The environmental industry in transitional China: barriers and opportunities between state and market

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Abstract: The environmental industry has been cited as a crucial industrial sector that developed parallel to the increasing focus on ecological and environmental issues in the modernisation process. Notwithstanding its rapid growth in recent years, China's environmental industry is still immature in comparison with that of developed countries. A review of the development of China's environmental industry points at several fundamental constraints. Both at national and regional levels, barriers relate to the demand side and the supply side of environmental industry, linked to rapid economic and social transitions. In addition, political constraints for innovation in environmental industry relate to the underlying administrative hierarchy and governmental regulation.

Keywords: environmental industry; innovation; demand; supply; environmental regulation; China.

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1 Introduction

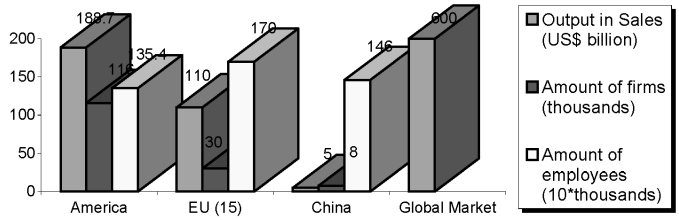
Profit-oriented industries and business activities are often believed to be at the source and origin of increasing resource depletion and environmental deterioration. In this respect, the *Environmental Industry EI*,[1] can be seen as an exception. While it developed into a significant industrial sector in the 1990s, it emerged in the 1970s along with the increasing focus of industrialised societies on ecological and environmental issues. Instead of the resource consumption and environmental pollution of the traditional industrial sectors, the pollution control products and environmental services of environmental industries do not only bring economic benefits but also entail environmental gains, contributing to environmental compensation, rehabilitation, re-use and improvement. The EI is often seen as contributing to a path towards sustainable development of human society on a macro-level and an efficient linkup between industrial productivity and environmental protection on a meso-level.

Unlike most conventional industries, EI firms fall under a wide range of industrial classifications. The characteristics of EI are ambiguous, making it difficult to identify and define whether and to what extent a particular industry or firm belongs to EI or not. This is also valid for companies engaged in environmental consultation and services. That brings with it considerable difficulties in investigation, collecting industrial statistics and comparing EI development between different countries. Most countries (such as the USA and Japan) adopt 'broad' definitions, which generally include a diversity of products and services related to environmental improvements during the overall life-span of materials and products that could pollute the environment. China uses a more 'narrow' definition, which takes into account only products and services aiming at clean-up actions and remedial measures; thus having a strong focus on 'end-of-pipe' technologies (see Section 4).

After 1990, EI has grown rapidly and has been a large source of revenues in many developed countries. In the USA, EI is estimated to have had US $188.7 billion in sales in 1998, with 1,354,100 employees in 115,850 companies. This exceeds figures of several major manufacturing sectors, including chemicals, paper, and aerospace (Diener and Terkla, 2000). In the EU (EU15) EI has a turnover of approximately US $110 billion in 1998 and consists of 30,000 companies with 1,700,000 employees (ECOTEC, 1999).[2] The growth rate of EI in developed countries, in terms of sales, has slowed down somewhat in recent years.

China, as a developing country in transition from a centrally planned to a market-oriented economy, has been suffering severely from resource depletion and environmental deterioration. Especially in the 1990s, environmental problems in China have received more and more attention from the government and the public, both nationally and internationally. Some enlightened politicians, government officials and industrial managers in China have demonstrated their active concern for reducing pollution and encouraging cleaner production, and environmental protection has recently been elevated to the status of 'National Fundamental Policy' (Vermeer, 1998). Consequently, a huge market for environmental products and services has been formed in China. For instance, the urban infrastructure construction cost for improved treatment ratios of urban wastewater and domestic waste is predicted to be US \$61.7 ~ 74.1 billion,[3] and an additional amount of US \$8.6 ~ 9.9 billion will be needed annually for operational environmental management in China (Chen and Chu, 2001).[4] In contrast to this 'huge' demand, however, China's EI has not been stimulated strongly by governmental regulation and public pressure, having only US \$13.3 billion in sales in 2000, representing less than 1% of China's gross domestic product (GDP) and only about 1% of the global sales volume (see Figure 1). With a planned growth rate of about 15% each year within China's Tenth Five Years Development Plan ('*Shiwu Plan*'),[5] and a prediction that gross production would achieve US \$24.7 billion in sales in 2005, China's EI could still be seen as relatively immature. The predicted 2005 production level would then consist of environmental equipment production (US \$6.8 billion, 27.5%), comprehensive utilisation (o: re-use and recycling) of resources (US \$11.7 billion, 47.5%), and environmental services (US \$6.2 billion, 25.0%).

Figure 1 A comparison of EI's development among countries in 1998 and the global market in 2000



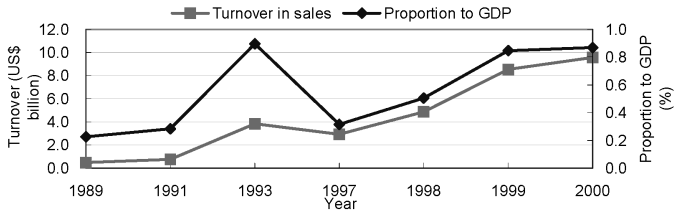
Source: Diener and Terkla (2000), ECOTEC (1999) and the China Environment Statistical Report (1998)

The purpose of this paper is to analyse the strength and weaknesses in the further development of China's environmental industry towards maturation. Section 2 starts with a short review of China's EI, involving historical trends and the present status quo in comparison with global markets and domestic economic growth. Section 3 provides a discussion on some of the EI's developmental mechanisms, both from demand and from supply perspectives, respectively. Because institutional constraints with respect to the administrative structure and environmental regulation form the key factors hampering EI's innovation in future China, it is given special attention in Section 4. Conclusions with respect to the prospect of China's EI are drawn in Section 5.

2 The development of China's environmental industry

Although China's EI has made considerable progress in a few coastal cities in the last ten years (see Section 3.3), in comparison with both EI's global development and the national GDP there is no evidence that indicates a significant overall innovation and development in this industrial sector. Figure 1 shows that although the absolute amount of firms and sales might look considerable, relatively it is far less than that of the USA or the EU (15) in 1998.[6] The exception here is the employment rates, which are of a comparable magnitude, showing especially the inefficiency of China's EI. The evolution of China's EI (illustrated in Figure 2) shows gradually increasing trends, indicated by the proportion of sales to GDP which increased from 0.22% in 1989 up to 0.87% in 2000. This is even more spectacular when taking into account the rapid economic growth.

Figure 2 EI's turnover in sales and proportion to GDP in relevant years



Source: The China Environmental Statistical Report (1997–2000, various years); SEPA (2001); China Statistical Yearbook (2001)

This capital growth should not distract our attention from the relative underdeveloped status of China's EI. Several qualitative features indicate this underdevelopment.

- China's environmental industries are characterised by their small-scale and scattered distribution. The township and village enterprises (TVEs) account for a major share in this sector.
- The quality of most environmental equipment, products and services is rather low. We have argued that the technological level of China's EI is comparable to the level of western industry during the 1960s and 1970s (Chen and Liu, 2001). Only a few companies can match current international standards. Repeated investment in R&D for low-technology equipment, mass production of standard, low quality technologies, and even simple imitation, are prevalent among Chinese firms, particularly among TVEs.
- Incomplete and inadequate competition caused by an immature market mechanism and regional protectionism significantly undermines the innovative and R&D capability and capacity of Chinese EI, and results in a disadvantageous position in the global market. Pessimistic leaders believe that fifty per cent of the companies will disappear within the coming three to five years, due to various reasons.[7]
- Most environmental companies and enterprises in China provide environmental equipment and products for end-of-pipe pollution control of industries, rather than focusing on ecological rehabilitation, environmental management and services of engineering projects, and information and consultation.

To summarise, China's EI is in a preliminary stage in which its development is dominated by, not very advanced 'end-of-pipe' technologies, strongly triggered by command-and-control regulation. Only marginal attention is paid to cleaner production, greening products and environmental services.

What is behind China's limited capability to develop EI further, both qualitatively and quantitatively? Broadly speaking four causes can be identified.

- The combination of weakened centralism and incomplete market liberalism, characteristic of the current transitional process in China towards a Socialist Market Economy,[8] brings with it compartmentalisation of administration and regulation, market fragmentation, and regional protectionism (see also Section 4). Despite increasing environmental policy capacity,[9] the implementation of environmental policies and standards falls short, leading to China's incapacity to stimulate market demands of EI (Chen et al., 2001).
- The current financial regime and practice of environmental protection in China is rather conventional, lacking sufficient and efficient fiscal and financial incentives. Government has a central position in investment, construction, and operation of environmental infrastructure, but fails to commercialise this successfully (Chen et al., 2001).
- China has inadequate capacity to commercialise scientific and technical R&D results at both national and industrial levels. The organisational structure of R&D in China fails to bring together research results of scientific and technological research institutions, environmental improvement demands of industrial firms or commercial companies, and State environmental regulation and policy. This significantly weakens the supply side: the effective and sufficient provision of advanced environmental equipment, products and services. China has not been very successful at applying domestic R&D results, nor at absorbing and assimilating imported environmental technologies (Alam, 2001).
- China misses a strong civil society articulating environmental interests, pressing the implementation of environmental policies and thus promoting market demand for the products of EI. The consultation and participation of environmental NGOs, communities and the public in environmental policy-making are still underdeveloped in China (Gunningham and Sinclair, 1998; Ho, 2001; Martinsons et al., 1997), while their freedom to widely circulate and publicly articulate environmental concerns is still restricted.

Besides ineffectiveness in dealing with (industrial) environmental problems, the underdevelopment of the environmental industry also has economic consequences. EI's underdevelopment results in large national pollution regulation and control costs and puts a heavy financial burden on central and local governments. In addition, it is argued that the annual national wealth loss of China caused by environmental pollution and ecological deterioration accounts for 3.5–7.7% of GDP. Inefficient construction and poor management of urban infrastructure is responsible for 20%–25% of this total loss (Chu and Chen, 2001).

It is apparent that EI's further development in China is strongly related to a successful transition, both in the economic and the political system. Under a market regime, it is possible to install a better incentive system to undertake technological and managerial

environmental innovations, to stimulate adoption of advanced environmental technologies and to promote the innovation of products and services. A more liberal political system will put stronger civil societal pressure on reaching high levels of environmental quality and provide transparency on procedures, costs and information on the environment. Undoubtedly, EI's innovation and development in future China will be forced by four major mechanisms:

- public environmental interest and demand for high quality of life
- governmental rules, regulation and enforcement, with a focus on cleaner production and technologies
- continuous governmental investment and financing in public environmental infrastructure
- industrial polluters seeking for cost-reduction by lowering consumption of energy and materials and more (cost-)effective environmental technologies.

3 Demand and supply for China's environmental industry

The innovation and development of environmental industries are determined by both the demand side and the supply side. Increased market demand lowers political and economic risks and market barriers for environmental industries, leading to large-scale environmental industries and contributing to national economic growth. An effective supply structure of environmental techniques, products and services may match the political and social requirement for environmental improvements.

3.1 Analysing the demand side

Market demand for environmentally sound technologies, products and services is to be initialised and shaped by governmental promotion, industrial environmental performance requirements, and public pressure. The EI's market in China comprises:

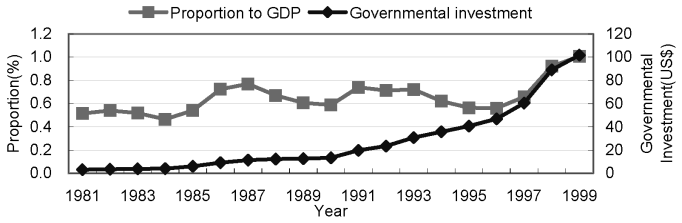
- governmental purchase programs or projects for ecological remediation and pollution control at the national and regional levels
- municipal infrastructure development for public health and urban development
- industrial need for pollution control, cleaner production and optimal usage of resources or materials (Murphy and Gouldson, 2000)[10]
- household consumption focused on better physical health, comfort and environmental preferences
- global market demand.

It is rather difficult to measure how large the total market demand is with respect to these five clusters. Existing estimates mainly focus on the market for urban infrastructure and industrial environmental improvement (such as those listed in Section 1). These two clusters also form the major share of EI's market in China, due to the fact that urban infrastructure takes a priority within governmental programs, private environmental

consumption has not been successfully motivated nationwide and international market demand is not very relevant for Chinese environmental industries.

Investments by the central and local governments, partly dependent on the national and local economic development, are the major drivers and financial source for urban infrastructure construction and public sanitary improvement. As shown in Figure 3, notwithstanding the gradual increase of governmental environmental investment, the environmental investment per unit GDP has fluctuated and stagnated, at least until 1997. And even the highest level of 1.0% of GDP in 1999 is still much lower than that witnessed in industrialised countries. Chu and Chen (2001) argue that, if the Chinese government maintains its existing financing pattern, the capital shortage for urban water treatment infrastructure construction would, in ten years, reach 30–60% of the total needed capital, contributing to a considerable loss of national wealth. A healthy and sustainable development of China's EI depends on whether governments can successfully diversify the environmental capital sources in the next few years.

Figure 3 Environmental investments by government in China, absolute (in million US$) and as proportion of GDP



Source: Zhang (1992) and the China Statistical Yearbook (2001)

Environmental strategy and policies through governmental regulation and intervention (Gunningham and Sinclair, 1998) are still the main incentives to industrial environmental performance. Only in a few cases, does endogenous environmental improvement arise in traditional industrial sectors in China (Vermeer, 1998; Ma and Ortolano, 2000; Mol, (forthcoming). How the government regulates polluting industries and to what extent it is successful has major consequences for EI's market demands on industrial point sources. Regulation and legislation, and especially implementation and enforcement, are still too weak to foster EI's healthy growth in China (Lieberthal, 1995; Ma and Ortolano, 2000). Too often the primary and only concern in China's political and administrative system is about economic growth (Jahiel, 1998). Local environmental protection bureaus, the main regulators of industrial pollution control and promoters of EI's growth, have to take economic growth concerns of local governments into account when regulating industries, since they are strongly dependent on local governments for budgetary funds and the allocation of administrative resources (see Section 4). At the same time, even under public pressure and governmental force, industries hesitate to improve their environmental performance, because environmental costs cannot be fully measured in advance, pollution charges are not fully returned to the polluting industries that paid them, and environmental investments cannot bring immediate economic profits. Industries also fear that environmental measures will prove to be not as cost-effective as promised initially, as rules change regularly following policy fluctuations in a period of rapid transition. Most environmental officers in polluting industries focus on risk

avoidance and security management, instead of creating environmental-economic opportunities (Preston, 1997).

It is difficult to consider public environmental consumption as an effective factor in market demand for EI's innovation in contemporary China. While in the major urban centres, green consumption is starting to become an issue among small groups with high cultural and financial capital, in the large majority of urban and rural areas and social strata, limited environmental articulation in consumption does not trigger environmental industry development. According to an investigation in YunNan province in southwestern China, rural residents of five towns and seven villages surrounding the extensively eutrophicated Dianchi Lake, were willing to pay an average of US $21 per household (RMB¥170; 1.7% of an annual total household income) for environmental improvement and ecological restoration of the lake (Wang et al. 2001).[11] While a few interviewees acknowledged a common duty among citizens to clean-up the lake, 34.3% of the interviewees considered that the government was responsible for the Dianchi Lake clean-up and refused to pay anything for environmental restoration.

3.2 Supply side analysis

Chinese environmental industries supply different products and services. Chen and Lui (2001) have categorised these as follows:

- environmentally sound technologies and related technological support
- environmental products and equipment, including physical installations, debugging, operation and maintenance
- programs – consisting of proposals, planning, design, construction, operation and management – for ecological restoration and environmental improvement
- environmental information and consultation for industries, public and government
- environmental training, management and other services.

It is not always easy to sharply distinguish these five categories in practice.

Research and Development (R&D) capacity is crucial for the supply of environmental goods and services as it is one of the conditions for industrial technological capacity and market competency. But research and development capacity alone is not enough for an adequate supply structure. China's academic research on environmentally sound technologies can keep pace with that of developed countries in general, but product invention and design, product manufacturing, product quality, and systematic automatic control lag behind. There are several causes behind China's limited institutional infrastructure for environmental knowledge transfer and R&D application in both public and private sectors (Asuka-Zhang, 1999; Guerin, 2001).

- In China, technological innovation and innovative research takes place primarily in academic institutes and public sectors, but hardly in industries themselves.
- Academic R&D results do not match industrial demands and are often unsuitable for large-scale commercial application, leading to low levels of commercialisation and utilisation of environmental R&D results.

- Innovative capabilities and capacities are predominantly geared towards absorbing, adapting and duplicating technologies already developed in industrialised countries. Little progress on novel environmentally sound technologies has been made in China up to date.
- This tendency is further strengthened by demand side factors: polluting industries prefer overseas environmental technologies, even in cases where domestic ones have lower prices, are easier to maintain and have comparable quality. Most of the polluting industries consider foreign products superior in quality and performance, and find foreign suppliers more reliable and experienced.
- There are financial reasons behind the shortfall in developments on the supply side, to be broken down as follows (Preston, 1997):
    - Academic environmental R&D lacks sufficient governmental subsidies.
    - Polluters are charged with very low fees which undermines the incentives for industrial environmental innovation.[12]
    - Lack of funding weakens the environmental R&D undertaken in industries.
    - Relative high market risk for suppliers, also due to regulatory failure. Most 'technology-based regulation' focuses on 'choosing' existing technologies, rather than encouraging 'technology development'.[13]
    - Little interest of private investors and capital suppliers in environmental business, because of the large capital amount needed, long payback periods, high risks, and regulatory uncertainty. The government–market gap in environmental technology commercialisation is too large to bridge; the gap that exists after the government officials conclude the project to be too commercial to fund, and before investors are willing to make risky investments.

The global suppliers' impact in China was already large in the late 1990s (see Table 1), but was further strengthened after China became a member of the World Trade Organisation (WTO). Although lower barriers are beneficial for China's EI in terms of foreign capital, advanced technologies and management experiences, the parallel severe international competition pushes national industries out of domestic markets. China's water treatment systems, for instance, have been plagued by debt and low environmental efficiency under State-owned enterprises. The French company Suez Lyonnaise Des Eaux, one of the world's biggest suppliers of water treatment technologies and services, is increasingly active in contemporary Chinese water treatment programs, setting up nine jointly owned water treatment plants in China recently (Ehina Daily, 2001, 2001a).[14] These and other foreign investments bring modern technology and equipment to China, as well as efficient management, that help in reducing costs and increasing profits. If the immature domestic environmental industry cannot compete with the new entrants in the Chinese market, China might in the end also lose relatively low cost domestic pollution control.

Table 1 Market size and major supplier shares in 1999

Market	*Market size (billion Euro)*	*Domestic share* (%)	*US share* (%)	*Japan share* (%)	*EU share* (%)
North America	132	96	–	1	2
EU	104	97	2	1	–
Japan	62	97	2	–	1
SE Asia	9	48	20	15	15
China	*4*	*55*	*15*	*15*	*12*
South America	4	44	30	5	18
CEE	4	27	20	3	45
Australia/NZ	4	59	25	10	5

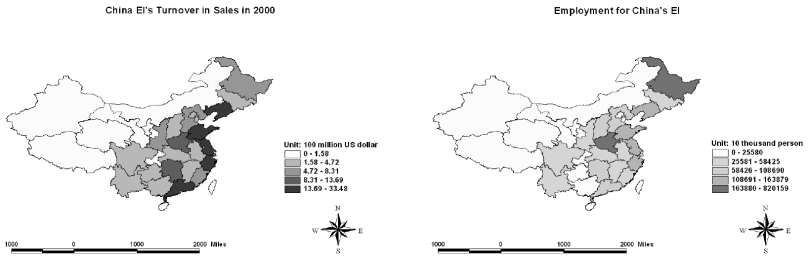
Source: ECOTEC (2002)

3.3 Regional differentiation

Although in general, China's EI is still immature, environmental industries in a few economic regions have made considerable progress. In Shanghai city, the most energetic area in China, the environmental industrial system consists of 630 domestic and foreign enterprises and nearly 100 research institutions, with environmental investments of 2.8% of total GDP in 1996–2000, which ranks 1.8 points higher than the national figure. Most developed countries average only 2% of their GDP (China Daily, 200b).[15] In Shenzhen in Southern China, EI's sales achieved 318.8 million dollars in 2000 (23 times higher than sales in 1997), while local GDP reached 20.6 billion dollars in the same year (Shenzhen EPB, 2001).

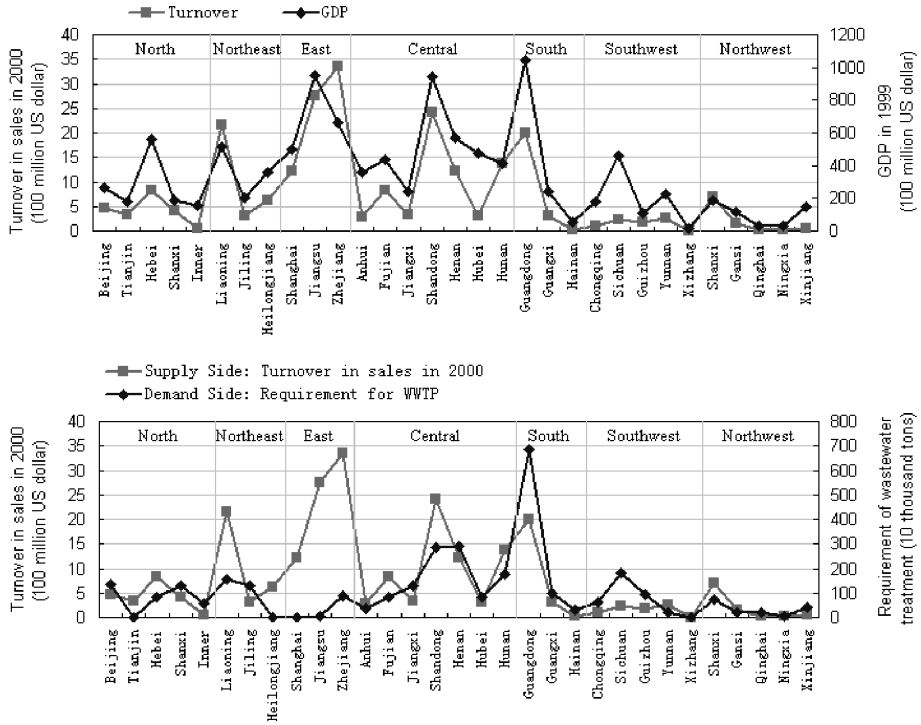
The geographically uneven development of China's EI is shown in Figure 4. EI's sales indicate an uneven supply of environmental technology and services, ranging from high amounts in the southeast to much lower ones in the northwest. Regionally uneven economic development parallels the imbalance of China's EI, which is further illustrated in Figure 5(a). This is not surprising because local economic potential and capital availability, among others, stimulate the development of environmental businesses in local areas, as well as the application of their goods and services. While the overall regional distribution of employment in the environmental industry is consistent with that of its sales, Figure 4(b) illustrates that in some inland areas, such as Heilongjiang and Henan provinces, market supplies go together with relatively high employment figures, while other provinces, such as Guizhou and Guangxi Zhuang, show low employment rates with relatively high sales.

Figure 4 Regional development of China's EI in 2000: (a) turnover in sales and (b) employment



Source: SEPA (2001)

Figure 5 Regional development of China's EI: comparisons of market supply in terms of turnover in sales with (a) local GDP and (b) market demand for wastewater treatment



Source: SEPA (2001) and the China Statistical Yearbook (2001)

There are also strong local differences in the 'gaps' between supply and demand. Using the shortage of urban wastewater treatment to represent market demand,[16] market demand and supply are compared at the local level (as illustrated in Figure 5(b)). In some regions, such as Shanghai, Jiangsu, Zhejiang and Liaoning provinces, EI's supply seems to be sufficient to meet the demand for urban wastewater treatment. But in some other provinces, involving Guangdong, Shangdong and Henan, notwithstanding the relative high market supply of local environmental industries, there exist still large gaps between present treatment capacity and the volumes of urban wastewater discharged. Note that overall, the limited supply of environmental industries in the northwest region is sufficient to meet wastewater treatment demand. It goes without saying that in each of these regions and provinces the averages hide local situations with major shortcomings in treatment capacity.

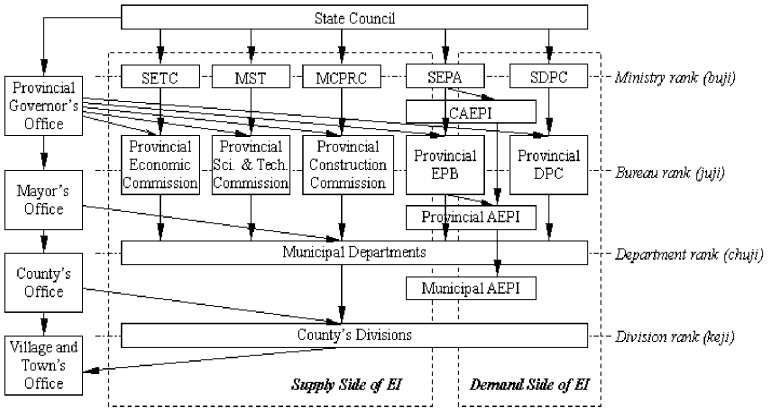
4 Regulating environmental industry in China

Since environmental regulation is fundamentally related to both demand for and supply of EI's products and services, it is interesting to analyse the State's institutions for environmental improvement and pollution control in relation to the development of EI.

4.1 The environmental matrix problem

The environmental regulatory administrative system is organised as a hierarchical system: from the national level, via the provincial, the municipal, and the county level, to the township level.[17] The administrative (or bureaucratic) rank is an important reflection of power and status. The highest-ranking units under the State Council are the comprehensive Commissions, which rank higher than ministries. So far as the EI's innovation and development are concerned, these involve the State Development and Planning Commission (SDPC) and the State Economic and Trade Commission (SETC), which have responsibilities that cut across sectors and geographic regions and contribute to the supply side and demand side respectively (see Figure 6). The other relevant units at the national level are the Ministry of Science and Technology (MST; responsible for the innovation and supply of environmental sound technology), the Ministry of Construction People's Republic of China (MCPRC; responsible for urban infrastructure and environmental facilities), and – last but not least – the State Environmental Protection Administration (SEPA; the major advocator and promoter for environmental interests and EI's innovation).

Figure 6 Regulating EI in China: the framework of administrative hierarchy



At the township level and above, governmental organs are connected in two distinct ways: by function and by geographical area, as shown in Figure 6. The Chinese use vivid terminology to describe these criss-crossing jurisdictions: the vertical bureaucracies are called lines (*tiao-tiao*) and the horizontal coordination at various levels is called pieces (*kuai-kuai*). Western scholars of organisational dynamics label this dualism of horizontal and vertical authority a 'matrix' problem (Lieberthal, 1995, p.169). In the complex *Tiao-Kuai* (matrix) relationships each unit reports to both an upper-level department in the same functional area and the government of the geographical area in which it is located.

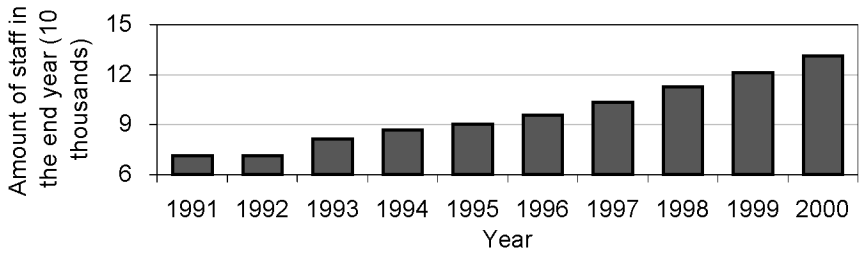
In designing pollution control policies and related programs, SEPA plays a key role. SEPA was elevated in the administrative reforms in March 1998,[18] from vice-ministerial to ministerial ranking, and the number of employees in the SEPA line (*tiao*) nation-wide has almost doubled in a decade: from some seventy thousand in 1991 to over one hundred and thirty thousand in 2000 (see Figure 7). But SEPA's role in day-to-day implementation of environmental regulations is still limited. SEPA implements rules only

for projects undertaken by national-level agencies, or activities that are otherwise of national significance, such as the famous 'three rivers and three lakes' project. In all other cases, Environmental Protection Bureaus (EPBs) or Environmental Protection Offices (EPOs), replacing SEPA through successively lower levels of the administrative hierarchy, enforce environmental laws, implement policies designed by SEPA and assist in drafting local regulations to supplement central ones (Ma and Ortolano, 2000, p.9; Jahiel, 1998; Vermeer, 1998). Higher-ranking organs provide lower ranking ones with policy directives and guidance for implementation, but normally it is the local government that provides corresponding affiliated organs with annual budgets and funds and approves institutional advancements. Therefore, the local government is usually more powerful in directing EPBs than EPOs: the '*tiao*' serves the '*kuai*'. Local government budgetary control of regulatory agencies suggests that local governments may have a larger influence on how policies are implemented than central level regulatory agencies responsible for formulating policy. The central government's ability to coordinate policy across regions may be seriously limited (see also Jahiel, 1998).

In 1993 SEPA set up the China Association of Environmental Protection Industry (CAEPI), apart from this bureaucratic hierarchy but with local branches, in order to accelerate the growth of China's EI. In almost ten years CAEPI has made various contributions to the development and innovation of the environmental industry, among which three are surveys on EI's development in 1993, 1997 and 2000 respectively.[19] Although it has a semi-official position, CAEPI is excluded from the policy-making bureaucracy. Without administrative ranking CAEPI has no administrative privilege and governmental policy instruments to press and promote EI's innovation at the national or local level. Although it has received some 'administrative' regulation power and budget from SEPA, it can only wander in the complex and confused matrix to try to set favorable conditions for the development of environmental industries.

While the 1998 administrative reforms reduced the number of agencies involved in environmental protection, it did not completely eliminate the authoritative fragmentation. Besides SEPA there are still several other agencies having jurisdiction over various aspects of environmental protection (such as SDPC, SETC, MST and MCPRC; see Figure 6). This complex arrangement of diffuse organisational tasks and responsibilities for environment and EI has several notable implications. First, not all responsible organisations are strongly inclined towards environmental interests as a prime motive. Second, this fragmentation creates competition for scarce environmental funds. Finally, fragmented, and in some cases overlapping, regulatory authority hinders the coordinated management of environmental issues as well as EI's innovation (Jahiel, 1998).[20]

Figure 7 Amount of staff employed for environmental protection in years-end in China



Source: The China Environment Statistical Report (1991–2000)

4.2 SETC and SEPA: hierarchical ranking vs. 'orbits'

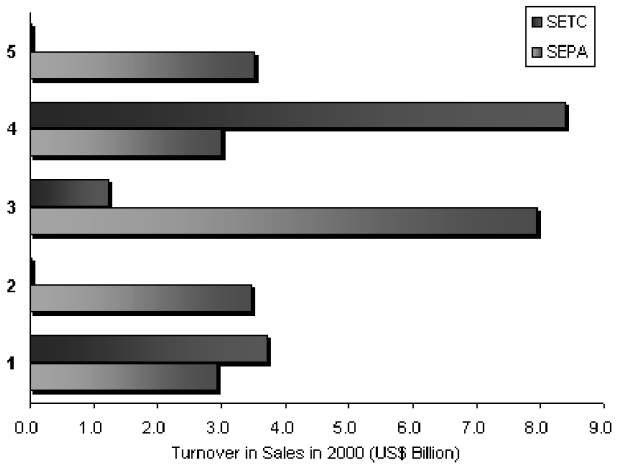
A remarkable institutional transition is the fact that SEPA's jurisdiction on the development of EI was passed to SETC in the 1998 administrative reforms (SEPA, 1999).[21] This regulatory re-structuring implies the recognition of the significance of EI for the national economy.[22] SETC and the comparable organs responsible for economic development and trade at lower levels have a higher administrative ranking than SEPA and EPBs. However, it seems that SEPA does not completely comply with this institutional adjustment. Two evidences are presented to understand the institutional overlap and conflict caused by the re-structuring:

- after the reforms an important inner department, called the Department of Technological Policy and Industry Direction within the Technology and Standard Bureau in SEPA, remains responsible for EI's development by taking serious account of technological innovation of EI suppliers rather than only the demand side
- SEPA initiated a comprehensive investigation on EI's development at the national level in February 2001 (carried out by CEAPI) and came to conclusions (in the form of an inter-report) which are considerably different from the ones in a report SETC launched in the same year.[23]

Three differences can be noted between the CAEPI/SEPA report and the SETC study: the differences in the label for EI, discriminating definitions of China's EI and (consequently) deviations in conclusions. Even when taking into account the diverse terminology used to present EI world wide (see Note 1), differences in labels cannot be ignored in China because they are grounded in the conflict and contest between SETC and SEPA for regulatory domination. Following definitions of EI that are claimed to be more consistent and comparable with those used in Western countries, SEPA applies a broader definition than SETC, extending EI's category into five aspects: environmental protection products, clean products, environmental protection services, waste treatment and disposal, and nature and ecology protection. SETC still adopts the prevailing narrow definition, including three categories: environmental equipment, environmental services and comprehensive resource utilisation (=waste treatment and disposal). No coordination or attempts at harmonisation takes place between these two organs. In addition, SETC statistical data rely on different sampling techniques and survey methods. Even when we exclude the two supplemented categories of SEPA's definition (clean products and nature and ecology protection), the statistical data of EI's sales in 2000 differ considerably between the SEPA and SETC reports, especially regarding environmental services and comprehensive resource utilisation (waste treatment and re-use) (cf. Figure 8).

Apart from SEPA and SETC, there is a third data source related to the development of EI: the China Environment Statistical Report (CESR). The CESR is promulgated by SEPA annually to proclaim fundamental statistical information on China's environment, normally involving loading and control of pollutants, natural ecology protection, environment regulation and management, capacity building, and so forth.[24] A comparison of the three sources (Figure 9) makes it clear that EI's total turnover, amount of units and employees derived from the SEPA investigation are much higher than those derived from the other two investigations. If the broader SEPA definition is appropriate, it suggests that the development of China's EI has been underestimated over a long period.

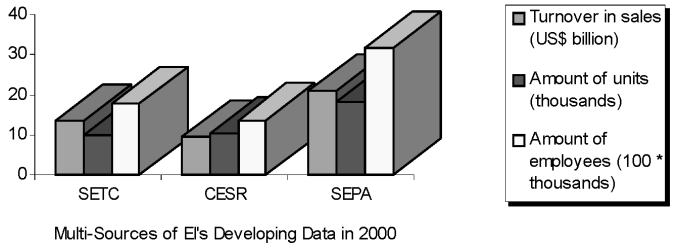
Figure 8 Statistical inconsistency between SETC and SEPA in terms of EI's turnover in sales in 2000



	SETC	SEPA
1	Environmental equipments	Envionmental protection products
2	/	Clean products
3	Environmental service	Environmental service
4	Resources comprehensive utilization	Waste treatment and re-use
5	/	Nature and ecology protection

Source: SEPA (2001)

Figure 9 Comparison of data derived from multiple sources on EI development in China in 2000



Source: SEPA (2001) and the China Environment Statistical Report (2000)

The implications in terms of administrative conflicts involving overlap and fragmentation, which go behind these data sets, are more interesting than a quantitative analysis of data uncertainty. Depending on CESR and its subordinate affiliations, SEPA can be considered to play a dominant role in the EI regime development. With a weakened regulatory function after 1998, SEPA still conducts EI's investigations, promulgates the development EI to other governmental agencies and the public and tries to exclude any participation of SETC in this. The fact that a higher-ranking organ, SETC, cannot always intervene in an assignment organised by a lower-ranking one, SEPA, or re-arrange and incorporate a program with it, strongly suggests that – besides ranking – another critical force defines administrative jurisdiction in the huddled matrix. There exist 'legitimate' privileges in the conventional '*orbit*' or '*perisphere*' occupied by each governmental organ, which are strongly institutionalised in the custom of Chinese policy culture and historically developed bureaucracy. In this case of distinct representations and positions on China's EI, SETC barely manages to intervene in SEPA's conventional and institutionalised environmental routines and domains, even though the former has a higher rank designated by the Center.

On the other hand, however, SEPA's 'conventional orbit' cannot fully prevent SETC from taking forward steps on regulating EI (and other environmental policy domains).

SETC has its own data sources and relies on its own definition in assessing EI's development. For SETC it important that it can also promulgate the status of developing EI in China in the form of its own documents, despite data gaps. After the 'Encouraged Catalogue of Industries, Products and Technologies' issued by SDPC in 1997 in which the environmental subcategory was included, SETC documented the 'Encouraged Catalogue of Equipment (Products) of Environmental Protection Industry by the Government (the First Batch)' in 2000. This can be viewed as the first important step in the direction of effective policy-making on the environmental (technological) industry.[25] In the next year, a formal document, named 'Suggestion on Acceleration of the Development of the Environmental Protection Industry in China', was written by SETC and jointly issued by eight ministries and commissions.[26] The document claimed that – by its own words: different from SEPA – EI is a technological guarantee and physical base for environmental protection undertakings and an increasingly significant contributor to national economic development, and promotion of EI is a crucial measure towards sustainable development.[27] SETC strongly recommended in the document that EI should be treated as a dominant sector promoted by government in the local economy as well as in social development planning and future goals.

In general, China has not built up an integrated and highly efficient regulatory and promotional system for EI's innovation and development, nor an effective policy-making and implementation on both the demand and supply sides. The distinction between the administrative hierarchy and ranking (SETC) on the one hand and the conventional 'orbit' (SEPA) on the other constitutes a major barrier in coherent and consistent regulatory jurisdiction, environmental reports, data collection and promotional policy.

5 Conclusion

The market and regulatory potential for promoting EI's innovation in relation to both demand and supply have taken a central place in this contribution. With respect to the demand side, the emphasis should be on the possibility for ecological-economic 'win-win' solutions, by changing technical progress into a more ecological-efficient direction that also contributes to the overall competitiveness of Chinese industry. Although regulation can be used to force the process of industrial eco-innovation, regulatory intervention cannot completely overcome the institutional and structural constraints that environmental industries are facing in their development. Even if environmental regulation can trigger more than incidentally incremental or radical innovation in polluting industries, there may in the end be institutional, political and economic constraints, particularly in transitional China, which make continuing combined economic and environmental improvements impossible and constitute market barriers and ineffective demands.

For the supply side, attention should be given to the innovative potential of environmentally sound technologies. Generation, screening, and effective exploitation of eco-industrial innovations depend on the underlying technological trajectories, the nature of market demands, and the characteristics of the organisations supplying them (Rennings, 2000). While technological investments are necessary, institutional and organisational innovations seem at the moment, to be more crucial in helping to secure the direct and indirect benefits associated with the new technology, also by facilitating further incremental improvement along existing trajectories or paths. Successful

innovations and their application depend on a combination of advances in scientific understanding, efficient co–operation between academic organisations and environmental industries, appropriate political and policy programs, smart strategy design, environment-oriented institutional changes and scale and direction of new investments.

In both supply and demand, policies and regulations can take a crucial position. Conflicts in the form of functional overlap and fragmentation among SETC, SEPA and the local governments have existed for years, and we have elaborated upon them in terms of administrative ranking and conventional orbit. It is clear that China has not built up an effective and efficient administrative regulation system for EI's innovation and implementation, on either the demand or the supply side. Since no effective and efficient administrative coordination and policy harmonisation take place among these organs, EI's innovative capacity has been undermined. There is a strong need for cleaning up the governance framework in an effort towards better performance. With the growing internationalisation of the Chinese market for environmental goods and service, there is not much time for the Chinese environmental industry to waste.

References

Alam, G. (2001) *Acquisition of Environmentally Suitable Technologies by China – The Case of Circulating Fluidized Bed Combustion Boilers*, Report prepared for the United Nations Industrial Development Organization, UNIDO.

Asuka-Zhang, S.J. (1999) 'Transfer of environmentally sound technologies from Japan to China', *Environmental Impact Assessment Review*, Vol. 19, No. 5, pp.553–567.

Chen, J. and Chu, J.Y. (2001) *Future Scale and Market Capacity of Urban Water Environmental Infrastructure in China: A Study on System Dynamic Model, Research Report*, Institute of Environmental Industry, Department of Environmental Science and Engineering, Tsinghua University, China, in Chinese.

Chen, J. and Liu, Y. (2001) 'The barriers and opportunities of EI's innovation in China', *Proceedings of '21cn Forum – Green and Environmental Protection, The Chinese People's Political Consultative Conference, CPPCC*, September 4–6, Beijing, also published in China Machinery and Electronics Daily, Zhongguo jidian ribao, January 16, 2002, p.6, in Chinese.

Chen, J. *et al.* (2001) *Governmental Regulation on Commercialization of Environmental Infrastructure*, Research Report, Institute of Environmental Industry, Department of Environmental Science and Engineering, Tsinghua University, China, in Chinese.

China Daily (2000a) August 10.

China Daily (2000b) September 2.

China Daily (2001) March 29.

Chu, J.Y. and Chen, J. (2001) 'Financing analysis for urban water environmental infrastructure', *Environmental Protection*, huanjing baohu, Vol. 290, December, pp.18–21, also published in Market Economy and Environmental Protection, Chemical Industry Publisher, 2001, pp.158–162, in Chinese.

Diener, B.J. and Terkla, D. (2000) 'The environmental industry in Massachusetts: from rapid growth to maturity', *Corporate Environmental Strategy*, Vol. 7, No. 3, pp.304–313.

ECOTEC (1999) *The EU Eco-industry's Export Potential – A Final Report to DGXI of the European Commission*, ECOTEC, Birmingham.

ECOTEC (2002) *Analysis of the EU Eco-Industries, their Employment and Export Potential*, ECOTEC, Birmingham.

Guerin, T.F. (2001) 'Transferring environmental technologies to China: recent developments and constraints', *Technological Forecasting and Social Change*, Vol. 67, pp.55–75.

Gunningham, N. and Sinclair, D. (1998) 'Designing environmental policy', in Gunningham, N., Grabosky, P. and Sinclair, D. (Eds.): *Smart Regulation: Designing Environmental Policy*, Clarendon Press, Oxford, pp.375–453.

Ho, P. (2001) 'Greening without conflict? enviornmentalism, NGOs and civil society in China', *Development and Change*, Vol. 32, No. 5, pp.893–921.

Jahiel, A.R. (1998) 'The organization of environmental protection in China', *The China Quarterly*, Vol. 156, December, pp.757–787.

Lieberthal, K. (1995) *Governing China: From Revolution through Reform*, W-W-Norton and Company, Inc., New York.

Mol, A.P.J. and Ying Liu (2005). 'Institutionalising cleaner production in China: the cleaner production promotion law', *Int. Journal Environment and Sustainable Development*, Vol. 4, No. 3, pp.227–245.

Ma, X. and Ortolano, L. (2000) *Environmental Regulation in China: Institutions, Enforcement, and Compliance*, Rowman and Littlefield Publishers, Inc., Lanham [etc.].

Martinsons, M.G., et al. (1997) 'Hong Kong and China: emerging markets for environmental products and technologies', *Long Range Planning*, Vol. 30, No. 2, pp.277–290.

Mol, A.P.J. (forthcoming) 'Environment, modernity and transitional China, at the frontier of ecological modernization', *Development and Change*.

Murphy, J. and Gouldson, A. (2000) 'Environmental policy and industrial innovation: integrating environmental and economy through ecological modernization', *Geoforum*, Vol. 31, pp.33–44.

Preston, J.T. (1997) 'Technology innovation and environmental progres', in Chertow, M.R. and Esty, D.C. (Eds.): *Thinking Ecologically – The Next Generation of Environmental Policy*, Yale University, pp.136–149.

Rennings, K. (2000) 'Redefining innovation – eco-innovation research and the contribution from ecological economics', *Ecological Economics*, Vol. 32, pp.319–332.

SEPA (1999) *A Complete Volume of Laws and Regulations of China's Environmental Protection: 1997–1999*, Depaprtment of Policy, Law and Regulations (ed.), Xueyvan Publisher, Beijing.

SEPA (2001) *The State of the Environmental Protection Relevant Industry Report in China*, See http://www.zhb.gov.cn/english/soe.

Shenzhen EPB (2001) *Investigative Report on Environmental Protection Relevant Industries in Shenzhen City*, EPB, Shenzhen.

State Economic and Trade Commission (SETC) (2001) *The Tenth Five Year Plan for the Development of Environmental Industry in China*, available at http://sd-ep.cei.gov.cn/index/d/dindex.htm

The China Environment Statistical Report (1998) SEPA (State Environmental Protection Administration).

The China Environment Statistical Report (2000) SEPA (State Environmental Protection Administration).

The China Environment Statistical Report (1991–2000) SEPA (State Environmental Protection Administration).

The China Statistical Yearbook (2001) *NBS (National Bureau of Statistics of China)*, China Statistics Press, Beijing.

Vermeer, E.B. (1998) 'Industrial pollution in China and remedial policies', *The China Quarterly*, Vol. 156, December, pp.952–985.

Wang, B., Zhang, T.Z. and Chen, J. (2001) *Valuing Dianchi Lake of China with Contingent Valuation Method*, Research Report, Institute of System Analysis, Department of Environmental Science and Engineering, Tsinghua University, China, in Chinese.

Zhang, K.M. (1992) *Report on China Environmental Investment*, Tsinghua University Publisher, Beijing, in Chinese.

Notes

[1]'Environmental Industry' has been reviewed in different terminological way world-widely. It is named as 'environmental protection industry' in China, as 'eco-business' in Japan, and as 'environmental industry' in the USA. In other OECD countries EI is cited as 'environment industry' or 'eco-industry' frequently and as 'environmental goods and services industry' seldom.

[2]Figures for 1999 are even higher: a turnover of 183 billion Euro and employment of 2 million full-time jobs (ECOTEC, 2002).

[3]An exchange rate of 1 US$ for 8.1 RMB yuan is used in this paper.

[4]Some other relevant data show: 1) desulphurisation of 5% of the coal-burnt power plants in China could create a considerable market demand of RMB¥ 6 billion annually; 2) products for more silent and cleaner motor manufacturing could lead to more than RMB¥ 4 billion in sales each year; 3) while the construction of a domestic waste incinerator of 1,000 ton/day capacity costs about RMB¥ 0.6 billion, there are over 600 cities in China that need but have no waste incinerator. See details on the website of http://sd-ep.cei.gov.cn/.

[5]Research Office of the State Economic and Trade Commission (SETC) (2001). Some of the fundamental aims for environmental protection within the period of '*Shiwu Plan*' (by the year of 2005 compared to 2000) are: 1) the total amount of major industrial pollutants on a national level should be reduced by 10%; 2) the emission loads of SO_2 within Double Control Area ('*Liang Kong Qu*') should be reduced by 20%; 3) the treatment rate of domestic waste water should achieve 45% on a national level; 4) environmental pollution of a greater part on national level should be reduced, and environmental quality of key cities and regions should be improved; 5) the trend of increasing ecological deterioration should be reversed. For details, see the subject 'Environment and Development', co-operatively sponsored by the State Development and Planning Commission (SDPC) and the National Information Centre, on the website http://sd-ep.cei.gov.cn/.

[6]EI definitions vary among these countries. Therefore, the comparative analysis should be interpreted as a qualitative illustration. Statistical data for industrial development derived from multiple sources show limited differentiation in magnitude (cf. Section 4). This fact justifies the conclusion on the status of China's EI, as drawn from the figure.

[7]According to two CEOs from different advanced companies engaged in field of environmental protection in China. For details see: http://sd-ep.cei.gov.cn/.

[8]'Socialist Market Economy' is a specific concept that emerged in the 1980s in China and was formally defined in the early 1990s. That 'a socialist economy can also be a market economy' is a historical and revolutionary breakthrough of traditional Marxist-based theory on socialist society. Learned from its own and other socialist societies' past experiences and lessons, China finally determined that 'establishing a socialist market economy' is the goal of economic reform. Consequently, market competition has been introduced into China's economy. This change has far-reaching impacts on Chinese society. Although it is still too early to grasp the final end-stage China is moving to, it is clear that China would have lost its 'global identity' if it had not taken the path to a market economy.

[9]See data on the number of environmental protection institutions, monitoring centres and staff officials at various levels over the years 1997–2000 in several State of the Environment China reports over the years 1997–2001: http://www.zhb.gov.cn/english/soe/.

[10]Environmental technologies can be sharply split into control technologies and clean technologies. Normally control technologies do not require a significant redesign of the production process or products. The compatibility of clean technologies with existing systems of production is usually more limited. Thus, there is a relatively clear market demand for control technologies, while that for clean technologies is relatively vague and difficult to identify and estimate. See also Murphy and Gouldson (2000).

[11]This investigation was conducted by experts and students of Tsinghua University (China) in 2001. Totally 1024 households were interviewed to assess willingness to pay for environmental restauration. According to statistical analysis using contingent valuation method, estimated payment willingness is averaged 32.6 US$ (264.17 RMB Yuan) per household per year, with a sampling error of 3.5% within 95% confident interval. Note the difference between the average value of samples and the calculated value. For details see Wang et al. (2001).

[12]This is also an important factor influences industries' decision on environmental performance. See Ma and Ortolano (2000) for an empirical study and rich discussion on the gap that exists between the goals embodied in China's environmental laws and regulations and actual levels of environmental quality.

[13]There has been a remarkable shift in the technology polices of developed countries. Governments are increasingly seen as facilitators rather than providers of direct support to innovative activities. Consequently, while governments continue to provide fiscal support to R&D, the focus of policy has shifted to strengthening the inter-firm and academic-industrial linkages. See details in Alam (2001).

[14](China Daily, 2001) In Chengdu, the capital of Southwest China's Sichuan province, a foreign-owned water project called Vivendi Waterworks will begin supplying tap water in March 2002. The France-based Vivendi Water, one of the world's top companies in this field, set up Vivendi Chengdu Waterworks Co Ltd for water supply (China Daily, 2000a).

[15]Shanghai aims to evolve its environmental protection sector into a principal industrial sector by 2015 with a total output of US $12.3 billion. Sales in environmental protection facilities and equipment are expected to reach US $1.85 billion in 2000 and US $4.9 billion in 2005, with an annual growth rate of 21.6%. Output is expected to amount to US $1.1 billion in 2000 and US $2.5 billion in 2005, taking a 25% share of the domestic market. ('Profits make for a greener city', China Daily, 2000b).

[16]Calculated by the difference between the volumes of urban wastewater discharge and the treatment capacity in 1999.

[17]Governments at the township level and above are 'official' in the following sense: they receive budgetary support from the Centre and their employees are regarded as formal governmental staff. In contrast, the governing body in a village is called 'village committee' which consists of a leader, a deputy leader, an accountant, and so forth. See details in Ma and Ortolano (2000, p.34). In fact, two bureaucratic hierarchical systems exist: the territorial one (centre-province-city-county-township) and the administrative one (state-ministry-bureau-department-division). The relations between these two hierarchical systems are in China referred to as: *shengji-buji*, *tingji-juji*, *diji-chuji*, and *xianji-keji* (see Figure 6). To complicate matters further, there is a complex hierarchical relation between the state government and the communist party at each of these levels (e.g., Lieberthal, 1995).

[18]The Ninth National People's Congress (NPC) turned out to provoke a radical reform of government administration. When the dust had settled, the number of ministry-level bodies had been reduced from 40 to 29, and 50% of the governmental position had been listed for removal from the governmental payroll within three years. See details in Jahiel (1998).

[19]The major goal of CAEPI is to actively participate in governmental regulation for EI's innovation and development. In practice, this includes among others: 1) taking part in environmental industrial survey, strategy planning, and developing policies; 2) studying and reporting on EI's strategy and policy; 3) providing necessary information and consultation on environmentally sound technologies, equipments and services for polluters and suppliers; 4) assisting environmental industries with respect to technological, financial, and facility aspects. See http://www.beijingwindow.com/jj /hbcy/cyxh/.

[20]Local government budgetary control of regulatory agencies suggests that local interests may have more influence on how policies are implemented than the central-level regulatory agencies responsible for formulating policy. Consequently, the ability of the central government to co-ordinate policies across regions may be seriously limited. For a rich and sophisticated discussion, see Jahiel (1998).

[21]The details were promulgated in SEPA (1999)

[22]But there might be more at stake. SETC, and not SEPA, also managed to become the first responsible agency for, among others, the Cleaner Production Promotion Law. See Mol and Liu (2005).

[23]The inter-report, named the State of the Environmental Protection Relevant Industry Report in China, has an appendix in which the deviation in acknowledgements of EI's status are emphasised and interpreted. Apparently, SEPA tries to highlight the significance of the report and advocate the 'novel' notions by comparing its study with SETC's 'out-of-date' one. It implies that SEPA is actively striving for the regulatory domination that was weakened in the administrative reforms. However, this last section of the inter-report was excluded when it was circulated to the wider public under the same title but a different content in December 2001.

[24]While SEPA claims their industrial investigation reflects the actual status of China's EI, with an elaborate explanation of the extended categories in its report, the data series abstracted from CESR are adopted consistently in this paper, since that seems to be in a better order and more appropriate for temporal dynamic analysis (see Figures 1, 2 and 7). On the other hand, whatever data series is used for comparative analysis as discussed in Sections 1 and 2, the conclusion will most likely be the same: China's EI is relative immature.

[25]The catalogue includes eight sections: 1) air pollution control; 2) water pollution control; 3) waste disposal and treatment; 4) noise control; 5) environmental monitoring; 6) energy saving and re-generated energy utilisation; 7) comprehensive utilisation of resources and cleaner production; and 8) environmentally friendly materials and medicament. See http://sd-ep.cei.gov.cn/.

[26]The eight units include SETC, SDPC, MST, the Ministry of Finance People's Republic of China (MFPRC), MCPRC, The People's Bank of China (PBC), the State Administration of Taxation of China (SATC), and the State General Administration of the People's Republic of China for Quality Supervision and Inspection and Quarantine (SGAQSIQ). Note that the last unit was newly established on April 16, 2001, which is actually a merger of two former government departments, namely, the State Administration of Quality Supervision of the People's Republic of China, and the State Administration for Entry-Exit Inspection and Quarantine of the People's Republic of China. SEPA was not among the eight.

[27]The document mentioned three key domains supported by central government: 1) environmental technology, equipments, environmental materials and medicament; 2) comprehensive utilisation of resources; and 3) environmental consultation and information, technological services, and operational service of environmental projects and infrastructure. These three categories are consistent with those of the definition advocated by SETC. On the other hand, it is clear that SETC is striving for upgrading EI's position in the whole national economy. For example, the vice-director of SETC said that the National Planning of Ecological Construction and Environmental Protection in China's the Tenth Five Years Development Planning ('*Shiwu Planning*') treats EI as a novel and raising industry and it will certainly and significantly contribute to the national economy by the central government's stimulation of environmental investment and environmental policy-making (Source: National Working Conference of Environmental Protection Industry held on July 5, 2001 in Beijing).