five-year plan from 2001 to 2005 is:1) By 2005 the general agriculture technology is increased to the level that lags behind international advanced level 5 years; 2)The technology and equipment level in several key industry sectors like ICT and manufacturing sector matches the level of developed countries in the mid of 1990s;3) Develop the technology related to environment protection and sustainable development; 4) Support the enterprises to be the major technological innovators.
State Key Laboratories Program *(Guo Jia Zhong Dian Shi Yan Shi Ji Hua)*	1984	Support selected laboratories at public or private facilities.	This program is intended to promote the research and advanced training in the 159 laboratories (2002 data) belonging to universities and R&D institutions and establish a string of national engineering research centers.
Spark Program *(Huo Ju ji Hua)*	1986	Support technology transfer to rural area to promote the rural area development.	In 1990s the government appropriation for this program hardly surpassed 5%. The bank loan and enterprises own capital occupied the majority investment of the projects. In fact, the projects sponsored by this program attain the government credit for the bank loan application. In 2000, 16.8% of total investment of this program came from bank loans.
National Natural Science Foundation of China (NSFC) *(Guo Jia Zi Ran Ke Xue Ji Jin)*	1986	Support basic research through directly funding the projects.	From its establishment of 1986 to 2000, the NSFC has funded over 52,000 research projects of various categories by investing a total sum of RMB 6.6 billion. More than 60,000 scientists are supported by NSFC to conduct basic research. In 2004, the NSFC received over 40,000 funding applications.
High Technology R&D Program (863 Program) *(863 Ji Hua)*	1986	Enhance China's international competitiveness and improve China's overall capability of R&D in high technology.	The Program is concentrating on mid to long-term development in both civilian and military areas. This Program is co-managed by MOST and the Commission of S&T and Industry for National Defense. The Program covers 20 subject topics selected from eight priority areas: Biotechnology, Information, Automation, Energy, Advanced Materials, Marine, and Space and Laser. Recent years 863 program continuously increased the funding for R&D projects undertaken by enterprise.
National New Product Program	1988	Compile the annual list of new and high technology product and fund those products	In 2002, 71.86% of the program's funding is by the means of grants and 28.14% is through interest subsidiary.

(Guo Jia Zhong Dian Xin Chan Pin Ji Hua)		selectively through the grants and interest subsidiary.	
Torch Program *(Huo Ju Ji Hua)*	1988	Support high technology industry sector development through setting up science park and incubator, funding projects, and human resource training etc.	By the end of 2003, through Torch Program the governments have established the structure such as science park, incubator, software park, university science park etc. Inside these science parks and incubators, 28,504 high technology enterprises had been founded and created 3.49 million jobs. The program had funded 10,261 projects.
Key Basic Science R&D Program (973 Program) *(973 Ji Hua)*	1997	Support basic science research.	The 973 Program's specific tasks are to support the implementation of key basic research in important scientific areas related to agriculture, energy resources, information, resources & environment, and population & health; to provide a theoretical basis and scientific foundation for innovation; to foster human resource; and to establish a number of high level scientific research units.
The Innovation Fund for Small Technology Based Firms (IFSTBF) *(Ke Ji Xing Zhong Xiao Qi Ye Chuang Xin Ji Jin)*	1999	Support the establishment of Newly Technology Based Firms.	The financial support includes interest subsidiary, grants and capital investment. The fund connects to Key Technology R&D Program, 863 program and Torch Program to facilitate the technology transfer from the R&D projects funded by them.

Source: Key Technology R&D Program (2004a, 2004b), National Key Laboratories Program (2004), Spark Program (2004), National Science Foundation of China (2004a, 2004b, 2004c), 863 Program (2004); National New Product Program (2004), Torch Program (2004), 973 Program (2004); Innovation Fund for Small Technology Based Firms (2004).

Table 4: The Funding for Current Chinese S&T Program (1996-2004) [1]

	1996	1997	1998	1999	2000	2001	2002	2003	2004[3]	Ratio of Funding in 2000 to GDP[5]	Ratio of Funding in 2000 to Gross Domestic Expenditure on R&D (GERD)[5]
Key Technology R&D Program	1.06[4]	1.06[4]	1.06[4]	1.06[4]	1.06[4]	1.545[4]	1.545[4]	N/A	1.5	0.012%	1.18%
National Key Laboratories Program	N/A	N/A	N/A	N/A	1.542	1.737	2.212	N/A	N/A	0.017%	1.72%
Spark Program	28.804	35.754	34.008	38.43	48.213	N/A	N/A	N/A	N/A	0.546%	53.83%
National Science Foundation of China	0.646	0.777	0.889	1.084	1.284	1.598	1.968	N/A	2.246	0.015%	1.43%
863 Program[2]	0.45	0.65	0.67	0.8	0.9	Over 2	Over 4	N/A	5.5	0.010%	1.00%
National New Product Program	N/A	N/A	0.135	0.14	0.14	0.14	0.1386	N/A	N/A	0.002%	0.16%
973 Program	Not Start	0.625[4]	0.625[4]	0.625[4]	0.625[4]	N/A	N/A	N/A	0.9	0.007%	0.70%
The Innovation Fund for Small Technology Based Firms	Not Start	Not Start	Not Start	0.816	0.695	0.8	0.5	NA	NA	0.008%	0.78%

Source: Key Technology R&D Program (2004a, 2004b), National Key Laboratories Program (2004), Spark Program (2004), National Science Foundation of China (2004a, 2004b, 2004c), 863 Program (2004); National New Product Program (2004), Torch Program (2004), 973 Program (2004); Innovation Fund for Small Technology Based Firms (2004).

Note: 1. Unit: Billion RMB. The data of Key Technology R&D Program, National Science Foundation of China, National New Product Program and 973 Program only include the funding from central government's appropriation. Differently, the data for State Key Laboratories Program and 863 program include the fund from local government and enterprises. The funding of Spark Program is mainly from the bank loan and enterprises' own capital. Since 1990 the government appropriation for this program has hardly surpassed 5%.

2. The data for 863 Program are estimated by authors from the figures of various annual reports of 863 program. The 2001 data in 2002 Annual Report seems to be over 2 billion RMB, however, in 2001 Annual Report appears to be 1.7 billion RMB.

3. Source of 2004 data: Ministry of Science and Technology (2004).

4. The data is annual average data are calculated by the authors by simply dividing the aggregate data. The central government funded 5.3 billion RMB from 1996 to 2000 and 3.09 billion RMB from 2001 to 2002 for Key Technology R&D Program, 2.5 billion RMB for 973 Program from 1997 to 2000.

5. The data of GDP (2000) is from in *China Statistical Yearbook 2002* and the data of GERD (2000) is from *China Statistical Yearbook on Science and Technology 2002*.

incubators also exist. By 2002, at the national level alone over 400 business incubators and 53 high-technology development zones (the name of high-technology development zones is translated exactly from Chinese, actually they could be referred as science parks) have been developed through governmental support, mainly through Torch Program.

It seems that some recent discussion on Chinese manufacture sector's competitiveness and emerging high technology sector in China did not fully refer to the role of the science park and development zones (Deloitte Research, 2003). According to Torch Program's statistics data, the output value from the 53 high-technology development zones in 2001 already dominated in the gross output value of high-technology sector across the country and amounted around 12% of gross manufacture output value in China (See Table 5). In 2002, there were 3.49 million employees hired by the enterprises in those zones; the expenditure on R&D inside the zones reached RMB 31.47 billion (US$ 3.79 billion), that is, 24.4% of gross expenditure on R&D (GERD) in China and 40% of business expenditure on R&D (BERD)(Ministry of Science and Technology, 2003).

As an intermediary event, China Hi-Tech Fair (CHTF) now receives strong support from the central government to play a role of linking Chinese and overseas high-tech industry sectors. Since 1999, the fair is held every fall in Shenzhen, and is jointly hosted by the Ministry of Commerce, MOST, Ministry of Information Industry, National Development and Reform Commission, Chinese Academy of Sciences and the Shenzhen Municipal People's Government. The contract value emphasized by CHTF in 2003 has reached US$ 12.84 billion, and there were 42 countries that attended the 2003 session (China Hi-Tech Fair, 2003). The Fifth CHTF in 2003 included the following three major programs: transfer of technological achievements, exhibition and transaction of hi-tech products, and hi-tech forum.

One of the biggest features of CHTF is that there has been a year round operating technology transfer center besides the annual fair in October of each year. CHTF has also attracted the active participation of overseas Chinese students. Since the late 1970s, China has sent students abroad to study. The overseas Chinese students form into a large and valuable human resource asset bringing back capital and technology mainly related to high-tech industry. CHTF creates a specific mechanism to attract them to participate in high-tech industry development in China.

Productivity Promotion Centers (PCCs) in China are deemed for a group of intermediary and consulting organizations, established since 1992 throughout the country to support innovation in the business sector. In 2002, there are 865 PCCs under the administration of provincial, municipal, county government and industry sector administrative departments. They provided consulting services, technology based services such as technology promotion and products testing, information collecting services, human resource services, training services and incubation services to the enterprises (Chinese Association of Productivity Promotion Centers, 2003).

Table 5: Chinese Science Park and Incubator Development[1]

	1991	1992	1992	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total Revenue of the 53 National High-Technology Zones[1]	8.73	23.09	56.36	94.26	152.9	230.03	338.78	483.96	677.48	920.93	1192.84	1532.64
Output Value of the Enterprises inside 53 National High-technology Zones[1]	7.12	18.68	44.73	85.27	140.28	214.23	310.92	433.36	594.36	794.2	1011.68	1293.71
Output Value at Current Prices of High Technology Sector across China[1,2]					409.8	490.9	597.2	711.1	821.7	1041.1	1226.3	
Output Value at Current Prices of Manufacture Sector across China[1,2]					4870	5130.1	5998.5	5966.8	6395.4	7510.8	8442.1	
Ratio of Output Value of the Enterprises inside 53 National High-technology Zones to Output Value at Current Prices of High Technology Sector across China					34.23%	43.64%	52.06%	60.94%	72.33%	76.28%	82.50%	
Ratio of Output Value of the Enterprises inside 53 National High-technology Zones to Output Value at Current Prices of Manufacture Sector across China					2.88%	4.18%	5.18%	7.26%	9.29%	10.57%	11.98%	
Number of Incubator	43	61	61	73	73	90	100	77	110	131	280	436
Number of Tenants	500	1,013	1,500	1,390	1,854	2,476	2,670	4,138	5,293	7,693	12,821	23,373
Number of Graduated Tenants				190	364	648	825	1,316	1,934	2,770	3,994	6,927

Note:

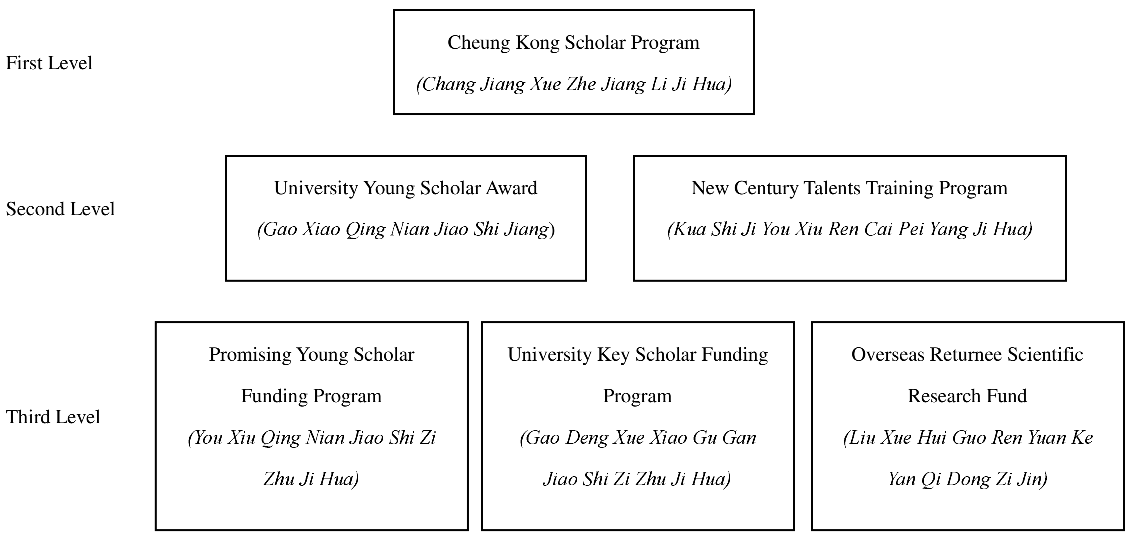
1. The unit is billion RMB. The values are treated as current price values. Source: Torch Program (2004).
2. Source: *China Statistics Yearbook on High Technology Industry 2002.*

3.4 Strengthening Human Resources Measures

The education development in China has made great strides in many aspects since the 1980s, such as that the average years of schooling of the population aged 15-64 increased from 4.10 years in 1980 to 5.96 years in 2000 (Cohen and Soto, 2001), ratio of population finishing junior secondary education increased from 15% to 34%, senior secondary education from 6% to 11%, tertiary education from 1% to 4% (Hu, 2003). According to official data, in 2000, in the region where 85% of the population is living, 9-year compulsory education is reinforced. In the whole country, gross entry rate to primary education reached to 99.1%, lower secondary education 88.6%, upper secondary education 42.8% (Li, 2001). Nevertheless, rural education remains a challenge and the country is still confronted with the problem of 85.07 million illiterate people, of which 20 million are at an age between 15 and 50 (People Daily, 2002).

The Ministry of Education cooperates with other organizations to develop a series of funding programs to recruit Chinese research talent around the world to work in China. This is accomplished by awarding the leading researchers, which elevates the research level of some key subjects. Figure 3 describes the priorities of the programs. The third and second level programs are targeted to young scholars and prepared human resources reserve for the first level program. The Ministry of Education and Li Ka Shing Foundation jointly established the Cheung Kong Scholars Program. (Mr. Li Ka Shing is a Hong Kong-based entrepreneur. He set up the foundation to manage his charitable donations to education and medical care projects in Hong Kong and Mainland China since 1980.) During the first phase of the program, they each contributed US$ 60 million to establish 300 to 500 professorships by special appointment at tertiary institutions within three to five years. Phase two would see the number of professorships increased to 1,000. The professor would receive a special stipend of RMB 100,000 (US$ 12,048) in addition to the regular remuneration package offered by the university in accordance with state guidelines (Ministry of Education, 2003b).

Figure 3 Ministry of Education's Human Resource Programs



Source: Ministry of Education, 2002

3.5 Legislative Actions

Law (2002) incisively analyzed the political reasons that just since 1970s, China's government began to develop the principle of governing the nation with law. Chinese leaders thought by law, the government could restructure the social relationships in the condition of the retreat of government's direct control, attract the foreign capital and correct the lawless situation in the years before, particularly in Culture Revolution (1966-1976).

Therefore, it is important to understand that the evolution of China's legal environment in regard to competition and IPR protection has been both recent and rapid. Over the past years, mainly since the late 1970's, China has instituted comprehensive reforms of legislation, including the Trademark Control Act (1963), US-China Agreement on Intellectual Property Protection (1979), Trademark Law (1982, revised in 1993), Patent Law (1984, revised in 1992), Copyright law (1990), Regulation on Computer Software Protection (1991), Unfair Competition Law (1993), Protecting Consumer's Rights and Interests Law (1993) and Regulations on Anti-dumping and Anti-subsidization (1997), Price Law (1998). In Addition, the General Principles of Civil Law (1986) and subsequent Civil Procedure Law (1991) recognize the right of Chinese citizens and legal domestic and foreign entities of holding and protecting IPR.

In the international arena, China was accepted as a member of World Intellectual Property Organization (WIPO) (1980); joined Paris Convention for Protection of Industrial Property (1984), Washington Treaty on Intellectual Property in Respect of Integrated Circuits (1989), Madrid Agreement Concerning the International Registration of Marks (1989), Berne Convention for Protection of Literary and Artistic Works (1992), Convention for the Protection of Producers of Phonograms Against Unauthorized Duplication of Their Phonograms (1993), Patent Cooperation Treaty (1993) (Oksenberg et al., 1996; State Council Press Office, 1994). China also cooperated frequently with WIPO and European Patent Office (EPO) on personnel training and promoted IPR teaching and research in over 70 universities. As far as the law enforcement, nearly 20 cities or provinces have set up IPR courts and the training programs for judicial officials. China's rapid development in the IPR legislation has gained the praise from the international community, especially from WIPO.

In the S&T and innovation field, Science and Technology Development Law (1993) regulating high-tech industry development, Agriculture Technology Transfer Law (1993), Strengthen Technology Transfer Law (1996), Dissemination of Science and Technology Knowledge Law (2002) and Small and Medium Enterprises Promotion Law (2002) show the efforts of China's government on legislative actions.

Since the 1980s, China's National People Congress passed 6 national education laws forming a legal framework regulating the education system. They are Regulations on Degrees (1980), Compulsory Education Law (1986), Teachers Law (1993), Education Law (1995), Vocation al Education Law (1996) and Higher Education Law (1998). In the same period, the central government issued hundreds of regulations and statutes reinforcing the administration and operation.

4 The Analysis of China's Innovation Policy in the OECD context

In order to benchmark the member countries' performance in the S&T and innovation field, OECD and European Commission systematically collect and analyze the innovation policy in member states. With this purpose, the EU launched a project in 1999 entitled " Trend Chart on Innovation in Europe". We try to utilize innovation policy classification in Trend Chart database, which contains the EU countries' diversified practices in innovation policy, to present the difference between Chinese and EU countries' policy development (Table 6). And we also cite the data from "OECD Science Technology Industry Scoreboard 2003" to form a quantitative illustration of the China and OECD innovation performance discrepancy (Table 7).

The comparison causes an impression that in some area China's innovation policies are concentrated and multi-dimensional, nonetheless, some of the others are unsuccessful in acting together with the well-built ones to enhance the country's innovation performance. They are deemed to be undeveloped in the areas of Education and initial and further training; Fostering innovative activities including promoting the research carried out in enterprises, particularly SMEs; Public authorities and support to innovation policy-makers; Protection of intellectual and industrial property; Innovation financing; Intensified co-operation between research, universities and companies.

Due to the authors' unavoidable limited knowledge about the policy design and implementation in a country like China, the above opinion should be stated and read carefully and some further rigorous analysis is encouraged. Even so, this tentative comparison could provide a way to discover the potential weakness in Chinese innovation system. In the following parts, based on the above comparison we select and explore two specific areas that China falls behind in the innovation policy design and implementation.

4.1 Education and Human Resources

China's education reform since 1980s has been discussed comprehensively in the literature, from the point of view of public policy (Kwong, 1996; Mok and Wat, 1998; Yang, 1998), the finance (Tsang, 1996), and the legislation (Law, 2002). Some empirical studies (Liu, 2004) and even the official address of the Chinese leaders (Zhu, 2001) also provided evidence for the conclusion reached in the theoretical analyses. Generally, it is agreed that directed by the principle of "Economic Rationalism" and assisted by the legislation efforts, China's reforms in education system through the decentralization in finance structure and diversification of finance sources does not increase the lingering ratio of public investment in education to total public expenditure. Moreover, the decentralization and diversification strategy in some degree gives rise to the unbalanced education development among eastern and western regions, also between urban and rural area. All of these, if last, will exacerbate the country's human capital resource development and limit the innovation performance in the long run.

Table 6: Comparison of innovation policy objectives in China and the European Countries

The EU Trend Chart Innovation Policy Classification System		Examples of Policy Practices in China
Policy Category	Policy Priority	
Fostering an Innovation Culture	Education and initial and further training	Regulations on Degrees (1980), Compulsory Education Law (1986), Teachers Law (1993), Education Law (1995), Vocation al Education Law (1996) and Higher Education Law (1998) showed the government's legislative efforts since 1980s. "211 Project" and series of award and training programs including Cheung Kong Scholars Program proved the recent policy actions. However, the education and training in China are still insufficiently invested. The further discussion is seen in the paper section 4.1.
	Mobility of students, research workers and teachers	Policy co-developed by Ministry of Education and Ministry of Personnel, supporting foreign experts working in China, attracting overseas Chinese students and scholars to return, and encouraging the placement of Ph.D graduate for post doctoral research in enterprises.
	Raising the awareness of the larger public and involving those concerned	Enactment of Dissemination of Science and Technology Knowledge Law (2002). Tax preference policy to activities and institutions disseminating S&T knowledge. Grants for the project of increasing public awareness of S&T.
	Fostering innovative organizational and management practices in enterprises	Not Available.
	Public authorities and support to innovation policy-makers	Not Available.
	Promotion of clustering and co-operation for innovation	Many of the strategies are developed by local governments. For example, the cooperation of the Shanghai municipal government and other neighboring provinces in the Yangtze river delta for strategy design and the similar one among Guangdong province, Hong kong, Macau and other neighboring provinces in south of China.
Establishing a	Competition	Enactment of Unfair Competition Law (1993), Protecting Consumer's Rights and Interests Law (1993) and Regulations on Anti-dumping and Anti-subsidization (1997), Price Law (1998) justified the government's legislative efforts. However, this young competition policy regime needs to be improved and strengthened (Lin, 2003).

Framework conducive to Innovation	Protection of intellectual and industrial property	MOST issued several regulations on IPR protection and exploitation. State Intellectual Property Office launched the projects to strengthen the awareness in the innovation-intensified organizations and disseminate the result to the populace. However, the IPR policy in China is still needed to restructured and improved. The further discussion is seen in this paper section 4.2.
	Administrative simplification	Regulations of simplifying administration to encourage creation of Newly Technology Based Firms (hereafter NTBFs) and attract FDI.
	Amelioration of legal and regulatory environments	Legislative actions taken in China cover the field of IPR, S&T and education, etc. The further discussion is seen in this paper section 3.5.
	Innovation financing	Foundation of IFSTBF.
	Taxation	Tax preference policy for encouraging creation of NTBFs and attracting FDI. However, the current tax preference policy for encouraging innovation in the established enterprises did not achieve excellent performance (Wu, 2003).
Gearing Research to Innovation	Strategic vision of research and development	Ongoing development of an outline document “2006-2020 Chinese National Science and Technology Development Plan”.
	Strengthening research carried out by companies	Some tax preference policy for enterprises in some industry sectors, like in integrated circuit manufacture sector. However, the effect of this group of fiscal policy is weak according to Wu (2003). 863 Program increasingly supported the R&D projects done in industry. In 2002, 30% of the projects financed by the program are implemented in the enterprises (863 Program, 2004)
	Start-up of technology-based companies	Policies targeting science parks and incubators, attracting overseas Chinese to set up NTBFs in China.
	Intensified co-operation between research, universities and companies	Created a new type of agency titled “Technology Transfer Center” in 2003.
	Strengthening the ability of companies, particularly SMEs, to absorb technologies and know-how	Not Available.

Source: European Commission (2000b, 2001b, 2002d)

Table 7: Selected Science and Technology Indicators for China and some OECD and non-OECD Countries

	China	Israel	Russian Federation	Singapore	EU 15	OECD Total	Italy	Japan	Poland	Sweden	US
Gross Domestic Expenditure on R&D GERD (million current PPP$)[1]	72,076.80	6,359.70	14,190.40	2,129.70	162,813.30	578,749.40	13,556.50[2]	96,532.30	2,367.70	9,232.70	252,938.50
GERD as a percentage of GDP[1]	1.29	4.73	1.24	2.19	1.93	2.33	1.07[2]	3.09	0.67	4.27	2.82
Total Researchers per Thousand Total Employment[1]	1.10	N/A	7.50	9.00	5.80[2]	6.50[2]	2.90[2]	10.20	3.80	10.60	8.60[3]
Percentage of GERD financed by Industry[1]	57.60[2]	69.60[2]	32.90[2]	55.00[2]	56.20	63.60	43.00[4]	73.00	30.80	71.90	68.30
Percentage of GERD financed by Government[1]	33.40[2]	24.70[2]	54.80[2]	40.30[2]	34.50	28.90	50.80[4]	18.50	64.80	21.00	26.90
Business Enterprises Expenditure on R&D BERD (million current PPP$) [1]	44,099.20	4,643.50	9,915.70	1,308.20	105,121.20	403,243.60	7,275.20	71,119.10	848.40	7,166.80	188,122.80
BERD as a percentage of GDP[1]	0.79	3.46	0.87	1.34	1.06[2]	1.48	0.43[4]	2.25	0.21	3.07	1.92
Number of "Triadic" Patent Families Per Million Population[5]	0.055	54.167	0.490	19.118	35.897	37.417	12.103	89.400	0.233	94.216	52.712
Number of Patents in the ICT Sector Applications to the EPO Per Million Population[5]	0.031	61.714	0.320	22.177	35.313	30.754	9.360	60.810	0.129	88.793	40.337
Number of Patents in the Biotechnology Sector Applications to the EPO Per Million Population[5]	0.008	11.739	0.095	2.294	5.341	5.153	1.042	4.691	0.052	7.456	9.634

Source: OECD (2003c).

Note 1. Non-OECD countries' data without the superscript are the year of 2002. The OECD countries' data without superscript are the year of 2001.

2. The data are the year of 2000.

3. The data are the year of 1999.

4. The data are the year of 1997.

5. The data are calculated by the authors. The patent data are the year of 1998. Source of Data of Population (1998) except for EU 15 and OECD Average: World Bank *World Development Indicators (WDI)* database Data Query. The data of EU 15 and OECD Average are from World Urbanization Prospects, the 2001 Revision, United Nations Population Division.

The OECD countries have already set the pace much faster than China in education and human resources field, either reflected by quantitative indicators or presented in policy focus. Now there is considerable evidence of lifelong learning's importance as a policy objective in almost every EU country, who would like to keep pace with accelerating technological progress and technology-driven social change. And in order to support the human resource mobility between public research institutions and private sector companies, many OECD countries have adopted measures like temporary placements and industry-funded PhD projects. According to the analysis of OECD and UNESCO' s World Education Indicators (WEI) Program (OECD and UNESCO Institutes for Statistics, 2000, 2001, 2003), China not only lags much behind the OECD countries' average level in many indicators but also stays in an unfavorable situation compared with the participating developing countries (hereafter WEI countries), including Argentina, Brazil, Chile, Egypt, India, Indonesia, Jordan, Malaysia, Paraguay, Peru, Philippines, Russian Federation, Sri Lanka, Thailand, Tunisia, Uruguay, Zimbabwe (Table 8).

It is mentioned above that China's education legal system has already established with the efforts of the government. However, unfortunately both government and non-government parties, including school, students and parents, frequently challenge these education law and regulations (Law, 2002). The Education Law stipulates that the governments of various levels have the legal obligation of enforcing that " the increase of education expenditure of government at various levels shall be at a higher rate than the growth of normal financial revenue". However, after its promulgation in 1995, the increase rate of total education appropriation of central and local governments in 1996 and 1997 were still lower than that of budgetary revenue. From 1999 to 2001 the central government itself failed to fulfill this legal obligation (Table 9). In most of the years in 1990s, the fact that China's fiscal appropriation to Education increased with a continuous lower rate compared with the increase of the budgetary revenue implies that the economic development in the past years in China does not proportionally benefit the country's education development and fails to diminish the gap with the world leading level.

Additionally, after the implementation of the reform strategy of education finance decentralization and diversification, local government's appropriation dominates public expenditure in education, showed by the decreasingly low ratio of appropriation of central governments to local government (Table 9). The crucial decisions like whether invest to education, how much invest, which area should be invested: primary, secondary or tertiary education, have depended much on local government's budget plan and the will of the local leaders. Inevitably, the regional and rural-urban discrepancy in education development has been widened since the economic development level already varied in different regions and between rural and urban areas after 1980s (Zhang; Wang, 2002).

4.2 Protection of Intellectual and Industrial Property

Since 1990s the issue of protection of IPR in China has been not only a national economic

Table 8: China’s Education Performance in World Education Indicators Program

	China’s Performance	WEI Average	OECD Average	Ratio of China’s performance to WEI Average	Ratio of China’s performance to OECD Average
School Expectancy for a five-year-old Child (Year) (2000)	10.3	13.0	16.8	79.2%	61.3%
Gross Entry Rates to Upper Secondary Education (2000)	42%	64%	-	65.6%	-
Entry Rates to Tertiary Education (2000)	14%	40%	60%	35.0%	23.3%
Average Years of Schooling in the Population Aged 15-64 (Years) (2000)	5.96	7.63	-	78.1%	-
Public Expenditure on Educational as a Percentage of GDP (1999)	2.1	4.3	5.2	48.8%	40.4%
Relative Proportion of Private Expenditure on Education Institutions (1999)	44.2%	28.3%	12%	156.2%	368.3%

Source: OECD and UNESCO Institutes for Statistics (2000, 2001, 2003).

Table 9: China's Budgetary Appropriation for Education in 1990s

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Data Breakdown
Government Appropriation for Education Expenditure[1] (Thousand RMB)	45,970,000	53,870,000	64,440,000	88,400,000	102,840,000	121,190,000	15,707,730	19,966,660	21,539,610	21,854,192	26,655,680	Central Government
							120,064,900	136,592,510	160,036,363	186,713,728	231,581,939	Local Government
Government Budgetary Revenue[1] (Thousand RMB)	314,948,000	348,337,000	434,895,000	521,810,000	624,220,000	740,799,000	422,692,000	489,200,000	584,921,000	698,917,000	858,274,000	Central Government
							442,422,000	498,395,000	559,487,000	640,606,000	780,330,000	Local Government
Annual Increase Rate of Government Appropriation for Education Expenditure [1]	5.9%	17.2%	19.6%	37.2%	16.3%	17.8%	12.0%	27.1%	7.9%	1.5%	22.0%	Central Government
								13.8%	17.2%	16.7%	24.0%	Local Government
Annual Increase Rate of Government Budgetary Revenue[1]	7.2%	10.6%	24.8%	20.0%	19.6%	18.7%	16.8%	15.7%	19.6%	19.5%	22.8%	Central Government
								12.7%	12.3%	14.5%	21.8%	Local Government
Ratio of Appropriation of Central Governments to Local Government	N/A	N/A	N/A	N/A	N/A	N/A	13.1%	14.6%	13.5%	11.7%	11.5%	

Source: *China Statistics Yearbook 2002*; *China Education Yearbook 1998,1999,2000,2001,2002, 2003*; *China Statistical Yearbook on Science and Technology 2002*.

Note: 1. The breakdown data of the local and central levels are not available from 1991 to 1996.

and juridical dilemma, but also a significant economic and political concern for a number of industry interest groups and governments in developed countries. The piracy problem in China has provoked much dispute between Chinese and its western counterparts, particularly between China and US (Oksenberg et al., 1996).

The estimates of the piracy and infringement of IPR in China is only available in statistical reports of the industry interest group such as International Intellectual Property Alliance and Business Software Alliance. Because lack of the third party's supporting statistics, the estimated figures issued in their annual reports (Table 10) should be assessed carefully. According to Business Software Alliance (2003), China's piracy rate showed modest improvement since 1994. Nevertheless, China had still the second highest piracy rate with 92% in the world after Vietnam and caused losses of US$ 2.4 billion in 2002, representing 44% of the total dollar losses in the Asia/Pacific region and 18% of the total world dollar losses.

On the other hand, the scanty Chinese application to the European Patent Office (EPO), the US Patent and Trademark Office (USPTO) and the Japanese Patent Office (JPO) ("Triadic" patent families) (Table 7) not only can be explained by the feeble R&D activities inside China, but also is the result of unfavorable social culture and limited policy incentive. It is believed that as the more Chinese domestic enterprises realizing the value of IPR in the fierce competition against multinational giants with IPR advantage and the government's stronger promotion, the patenting in China will improve in the near future. The studies have already showed some sporadically positive signs in industry sectors, like mobile phone manufacture sector (State Intellectual Property Office, 2004).

Table 10: Estimated Trade Losses (US$ Millions) Due to Piracy and Piracy Rate in China: 1999-2003

Industry	1999		2000		2001		2002		2003	
	Loss	Piracy Rate	Loss	Piracy Rate	Loss	Piracy Rate	Loss	Piracy Rate	Loss	Piracy Rate
Motion Pictures	120.0	90%	120.0	90%	160.0	88%	168.0	91%	178.0	95%
Records and Music	70.0	90%	70.0	93%	47.02	90%	48.0	90%	286.0	90%
Business Software Applications[1]	437.2	91%	765.1	94%	1140.2	92%	1637.3	92%	N/A	N/A
Entertainment Software	1382.5	95%	N/A	99%	455.0	92%	N/A	96%	568.2	96%
Books	128.0	N/A	130.0	N/A	130.0	N/A	40.0	N/A	40.0	N/A
Total	2137.7	-	1085.1	-	1932.5	-	1893.3	-	-	-

Source: International Intellectual Property Alliance (2004).

Note: 1. The Business Software Application's trade loss estimates in this table are different from Business Software Alliance's trade loss numbers released separated in its annual global piracy study. Detail information see the original table.

In their in-depth analysis of China's IPR protection issue from the point of view of politics and law, Oksenberg et al. (1996) examine the cultural and historical tradition of the denounced performance of IPR protection in China, that is, the Confucian tradition and the policy of the regimes in most of the time of the 20^{th} century, particularly in the Mao Era (1949-1976). They believe the traditional thoughts and current complex political-economic interrelationships in the central and local administration have great influence on the social norms that are unfavorable for IPR protection. For example, currently some Chinese officials and ordinary people still consider IPR to be a concept invented by developed countries to hinder transfer of advanced technologies and to exploit the developing world.

In the economics literature, there exists debate on whether strengthening IPR protection will separate the developing countries from the advanced technologies invented by the developed countries and the derivative problem of the anticompetitive abuse of IPR. However, recently Yang and Maskus (2003) demonstrated under the certain condition, the stronger IPR protection in the South would increase the rate of innovation and the extent of high-quality licensing from the North to the South. The condition specified in their work that the labor force input in innovation must be sufficiently small compared with that in production and the labor cost in the South must be sufficiently low, perfectly matches the case of China. Clarke (2001) pointed that stronger institutions and better protection of property rights encourage greater R&D expenditures in developing countries.

In OECD countries, the growing number of patents grants and applications showed the increasing importance of IPR in the innovation system of the member countries (OECD, 2003b). Recently the progress of current IPR policy practice in the European countries highlighted three main themes: Encouraging SMEs to apply for and exploit IPR; Promoting IPR in public sector research institutes; and Dealing with special issues such as IPR in software and biotechnology and the ongoing reforms of broadening ownership of IPR within higher education institution (European Commission, 2001b, 2002d).

Bearing in mind that China already aims to foster the innovation activities in the national R&D institutions and build the technological competitiveness of domestic enterprises in the international market, developing and enforcing IPR protection is the unavoidable choice for China's policy makers. For the outside world, the constructive attitude related to the IPR protection and exploitation in China is recommended that the industrialized countries should not ignore the progress that China has made in establishing an IPR regime in a relatively short time and their strengthened cooperation with China instead of the mere denouncement from the interest group that will finally expedite the improvement process of the regime.

5. Conclusion

This paper has provided a comprehensive description of China's innovation policy framework and analyzed the drawbacks of those policies by comparing with EU and OECD countries. The paper assembles the original information, qualitative and quantitative data for these purposes.

The paper gives out an analysis framework combining different macroeconomic and structural policy actions and highlighting the mutual support among them. It investigates the different policies that act important roles in China's innovation system, including reform in the public S&T institutions, financial policy, business innovation support structure, human resource policy and legislative actions. A detailed analysis of China's education and human resource policy and protection of Intellectual Property Right (IPR) is conducted. It is shown that several dimensions of the Chinese innovation policy that were designed and implemented very recently are still immature and incoherent.

The provided framework of China's innovation policy is helpful for the readers to learn about such a complicated innovation system in China, and provides a basis for future work. Furthermore, the comparison between China and other countries assesses China's innovation policy in the international context. Drawbacks of the policies dropped from the comparative analysis are significant for government to take into account.

It is clear that in China education must be set as the priority in central and local governments' budget appropriation and outlays. Moreover, it is necessary to define a long-term strategy to strengthen the legal and administrative regimes for IPR issues, especially at the local level. This should include the implementation of a "Rigorous Policy for IPR Protection" - compared with the current government's policy so-called "Most Rigorous Policy for Agricultural Land Protection".

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