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中国 ICT 产业的生态节能设计的经济分析，以及重庆地区的研究

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SUMMARY

ABSTRACT

ICT industry meets great expansion in China, in production as in diffusion. The derived environmental impact becomes an increasing key issue for Chinese relevant social planner. One question in front of the government is how efficient the regulation system is and how to measure this efficiency.

The analysis of the efficiency of the environmental legislative measures about the issue of ICT industry's environmental impact is deployed in the macroscopical view in our research, and devised into three dimensions: ICT industry's development in China and in Chongqing along with the environmental impact estimation derived from it; function of China's administrative system concerning ICT industry's environmental problems and the trend of policy-making in China; ICT manufacturers attitudes and actions about environmental measures.

As China has a vast territory with centralization of power on a grand scale, we are interested to introduce the geographical factor through the three studies. The other factor we take into account is the classical tool for ICT industry's environmental analysis, Life Cycle Assessment (LCA). The two factors are combined together to support this research.

In our study, we find that the geographically unbalanced ICT industry development in China together with inconsistent environmental balance according to categories of ICT products contribute the conflict to a certain extent with national legislative measures without regarding the geographical factor for policy-making. Furthermore, the inconsistency of policy-making about this issue exists between involved different social planners. Moreover, for some environmental measures, manufactures' attitudes and actions are also influenced by geographical factor and economical force.

Briefly, from the legislative measures' analysis, it's evident that social planner does not consider the fact that ICT industry's environmental impact in China is not proportionally distributed among different regions, and manufactures' environmental strategy reflects also the geographical shadow. This contributes implicit inefficiency of China's environmental policy-making about ICT industry's environmental

problems for the past, for today and prominently for tomorrow.

INTRODUCTION

Information & Communication Technology (ICT) industry's environmental problems have been one of the key environmental issues that increase to attract public and government's attention. China, as the most important country for ICT industry's production, and the market with the fastest growth for ICT diffusion, the accumulated environmental problems accompanying this development increase to attract attention at the policy-making level as at the academic level.

To develop the green ICT is the key part of promoting China's green economy, and Jing Zhang and Xiong-jian Liang's (2012) work has contributed to the frame analytical work of innovation system to aid the promotion of green ICT by Chinese policy maker, which could offer considerable experiences for other developing countries like these of BRICs (Xuening Yao et al. 2009).

The hypothesis made in our study as in many other environmental economic researches that "*social planner's goal is to reduce ICT industry's environmental impacts through ICT product's whole life cycle by most efficient way*" is broken by complicated administrative system, and the term "social planner" may be replace by "social planners" considering that multiple departments are involved in the regulations affaires, just from different perspectives.

Policy-making's objects should be all agents involved in the issue of ICT industry's environmental problem. Yet, there is an obvious trend that manufacturer is more and more focused agent to be liable for important responsibilities related to environmental impact through product's life cycle.

It interests us strongly to know what are these social planners in China are thinking and what did they do: what the social planners have done till now, and how will the regulations system be tomorrow. This kind of analysis together with the research of reaction between producers and policy system is valuable for us to assess the efficiency if it exists. Porter and van der Linde (1995) have argued that the use of environmental policy instruments has enhanced innovation in industry, and thus enhanced the competitiveness of companies in the countries using them.

Number of works have been contributed to the study of legislative measures' efficiency on the ICT or other products' environmental impact, and many of them focus principally on the wastes management. The trend of study in this field is on the impact of the extended producer's responsibility (EPR) principal based on the end of life management on the eco-design, in order to promote the sustainable development of this industry. Several researchers have analyzed the impact of WEEE directives in their respective countries, such as Walther and Spengler (2005) in Germany, Hicks et al. (2005) in China, Yoon and Jang (2006) in Korea, Hischier et al. (2005) in Switzerland, Feszty et al. (2003) in Scotland or Streicher-Porte et al. (2005) in India; other authors have taken into account the future of WEEE laws and have developed new techniques to design products and supply chains that are both economically and ecologically feasible (Krikke et al., 2003); the importance of extending the life cycle of electrical household appliances was stressed by Truttmann and Rechberger (2006); Gottberg et al. (2004) studied the effectiveness of EPR and policies to promote it by checking the effect of EPR in the wastes minimization and eco-design for the lighting sectors in Europe; from an economic point of view, the Directive (European Union, 2003a) implements the principle of producer responsibility, Y. Barba-Guti´errez et al. (2007) studied the environmental consequences of European wastes regulations and find that the negative effect of recycling activities; I.C. Nnorom and O. Osibanjo (2008) analyzed the poor wastes management application of legislations in developing countries; Panate Manomaivibool (2008) researched the EPR about management of waste electrical and electronic equipment in India, and found the active impact of EPR's practicing in these countries non-OECD[1]; Shan-Shan Chung and Chan Zhang (2011) consider that the relevant regulations in China meet great problems of enforcement with little effect on the environmental goal promised by government. In these previous works, we often find the dysfunction of EPR for eco-design. In our study, in stead of limiting our focus on the wastes management policy based on the EPR principle, we enlarge the view by introducing geographical

[1] OECD: Organization for Economic Co-operation and Development

factor, considering that the unbalanced geographical distribution of this industry for both production and diffusion is one of the important reasons to obstacle the legislative measures' practice in the real society.

Manufacturers' attitudes and actions are the reflections vis-à-vis the regulation system. Manufacturer's position in production chain, headquarters location, research and development (R&D) centers location, and production plants location even their markets geographical distribution become important factors in our study. This kind of manufacturer's internal spatial economic information could eventually have impact on his attitudes and actions toward series environmental measures through product's life cycle. To identify the impact is one of the key objective we research here, and it should be taken into account for policy-making.

Methods have been developed to analyze ICT product's environmental impact, from the energy consumption perspective and the materials consumption perspective. EPEAT[2] combines comprehensive criteria for design, production, energy use and recycling with ongoing independent verification of manufacturer claims; various tools have been developed under frame of Life Cycle Assessment (LCA) which is the most used for evaluating ICT product's environmental impact by quantitative way. These tools are widely applied related researches in different countries and regions. By Tak Hur et al. (2005), "*the usefulness of life cycle assessment (LCA) and a matrix method as tools for identifying the key environmental issues of a product system were examined*".

But, not too many studies have been developed for ICT products in China due to defect of Chinese statistics and the lack of transparency. Many studies have been contributed to this domain in order to perform the quantitative evaluation of the environmental impact of ICT and other products. For example, Niu et al. (2012) find that the environmental impact of incineration of CRT display has the greatest impacts based on LCA method; Deng et al. (2011) find that for laptop the manufacturing phase represents 62–70% of total primary energy of manufacturing and operation

2 EPEAT：Electronic Product Environmental Assessment Tool

according to LCA application, etc. This kind of studies focuses on concrete products, and only offers the way of evaluation, but not the way of comprehensive solution for ICT industry's environmental problems. As we intend to reveal the efficiency of ICT environmental policy in China, the detailed research of these methods is out of our scope, whereas it could be useful tool for our study.

To evaluate relevant environmental policy's efficiency, it's necessary to identify the objective corresponding to the goal of our research - ICT industry in China. The idea is to have clear information about ICT industry's development in China. As we strongly refer to LCA method that covers all parts of ICT product's life cycle, it's reasonable to study ICT industry's development by analysis of both ICT production and ICT diffusion. This way of analysis exclude the environmental benefice issue from the reduction of emissions due to the application of ICT service in other sector or individual's life as presented in the work of Paul Steenhof et al. (2012) and of Inge Røpke et al. (2012).

Having more information on effects and causes will allow decision-makers to optimize future development (Andrius Plepys, 2002). In our study, we introduce the geographical factor into the analysis of ICT industry's environmental impact in macroscopical view. This is based on the fact we observed from ICT industry's development in China, that evident unbalanced situation exists among different regions in China for ICT industry's development in both production and diffusion. The east region, as the most developed region, has advanced the rest of this country in both production and diffusion, for almost all categories of ICT products; the west region is the one the most left behind in China, in both production and diffusion, for almost all categories of ICT products, Chongqing's becoming the newest municipality is considered as the key step for the central governmental strategy about rebalancing the unbalanced development between the two regions of different economic level. The revitalization of Chongqing depends on the economic development of China's western region, while the prosperity of China's western region relies heavily upon the proper functioning of Chongqing as a growth center (Sun Sheng Han, Yong Wang, 2001). Under this background, we note that ICT's development matches well with this situation especially with the started trend of gap's closing between the developed regions and the distressed regions.

The above-mentioned geographical and economic phenomenon could have impact on one region's ICT industry's environmental impact according to the concept of spatial environmental balance (SEB) we introduced in the study. Different LCA results are used as tool for quantifying the SEB for each mentioned region. Numerous quantitative results show the geographical influence integrated in these regional SEB that should reasonably be integrated into policy-making strategy.

In Part I, we present the methodology applied in the research. The scope and data gathering, hypothesis are introduced. This part offers the frame of research, to orient the study along with the proposed pathway.

In part II, we work on the identifying concept of ICT industry in China. This work is necessary for our study before deploying analysis of this industry's environmental impact. In this part, ICT concept is concluded by its dynamic evolution and the fusion with EEE definition.

In part III, ICT industry's environmental impact is studied under frame of LCA method. The consistency of LCA results is also discussed in this part.

In part IV, General evaluation of the existing and potential environmental impacts of ICT industry in this country and in its economically and geographically crucial city Chongqing is quantified. This evaluation is obtained by quantitative analysis combining with geographical factor.

In part V, we deploy upstream analysis and downstream analysis for comprehending the trend of policy-making. The upstream analysis focuses on the understanding of social planners' strategy of policy-making upon their main functions; the downstream analysis focuses on the relative implemented laws and regulations, intending to find out the distribution of these legislative measures among parts of life cycle and among different agents according to different responsibilities.

In part VI, we make the interview to the sample enterprises with Switch-Asia programme. Based on the responses by these interviewed enterprises for the questionnaire we distributed, we analyze ICT manufacturers' attitudes and actions toward environmental measures, in considering their market force, their geographical factor.

In part VII, by reviewing precedent results of ICT development in China and in Chongqing, relative policy-making in China and manufacturers' attitudes and actions, we obtain the comprehensive conclusions for the efficiency of these legislative measures.

PART I - METHODOLOGY

The main objective of our research is to analyze the efficiency of environmental legislative measures about ICT industry's environmental problems in China, with perspective of ICT industry's geographical distribution (at national level and enterprise level) and economic development. Propositions based on these analyses are given for the eventual coming regulations adjustment.

The applied methodology is constituted of 5 steps: 1. to determine the scope of our study and to design the way on data gathering; 2. to analyze the influence factors of ICT industry's environmental improvements, from the perspective of manufacturer, consumer, recycler and social planner, by determining the links between these influence factors and the corresponding environmental improvements; 3. to take hypothesis on the environmental strategies of manufacturer, consumer and recycler; 4. to evaluate the relative environmental regulations and economic incentive policies, by referring to the hypothesis in step3; 4. to make conclusions based on the evaluations made in step4; 5. to offer recommendations for the future environmental policy and regulations making.

Section1 scopes of research

ICT industry's accelerated expansion in China is accompanied by more and more serious environmental problems as it is in the world. But these problems in China have their distinguishable characteristics compared with in other countries. China's central government has already realized the serious situation and shows its great motivation to reduce the existing and potential environmental problems issue from this industry. China's relative environmental regulations system has been greatly influenced by European, Japanese and American implemented systems. Learning from developed countries is a shortcut for remedying the pain at present, but never enough for systemically resolving the already emerged and potential problems. Reasons for this issue could be: first, the relative regulations system's adaptation has natural difficulties considering enormous differences between the regulations exporters and regulations importers in economic environment, political environment, cultural and educational environment, etc.; second, these regulations have their own problems of efficiency through implementation in countries that export these regulations.

With all this background, China's policy makers are aware of the shortage of simple importing regulations system, and the efficiency of the implementation of these regulations is well in question now. To analyze the inefficiency even failure of the regulations' implementation in order to offer useful recommendations for the eventual improvement is of great value.

The scopes of this study cover numerous aspects of the ICT industry in China, by reason that we ambitiously try to describe a general and valuable map of ICT industry's environmental situation in this country. We propose the analysis based on the life cycle impact assessment (LCIA) of manufactured ICT product from three dimensions: geographical and economic distribution of ICT industry at the national level and the enterprise level, social planner's strategy for relative policy-making in China, manufacturer's environmental attitudes and reactions toward the existing legislative measures:

- Geographical and economic distribution of ICT industry at the national level and the enterprise level: this spatial economic factor is the core as perspective of analysis. As it will be suggested in next section, manufacturers are profit maximizers, and consumers are utility maximizers, the economic incentive policy is referred by social planner to stimulate these agents to react correctly as expected considering the environmental externality through all life cycle of product.

  The geographical and economic distribution of ICT industry at the national level and the enterprise level is a crucial factor that is ignored in preliminary works for this kind of study. Geographical distribution of ICT industry according to different development level and different categories of products are inserted in our analysis in part IV, in order to find out the environmental impact for mentioned regions in China according to different ICT products. These findings could give valuable recommendations for policy-making in the conclusions in part VII.

- Social planner's strategy for relative policy-making in China: this analysis is run into two parallel ways in part V, firstly we review the administration system concerning the issue of our study, and secondly we review the relative laws and regulations in order to find out the correspondences between the content of these legislative measures (including laws and regulations), and different parts of ICT product's life cycle according to the concepts we will set up in section 2 of part III (parts of life from perspective of environmental impact and from the perspective of environmental reaction by correspondent agent). These correspondences serve for the identification of social planner's effective strategy on making relative regulations and the implementation of these regulations.

  Social planner is supposed to be the one who implements regulations in efficient way. But as this hypothesis is eventually weak and broken in China due to the actual complicate administrative system, considering that the term of "social planner" could become "social planners" in this context. This phenomenon is also discussed in part V.

- Manufacturer's environmental attitudes and reactions toward the existing legislative measures: in part VI, manufacturer's environmental strategies including eco-design, environmental management, etc., will be analyzed based on gathered data. How to make these two kinds of strategy depends on the internal and external factors. The internal factors could be the role of the manufacturers in the manufacturing chain, their awareness on the environmental efficiency of their products, their investment on eco-design and relative technology, their organization efficiency; the external factors include the market competition environment, the environment of relative laws and regulations at the international level as at the domestic level, the technology progress, the environmental pressure (air pollution，water pollution, depletion of natural resources and fossil energy resources) and the related social awareness on environmental protection which depends on the country's culture and people's richness level and education level. To study these correlations is useful for distinguishing these factors one to each other, such that the social planner could be able to know the exact objective constraints of their environmental policy's implementation and to evaluate these policies based on the principle of efficiency.

The geographical and economic distribution is also integrated in the analysis of manufacturers' attitudes and activities toward environmental legislative measures in part VI, based on the data collected from the survey (see section2), aiming at offering another perspective for social planner. This should be integrated into social planner's policy-making at the level of central government.

The life cycle impact assessment (LCIA) of manufactured ICT product is the basic tool for our analysis and discussed in part III where we make the correspondences between the environmental strategies of relevant agents involved in different parts of life cycle and correspondent environmental impacts. In part IV, ICT industry's development in China and the case study in Chong Qing City (CQ) follow the precedent discussions in figuring out an general estimation of the existing and potential environmental impacts of ICT industry in this country and in the geographically crucial city (South-West, the region economically left behind) which is at the stage of economic transition from heavy industry driven economy to light industry driven economy.

Section2 Data gathering

For the data and information gathering, we focus on two kinds of data: First，the laws and regulations already implemented or will be implemented in China and some important regulations implemented in countries or regions out of China. During this data collection, we also carry out interviews with important persons who participate in relative regulations making, in order to obtain profounder details about the strategy of China's central government for seeking solutions for the ICT industry's environmental problems: Miss Yang, directress of Information Center of the Ministry of Industry and Information Technology (MIIT), Miss Tong, professor of School of Environment and Civil Engineering, Beijing University, and Miss Tian, expert of China Household Electric Appliance Research Institute (CHEARI), have been well followed by regular phone conversation from March 2011 to early 2013, for the issue of the system of central governmental administration concerning ICT or EEE's environmental problems; M. Li, director of Laptop headquarters of Chongqing's Xiyong Micro-Electronic Zone, has been interviewed on December 2012 face to face, for the issue of the ICT industry's development in Chongqing (See Annex I);

Second, the attitudes and actions toward the environmental measures of interviewed ICT manufacturers implanted in China including Chinese brands and foreign brands. We carry out the survey together with Switch-Asia programme by sending designed questionnaire (see Annex III) to 68 ICT manufacturers in China (See Annex II). Switch-Asia programme is promoting Sustainable Consumption and Production (SCP) across the Asia region. It works with both producers and consumers on the ground as well as at policy-making level in formulating and implementing of SCP-related policies. A €152 million budget is earmarked for the programme under the Regional Strategy for Asia covering the period 2007-2013[3].

Third, we refer a lot to China Statistical Yearbook and Chongqing Statistical Yearbook.

Section3 Hypothesis

The hypotheses we make in the following give out the frame under which we extend this study. These hypotheses are made in order to facilitate our analysis. Some hypotheses are closely compact to the real world, and some are not so. The hypotheses that differ from the real world to certain extent give eventual further studies when released.

Hypothesis1 – All producers are profit maximizers.

[3] http://www.switch-asia.eu

Hypothesis2 – The ICT final products market is a perfect competitive market. Products of different brand are substitutable to a high extent. All manufacturers take the price of their product as given, they have no power to influence the market pricing individually.

Hypothesis3 – Products' design costs more and more as the competition in the market intensifies.

Hypothesis4 – The transport cost is linear function of the distance from the supplier to the buyer.

Hypothesis5 – The transport uses fossil fuel, in generating Green House Gas (GHG) that is considered as a serious environmental impact.

Hypothesis6 – Consumers are all utility maximizers. They plan to minimize their expense to achieve a given utility.

Hypothesis7 – Consumers are charged of operation cost. In our study, this cost is considered only as the electricity cost, which is second energy and is transformed by burning fossil fuel in generating GHG.

Hypothesis8 – Consumers are selfish, meaning that for the disposal of the ICT product at the end of use, they prefer the payment to the volunteer way, even though the first way is much unregulated compared to the second one.

Hypothesis9 – Recyclers and disposers are subsided by government according to the type and weight of the used products. At the same time, they are also profit maximizers.

Hypothesis10 –logistics servers are profit maximizers. This market is competitive at the national level, but could be less competitive at the local level.

Hypothesis11 – Regulations system in China is designed at the national level, and then conducted to the local level. This reveals that geographically, the local regulations system is consistent with the national one.

Hypothesis12 – Social planner's goal is to reduce ICT industry's environmental impacts through ICT product's whole life cycle by most efficient way.

Section4 Evaluations and conclusions

The goal of our study is to illustrate the strategy of China's environmental regulations making in identifying the correspondent reaction through ICT product's whole life cycle with the related players (manufacturer, logistics server, consumer, recycler and disposer), in order to verify the efficiency of these regulations' implementation. The evaluation is based on the data gathered from manufacturers in China, and the relevant laws and regulations. The principle of the evaluation is to see if to which extent the consistency exists between the correspondent reaction at different stage of life cycle and the provision of relevant regulation aiming at this reaction. The evaluation will take eco-design as a key point because of its relations with reduction of hazardous substances use, production process environmental control, operation energy cost reduction during the use, wastes reduction, even the reuse of recyclable materials, etc. Moreover, the economic geographical constraints are strongly imposed to complete the evaluation in order to make it

Following the evaluation, conclusions will be made on the laws and regulations system, in pointing out the endogenous inefficiency and exogenous obstacles.

Sections5 Recommendations

The most important part of these recommendations is contributed to the ongoing regulation adjustment or new ones' making. After the analysis from three dimensions (ICT industry's development along with its accompanied spatial environmental impact, legislative measures system run in China and producers' attitudes and reactions), we propose that it should be taken into account the geographical economic factor and the different categories of ICT products for policy-making.

PART II - CONCEPTUALIZATION OF ICT INDUSTRY IN THIS STUDY

Section1. Conceptual study about ICT

The concept of ICT industry is not static but dynamic one, and eventually varies across different countries. The evolution of ICT industry in China could be classified from the supply/demand side or complementary/substitute relation. By Wan Xing et al. (2011), during the period from 1997 to 2002, the supply side convergence dominated the convergence of China's ICT industry, while the demand-side convergence experienced little structural change. Before Wan's work (2011), studies have been contributed to the convergence of the ICT industry concept, and frame works and case study to analyze the mechanism of the convergence and its implications have been generally used. Some researchers emphasize regulation problems incurred by convergence (Clements, 1998; De Bijl & Peitz, 2008; Geradin, 2001; Ono & Aoki, 1998; Perrucci & Cimatoribus, 1997), some focus on firm strategies (Borés, Saurina, & Torres, 2003; Kaluza, Blecker, & Bischof, 1999; Pennings & Puranam, 2001), some study different stages of convergence from the perspective of evolutionary economics (Hacklin, 2008; Hacklin, Marxt, & Fahrni, 2009), some use the theory of industrial organization to analyze the phenomena (Eisenmann, Parker, & Alstyne, 2007; Huang & Teo, 2008), and some pay attention to value reconfiguration brought by convergence using the theory of value chain or value network (Pil & Holweg, 2006; Saxtoft, 2008; Wirtz, 2001).

Roy, Das, and Chakraborty (2002) and Heng and Thangavelu (2010) group sectors in input–output tables into two broad categories: information and non-information, concentrating on the role of information sectors rather than information technology sectors. Heng and Thangavelu (2010) include computer and computer peripherals, electronics and communication products, communications and information technology services, which is almost the same with the ICT sector classification in China's input–output tables.

Three factors drive the convergence of the ICT industry: technological progress, business model innovation, deregulation and demand evolution. Technological convergence starts industry convergence (Hacklin, 2008). Business model performs two important functions: value creation and value capture. For instance, Amit and Zott (2001) emphasize four interdependent key dimensions for value creation and capture bye-businesses, i.e. efficiency, complementarities, lock-in, and novelty. Reducing market entry barrier usually will bring new products or business models for an industry (Lei, 2000). As a result of the deregulation of the electronic communication industry in China, cable operators are permitted to provide internet access service with cable modem technologies, and telecom operators are allowed to provide IP TV—a form of digital TV service (Wan, Hu, & Wu, 2009).

The classification of industry convergence gives insight to convergence from the static perspective. Industry convergence can be classified from two dimensions-substitution/complementation and supply/demand (Pennings & Puranam, 2001). Stieglitz (2003) also recognizes the point ''a product convergence of substitutes is often followed and paralleled by technological convergence.''

After reviewing these previous academic works, we try to obtain the useful concept of ICT industry in comprehensive way from different official sources.

By Bart van Ark（2001）, the ICT-producing sector consists of IT hardware, radio, television and communication equipment, medical appliances and instruments and appliances for measure (together the ICT industry) and telecommunication and computer services (together ICT services).

This definition matches to the Variant of NAICS[4] 2007: Information and Communication Technology (ICT) Sector based on the 1998 OECD definition of the ICT Sector: ICT – Manufacturing consists of ICT – Machinery Manufacturing, ICT – Computer and Electronic Product Manufacturing and ICT – Electrical Equipment, Appliance and Component Manufacturing[5]. The NAICS system groups economic

[4] North American Industry Classification System – NAICS.

[5] For more details, see http://stds.statcan.gc.ca/spaggr-agrsp/ict-tic-2007/1998/tsearch-trecherche-eng.asp?criteria=31-33

activities completely according to production process homogeneity, which avoids the possible inconsistency of industry classification (Lind, 2005).

According to OECD classification, the principles of ICT definition are: (1) for manufacturing, the products should satisfy the function of information treatment, communication and display, indicating the equipment of information treatment and the carrier of communication; and the products must process the detection， measurement and/or recording of the physical phenomenon by electronic means, or control the physical process; (2) for service, the activities must serve the information treatment and communication by electronic means. Classification about ICT industry based on these principles was given out by the United Nations - Department of Economic and Social Affaires – Statistics Division, and consists of ICT manufacturing and ICT services.

In China, ICT concept and ICT sector is defined and classified by National Bureau of Statistics of China, and is structured in 4 parts: part 1, electronic information equipment, including manufacturing of equipment relevant to electronic information, wholesale and retail of electronic information equipment, rent of computer and communication equipment; part 2, electronic information dissemination including telecommunication service, broadcast service, satellite service and network service; part 3, electronic information technology services, including computer technology services and software programming services; part 4, other information services, including activities relevant to news, publish，broadcast, films, television, audio & video，library and archives. From this structure of definition, we observe that this definition matches the NAICS classification for the “information sector” if the first part is eliminated; it matches the “information technology industry” defined by OECD if the 4^{th} part is eliminated; and it matches the “information technology producing” defined by US department of commerce if the 4^{th} part and the rent of computer and communication equipment in the first part are eliminated.

From above, it’s not difficult to see that the ICT sector defined in China involves most of the definitions mentioned before, and could be also considered as constituted by two general parts as for UN: ICT manufacturing and ICT services.

Section2. Defining Electrical and Electronic Equipment

It is also very important to give out the clear definition of electrical and electronic equipment (EEE). A simple definition is: Equipment using electricity or through which electricity flows, and/or which contains an electronic circuit, i.e., a circuit with active and passive components. And The 5th draft directive on WEEE (CEC(b), 2000) defines EEE as "equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields falling under the categories set out in Annex I A and designed for use with a voltage rating not exceeding 1000 Volt for alternating current and 1500 Volt for direct current".

The EEE is defined as "equipment that is designed for use with a voltage rating not exceeding 1000 Volt for alternating current and 1500 Volt for direct current" in China in the China WEEE drafted by the Ministry of Industry and Information Technology[6]. The definition of EEE is almost the same in different countries and regions.

Section3. Defining the physical target of our research study

As our research is deployed under the title of "*How Eco-Regulations impact the eco-design of ICT products in China*", the physical target appears as ICT products. But the real problem in our research is the environmental problem of ICT products, which is always discussed in the field of wastes generated by EEE. It's why we were interested in the definition of ICT sector and EEE previously. Throughout the path of the ICT sector and EEE's definition travel, we observe that the domain of ICT sector is more complex than this of EEE. Under this background, we intend to give out the definition of our research's physical object by constraining the definition of ICT sector by EEE's definition, as figured out below.

6 see http://jns.miit.gov.cn/n11293472/n11295091/n11477337/13310408.html

We determine the definition of ICT products in our research by a stricter way corresponding to the intersection between ICT and EEE figured as part T in figure II.1.

Therefore, we give out the definition of ICT products in our research as: electronic information equipment, including manufacturing of equipment relevant to electronic information, wholesale and retail of electronic information equipment, rent of computer and communication equipment, that is designed for use with a voltage rating not exceeding 1000 Volt for alternating current and 1500 Volt for direct current.

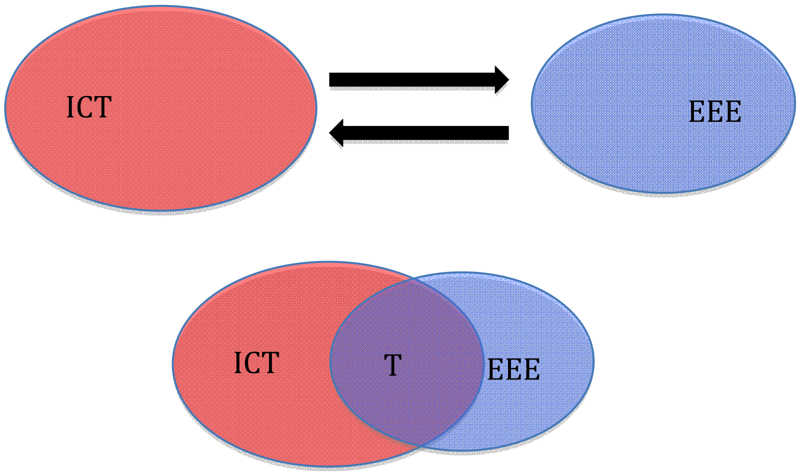

Figure II. 1. The physical object of our research study

This definition combines the manufacture of ICT equipment and the concept of EEE introduced earlier. For simplification, we identify ICT products and EEE in our research by identical definition determined just now, and in the rest of the paper, the same thing will be indicated when we talk about ICT or EEE.

PART III - ICT PRODUCTS' ENVIRONMENTAL IMPACTS THROUGH THE LIFE CYCLE

Section1 Understanding life cycle assessment – LCA of ICT product

1.1 The life cycle of a manufactured product

"Consecutive and interlinked stages of a product or service system, from the extraction of natural resources to the final disposal" is explicated as the definition of *life cycle* in ISO 14040[7].

The life cycle of a manufactured product covers the span from its manufacture to its recycling or disposal. Usually we define the ordered stages of the life cycle of a manufactured product as below:

1. Manufacturing of the product. At this stage, manufacturer organizes the production activities to realize the output. The raw materials, recycled materials and components enter the factory, and at the end of this stage, complete product is made out and put into the warehouse, in waiting for the logistics company to come to transport them out;
2. Transport. At this stage, logistics company contracts with the manufacturer and the sale company, in transporting the goods from the factory storage to the sale point, or contracts with manufacturers at different level of production chain, to transport the production factors from upstream ones to downstream ones. Transport tool could be various considering the different geographical conditions between the two points, and resulting important environmental impact consequences by energy consumption that we will discuss in more details later;
3. Use of the product. After purchase, consumer brings the product home, dismantle the package which could also have environmental impact，and start to use the product. For the ICT products that we studied in our research, the energy consumption as the indirect environmental impact is inevitable during this stage;

[7] ISO 14040.2 Draft: Life Cycle Assessment - Principles and Guidelines.

4. Recycling of the used product. After the use, product is recycled then resold to other consumers in the second-hand market if it is still in usable condition, or, is transported to the center of dismantling and selection where specialized enterprises extract the reusable materials or components in order to supply them to the manufacturer for new product production;
5. Disposal of the wastes. After reusable materials and components are sent to the new product production stage, the rest of the recycled rejects become the final wastes，and is destined to be disposed by landfill or incineration.

The 5 stages presented above describe the life cycle of a manufactured product in a standard and synthetic way. This description is suitable for most manufactured products in ignoring some details: the complicated production chain among suppliers on different level, suppliers and the manufacturer; the complicated sale net principally characterized by Business to Business （B2B）; etc. Despite of these details, the 5 stages offer an overview of the life cycle of a typical manufactured product, and strongly suitable for the environmental analysis of ICT product we study in our research, which will be discussed later in this part.

In addition, we should distinguish definitions of life cycle of manufactured product with another popular definition of "product life cycle (PLC)" which is widely used in marketing. Delicate difference between the two definitions on the same term and the way these definitions are ordered make them almost of totally different implication. The PLC is theoretically based on the biological life cycle （introduction， growth, maturity, decline） and then applied to the product's marketing. For example, the work of Steven Klepper (1996) offers model to predicts that over time firms devote more effort to process innovation but the number of firms and the rate and diversity of product innovation eventually wither; Louis T. Wells (1968) applied the concept of PLC to the international trade.

We mention this distinction of definition just for avoiding unnecessary concept confusion, and don't extend any more research on the PLC, by focusing our eyes only on the first definition of "the life cycle of a manufactured product".

To make our further analysis easier, we note the different parts of life cycle mentioned above as A, B, C, D, E, corresponding to the 5 stages presented just now.

1.2 The life cycle assessment (LCA)

By IOS 14040, ***Life Cycle Assessment (LCA)*** *is a technique for assessing the potential environmental aspects and potential aspects associated with a product (or service), by:*

- *compiling an* ***inventory*** *of relevant inputs and outputs,*
- ***evaluating*** *the potential environmental impacts associated with those inputs and outputs,*
- ***interpreting*** *the results of the inventory and impact phases in relation to the objectives of the study*[8].

By M. Demmers and H. Lewis, *LCA is used as a tool to assess the environmental impacts of a product, process or activity throughout its life cycle; from the extraction of raw materials through to processing, transport, use and disposal. In its early days it was primarily used for product comparisons, for example to compare the environmental impacts of disposable and reusable products. Today its applications include government policy, strategic planning, marketing, consumer education, process improvement and product design. It is also used as the basis of eco-labeling and consumer education programs throughout the world*[9].

As defined in SETAC (Society of Environmental Toxicology and Chemistry) （1992）[10], *LCA is a process to evaluate the environmental burdens associated with a product, process, or activity by identifying and quantifying energy and materials used and wastes released to the environment; to assess the impact of those energy and materials used and releases to the environment; and to identify and evaluate opportunities to affect environmental improvements. The assessment includes the entire life cycle of the product, process or activity, encompassing, extracting and*

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8 ISO 14040.2 Draft: Life Cycle Assessment - Principles and Guidelines.

9 M. Demmers and H. Lewis, Life Cycle Assessment: How Relevant is it to Australia?

10 See: www. setac.org

processing raw materials; manufacturing, transportation and distribution; use, re-use, maintenance; recycling, and final disposal[11].

According to VITO (Flemish Institute for Technological Research)（2007）, *LCA can be defined as a systematic inventory and analysis of the environmental effect that is caused by a product or process starting from the extraction of raw materials, production, use, etc. up to the waste treatment. For each of these steps there will be made an inventory of the use of material and energy and the emissions to the environment. With this inventory an environmental profile will be set up, which makes it possible to identify the weak points in the lifecycle of the system studied. These weak points are the focal points for improving the system from an environmental point of view.*

From the presented understandings of LCA, it's questioned that if LCA results converge or not for the same products? If not, what should be the reasons? This question emerges as more and more important for relative regulators，as the efficiency of the eco-regulations on ICT products is getting more and more doubtful, and the regulators are seeking the way to better identify the environmental impacts through all stages of product's life cycle and the way how to reduce the impacts by implementing more efficient regulations system.

The life cycle inventory (LCI)，as LCA's important content, is principally the energy and raw material inputs and environmental releases associated with each stage of production.

Recently, different systems such as polyols (Helling and Russell 2009), toys (Muñoz et al. 2009) and mountain huts (Goymann et al. 2008) have shown that LCA has the potential to point out the important issues from an environmental point of view. Furthermore, LCA has been used successfully to develop eco-design strategies in the electronics industry (Alonso et al. 2003; Gurauskiene and Varzinskas 2006; Yung et al. 2009). And the LCA results focus mainly on CO_2 equivalents (CO_2e), because they

11 Guidelines for Life-Cycle Assessment: A 'Code of Practice', SETAC, Brussels

are very important as one of the factors enhancing the acidification of the oceans (Rockström et al.2009).

Considerable researches have been contributed to the environmental impact due to the end of life of electronic and electric products. Huisman (2003) studied the recovery of base metal on e-waste recycling; Hischier et al. (2005) studied the complete Swiss WEEE recycling and disposal activities；

We review LCI by carding the relation between the inputs and outputs as demonstrated in table II.1.

The information revealed from table III.1 is that the toxic releases (output) is strongly linked with the raw materials (input), the GHG (green house gas) emissions are strongly linked with the energy inputs, and other impacts (implicitly include radio， noisy, etc.). Additionally, environmental impacts issue from the use of raw materials don't stay as the toxic releases but also the depletion of the natural resources; the energy input doesn't indicate only the energy use through the raw materials' extraction and the manufacturing process, but also the transport of the production inputs, of the product and of the wastes, and the energy consumption through the use of the product；the other impacts like radio and noisy are generated through the integrated components during product's function powered by electricity. This information is valuable for regulations making as it offers the path through which we set the efficient strategy by affecting the activities in all stages of product's life cycle. We will go further on this.

Table III.1. Relationship between inputs and outputs

Outputs / Inputs	Toxic releases	GHG emissions	Other impacts
Raw materials	▯		▯
Energy use		▯	▯

Life cycle impacts analysis（LCIA）constitutes the phase of LCA next to LCI. LCIA offers the methodology to evaluate the potential environmental impacts based on the LCI flow results. This assessment consists of: selection of impact categories, category indicators, and characterization models; the classification stage, where the inventory parameters are sorted and assigned to specific impact categories; and impact measurement, where the categorized LCI flows are characterized, using one of many possible LCIA methodologies, into common equivalence units that are then summed to provide an overall impact category total.

1.3 The consistency of LCIA for ICT products

As mentioned above, the environmental impacts through all stages of ICT products are closely linked with the outputs in the LCI analysis: the toxic releases and the contribution to the GHG emissions.

From the preliminary works on the consistency of the LCIA, some missing studies are noticed. By Anders S. G. Andrae & Otto Andersen（2010）, the LCA (generalized LCIA in their work) of consumer electronics is consistent for mobile phone and TV sets, but inconsistent for laptop and desktop computers. This study involved many preliminary works around the world especially involving the countries of East Asia (China，China(Taiwan), South-Korea, Japan), and all the works focus on the global warming potential during 100 years (GWP100) and on primary energy usage/electricity usage. The studied products include laptop PCs, mobile phones, desktop computers and peripherals, TVs.

Works presented by Tekawa et al.(1997), Lu et al. (2006), IVF report 2007a[12], PE International (2008), demonstrate that there exists very strong inconsistency among these LCIA results of laptop; based on research of Tekawa et al. (1997), Atlantic Consulting and IPU (1998), Kim et al.(2001), Williams (2004), Choi et al.(2006), Zhou and Schoenung (2007) and Duan et al. (2009)，the LCIA results showed the inconsistency for the desktop computers using CRT screen as for the desktop computers using LCD screen.

For mobile phone, the publication of Nokia (2005)[13], woks of Park et al. (2006), Frey et al. (2006), PE International (2008) and Bergelin (2008) lead to the fact that the LCIA results for mobile phone are relatively more consistent than those for laptop and desktop computer.

From the published works of Aoe (2003)，Dodbiba et al. (2008), Feng et al. (2009), and Barba-Gutierrez et al.(2008) and (2009), it seems that the LCIA results have the consistency to a relative larger degree for TV, with measure based on the GWP100.

Section2. Reactions in different parts of life cycle by corresponding agents and the effects on corresponding parts of life cycle

To better understand the impacts of relevant regulations on ICT industry's activities about the environmental issue, we consider that it's very useful to describe the objects of our research according to different parts of ICT manufactured product's life cycle by good arrangement.

Firstly, we set up three concepts here: environmentally effected part of life cycle (EEPLC), environmentally reacted part of life cycle (ERPLC) and environmental actor (EA). EEPLC is defined as the part of life cycle according to relevant environmental impacts which has directly happened, for example, EEPLC-A designates the manufacturing of products linking with the environmental impacts through the manufacturing process; ERPLC is defined as the part of life cycle in accordance with activities on the environmental issue, for example, the ERPLC-B designates the transport service where the dioxide emissions can be reduced by improving the organization of the logistic service by numerous ways; EA indicates the involved actors through the whole life cycle of ICT product, for example, EA-consumer indicates that the consumer is considered as actor who can influence ICT product's environmental impact by his effort like changing the consumption

[13] Nokia (2005), *Integrated product policy pilot project — Stage I Final report: life cycle environmental issues of mobile phones*.

behavior through the use. For abbreviation, we note the concerned EAs as M - manufacturer, T- transporter, Co - consumer, R - Recycler, Di - Disposer.

The table below shows the correspondence among the factors according to the three concepts based on the ICT product's life cycle, and the eventual distribution of EAs among these correspondences.

Table III. 2 Distribution of EA between ERPLC and EEPLC

	ERPLC-A	**ERPLC-B**	**ERPLC-C**	**ERPLC-D**	**ERPLC-E**
EEPLC-A	M			Co, M, R	Di, M
EEPLC-B		M, T			
EEPLC-C	M		Co		
EEPLC-D	M	R, T		Co, M, R	
EEPLC-E	M	Di, T		Co, M, R	Di, M

In table III.2, we observe the eventual correspondence among the three concepts that we come to set up: EA, ERPLC and EEPLC. We give out explanation in the following for some cases in this table that could be generalized to all the other cases.

ERPLC-A, EEPLC-C, (M): manufacturer makes effort on environmental issue in part A of life cycle, in influencing the environmental impact generated in part C of life cycle. This case could be realized by the fact that manufacturer invest on eco-design by improving product's performance in reducing the noise or radiation that could be harmful to consumer's health through his use of this product.

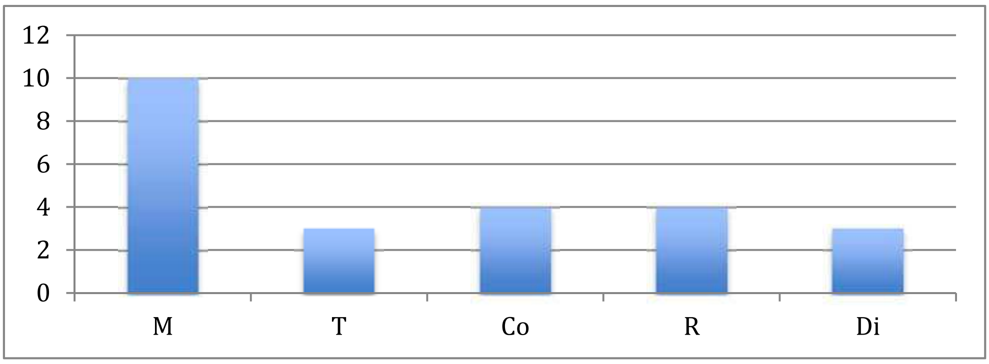
ERPLC-B, EEPLC-B, (M, T): manufacturer or transporter makes effort on environmental issue in part B of life cycle, in influencing the environmental impact generated in part B of life cycle. The actor could be manufacturer or transporter in depending on if the manufacturer delegates the logistics service to the special logistics company or undertakes this service himself. The transport can be better organized by using information technology like Global Position System (GPS), in order to improve efficiency of this service by reducing the energy consumption and the related GHG emissions during the transport.

ERPLC-E, EEPLC-A, (Di, M): manufacturer or disposer makes effort on environmental issue in part E of life cycle, in influencing the environmental impact generated in part A of life cycle. The actor could be manufacturer or disposer in depending on if the manufacturer delegates the logistics service to the special logistics company or undertakes this service himself. The transport system can be better organized by integrating information technology like Global Position System (GPS), in order to improve efficiency of this service by reducing the energy consumption and thus the related GHG emissions from the transport.

In the following figure, we present the simple statistic of the frequency of appearance of each EA.

From figure III.1, it’s obvious that manufacturer appears the most among all actors with 8 appearances, consumer and recycler take the second place as the same with 4 times of appearance, transporter and disposer have the least important place with only 3 appearances. This result implicitly tells that manufacturer is the most important player who should be taken into account for relevant policy-making.

Figure III.1 Frequency of EA appearance in the distribution between ERPLC and EEPLC



This analysis of the correspondence among EEPLC, ERPLC and EA paves the way for further analysis of social planner’s strategy on their relevant policy-making.

In part V, we will extend this analysis to strategies of policy-making consistency by adding the factor of different responsibilities for the environmental impacts through ICT product's life cycle, in order to have a better comprehension on the idea of China's government' policy-making.

Section3. Conclusion

The life cycle of a manufactured product is constituted of the 5 stages presented in section1. The life cycle assessment is considered as a tool to evaluate the environmental impacts through all stages of product's life cycle, in order to give quantitative guide for manufacturer's eco-design or environmental management, consumer's making choice on purchasing goods in considering environmental factor and social planner's implementing policies and regulations.
The LCIA results then represent important arguments for manufacturers to make their environmental strategy facing to policy makers, for consumers to make their choice in purchasing ICT goods in considering the environmental factor, and for social planner to implement efficient regulations system.
As we discussed in section 2, by reviewing preliminary published works, it's not evident that the LCIA results could be obtained consistently. The LCIA results vary to a great extent for some ICT products (laptop and desktop computer) as appear relative consistency for some other ICT products (mobile phone and TV sets). We don't go further for analyzing the various reasons for this phenomenon that has been studied in the work of Andrea et al. (2010), however we focus on two facts following the cited works: first, LCIA results appear inconsistencies for different products even for the same product, in a view of the distribution of environmental impact weight' among stages of product's life cycle； second, in the cited works in section2, the environmental impacts are analyzed basing on the GWP100 evaluation method, meaning that only the GHG emissions are taken into account, which are strongly related to energy using through the life cycle. In referring to table III.1, we find that the toxic releases and other impacts are absent in the LCIA analysis in the cited works，

in making these results incomplete for obtaining the exact environmental evaluation of the focused products. This fact could be explained that the toxic releases, other impacts and the GHG emissions are heterogeneous environmental impacts through the life cycle. They are often analyzed distinctly in a parallel way in stead of an overall evaluation system.

In section 3, we set up three concepts relating to ICT industry's environmental problems based on the 5 parts of life cycle, in setting up an analytical structural frame of studied objectives, for the purpose to better understand the way of policy-making, and then to evaluate the impact of these policies' implementation on the corresponding aims. Through the construction of this frame based on different parts of life cycle, it's obvious that manufacturer takes the most important place for product's environmental issue.

PART IV - ICT INDUSTRY DEVELOPMENT IN CHINA AND IN CHONGQING TOGETHER WITH THE DERIVED ENVIRONMENTAL PROBLEMS

Based on the relatively narrow concept of ICT presented in part II, which is extracted by suiting our research target, it appears necessary to know how the ICT industry develops in China and in Chongqing, in estimating the environmental problems related to ICT industry. We try to find out the repartition of the estimated environmental impacts from different stage of ICT product's life cycle. This exploration could help the diagnosis of environmental policy's effects through ICT product's life cycle.

It's dramatically difficult to obtain the accurate estimation for the whole ICT industry's environmental impact in China, because of the increasing diversity and the fusion among related sectors. So the overall estimation will be very general and stay very limited in giving references to the study. But, at the same time, we also focus on some particular ICT products, in order to find out clearer figure of the environmental impacts of some important and typical products.

By Qingxuan Meng et al. (2001) ICT industry is becoming the most dynamic sector in China's economy with active promotive policy system (Chen, X., Ma, J., & Yuan, D., 2004). There is, however, a clear digital divide among the nation's different economic regions. The economic geographical factor is taken into consideration. This analysis is deployed internationally and domestically. This analysis aims to present geographical distribution of the ICT industry in the world by pointing out the position of China in the manufacturing chain, and in China mainland by pointing out the position of Chongqing in the manufacturing chain. The results could be available for making diagnosis of the effect of the related environmental policies on ICT industry in China and in Chongqing.

Some works have contributed to the analysis of regional ICT industry's development in China like works of Y.H. Dennis Wei (2011), and of Carol Ting (2012). These regional analyses focus principally on the development of ICT industry at the regional level, but not on the environmental impact issue from the development, yet which is the focus in our research. Xin Tong et al. (2012) have researched on this topic in China, and they find that other than firm attributes, such as the position in the product chains and the firm-level environmental performance, two geographical factors, i.e., target markets and local cluster effects, are also significant in influencing firm's technological choices, while capital sources is less important.

Section1. ICT industry's development in China - production and diffusion

There is ample evidence that information and communications industry has contributed a great deal to the overall economic growth of the developed countries. (Kraemer and Dedrick 2001 and Jalava and Pohjola 2001). We observe the clear trend of ICT liberalization in many developing countries (Wong 2001 and Cogburn and Adeya 2001).

China is normally considered as developing country. As Sang-Yong Tom Lee et al. (2005) suggest, ICT contributes to economic growth in many developed countries and NIEs, but not in developing countries. China as the most important developing country, its ICT industry development may give example for other developing countries.

A wide range of economic and institutional factors characterizes the highly uneven state of informatization in China (Carol Ting, Famin Yi, 2012), at the background that the share of productive service increases in the whole economy of China (Wan, X., Fan, J., & Hu, H.， 2007). There has been also debate surrounding the role of government intervention in ICT industry's development in China, considering that China's government is characterized by powerful intervention in market. Opponents to public ownership claim that publicly owned operators have little incentive to strive for efficiency, financial independence and innovation. As a result, taxpayers will be stuck with a wasteful and obsolete technology (Bast, 2004; Lenard, 2004), and public investment will reduce incentive for private entry to the market (Feld, Cooper, & Scott, 2005).

In this section, we present the empirical evidence from both the production aspect and the diffusion aspect, all in considering the dynamic trend of the geographical distribution, in order to involve the spatial factor into the analysis of ICT industry's environmental problems in China. Hansmann (1988), Radford (2003) and Ting (2009) argue that public ownership may be more efficient; Harwit's book (2008) on China's telecommunication revolution chronicles the series of changes and reforms that enabled the rapid development of telecom service in most urban areas. The issue of urban–rural gap is left unaddressed. Xia and Lu (2008) argue that lack of checks and balances in the Chinese system will undermine independent agencies, opposing a separate universal service fund administration. Xia's (2010) study on China's approach to advanced in formation services in rural are as highlights a range of institutional issues for the design of a transitional regime to a layered system of governance. Qiang et al. (2009) describe a number of rural informatization efforts in China.

The above-mentioned works indicate out the problems of the unbalanced development of ICT industry between urban and rural regions. But not too much works are contributed to the analysis of the unbalanced development among regions of different economic level. As early as the 1990s, the Ministry of Environmental Protection of China [MEP, formerly known as State Environmental Protection Administration (SEPA)] ascertained from surveys that WEEE recycling was polluting many coastal areas in China (China Economic Times, 1995; Tong and Wang, 2004).

In our research, we consider that this lacked analysis is useful to give macroscopical view of the ICT industry's spatial environmental impact according to economically differently developed regions in China, in order to give another reference to China's government in geographical view.

Firstly, we focus on the electronic products' production, and then on the ICT diffusion by keeping eyes on the geographical distribution on the two aspects, which is strictly linked to important stages of product's life cycle (manufacturing process, transport, & use, disposal.).

1.1 ICT production in China

Measured as a share of GDP, the ICT industry is becoming an increasingly important sector in the world as in China. ICT's development has been tested to have strongly positive relationship with regional economy's growth (Seifallah Sassi et al., 2013).

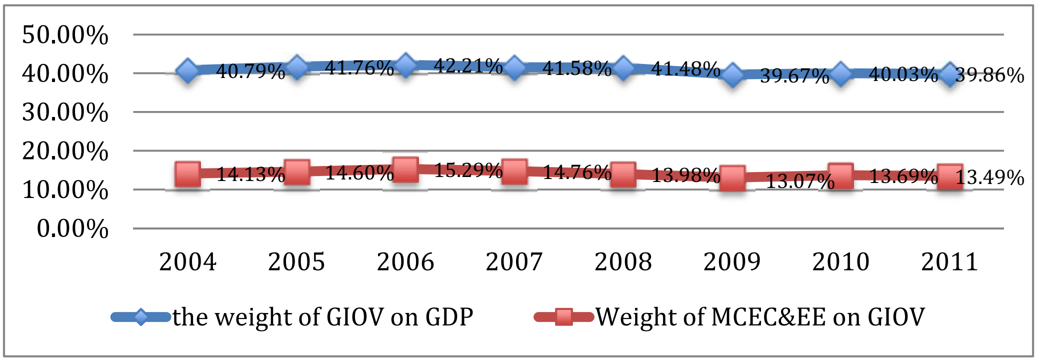
In this paper, China Statistical Yearbook is the principal data resource. It's recognized that this resource is not so accurate as we desired because of some artificial factor, but we consider that this resource reflects at least the general situation in China which orient the trend of policymaking, and, this is the most official one as we can obtain.

In figure IV.1, we observe that the dynamic trend of the weight of MCE&EE on GDP and the dynamic trend of the weight of GIOV on GDP keep almost the same pace: the two trends all achieve their peak in 2007 respectively (42.21% for GIOV on GDP and 15.29% for MCEC&EE on GDP), and then shrink in the following years (to around 39% for GIOV on GDP and 13.7% for MCEC&EE on GDP). The explosion of global economic crisis since 2008 could explain this phenomenon. From this observation, we also could conclude that the manufacture of EEE (or ICT) as well as the whole industry in China depends largely on export. So, geographically, the production of EEE in China is very linked to the oversea market, which makes the transport as considerable financial cost as well as the environmental cost to these ICT products.

For economic geographical distribution, China is constituted of five grand regions: North-China, East-China, South-China, Central-China and West China. By some economic analysis, we also have the following distribution: East-China, Central-China, West-China and North-China. The second classification integrates the North-China and South-China into its three regions, and reflects very well three different levels of economic development. In terms of economic development, the eastern region is the most advanced, followed by the central region and finally by the backward western region and northeastern region.

As the information of ICT manufacture according to different region is lacked in China Statistical Yearbook, we refer to the available data of important industrial indicators according to regions.

Figure IV.1 Output share of Industrial sector and Electrical and Electronic Equipment Manufacture in GDP of China



Data resource: China Statistical Yearbook

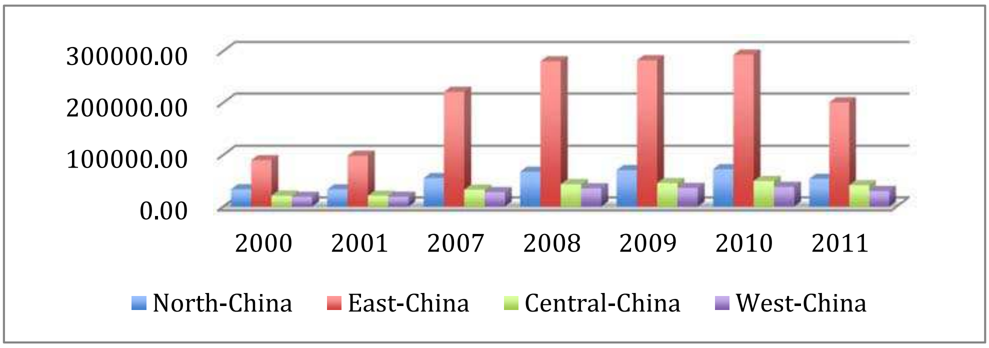
Note: GIOV = Gross Industrial Output Value;

MCEC&EE = Manufacture of Communication Equipment, Computers and Other Electronic Equipment

From figure IV.2, we observe that the industrial enterprises in China are mostly located in East-China compared with in other regions without any doubt. But, the gap between the first and the rest got narrow in 2011 with evident proof. It's also evident that West-China is the region the most behind for the industrial development according to the number of located enterprises. This could be good reference for the geographical distribution of ICT industry.

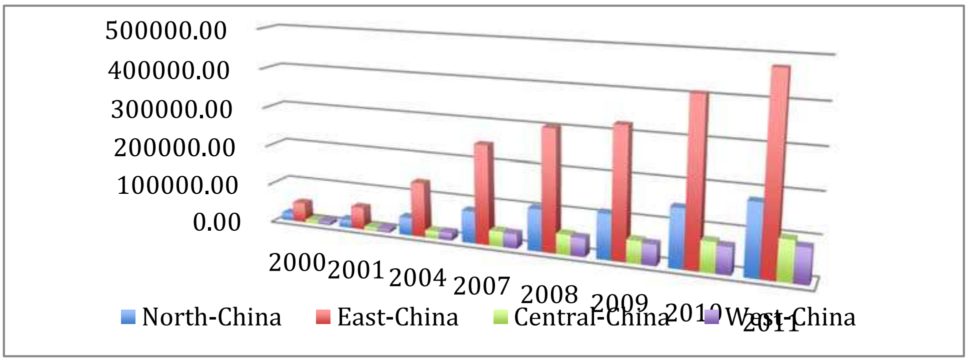
In figure IV.3, we observe that the dynamic evolution of GIOV according to geographical distribution in China for the last decade is almost compact with the case of the number of enterprises. The most advanced industrial development appears in East-China, as the West-China is the region the most left behind among all these regions.

Figure IV.2 Dynamic evolution of industrial enterprises' number according to geographical distribution in China



Data resource: China Statistical Yearbook

Figure IV.3 Dynamic evolution of GIOV according to geographical distribution in China (100 million Yuan)



Data resource: China Statistical Year Book

Implicitly, we consider that the gap in term of GIOV is being closed between the west and the rest regions of China (especially East-China) with retarded trend compared with the trend of evolution of the geographical distribution of industrial enterprises' number, because normally the benefice effect comes some time after the replacement of industry.

As there does not exist the data entry in term of GIOV of EEE manufacture according to different region in China Statistical Year Book, it makes obstacle for our research on the quantity of ICT products (or EEE) obtained by consumers according to different region. But, we find the existing statistical terms of data entry of the possession of main ICT products in geographical view that represent well the general

ICT products' geographical distribution in China, which reveals useful information of use of ICT product which is the important part life cycle - production，from a geographically national wide perspective.

Table IV.1 Main EEEs' output according to different region in China from 2003 to 2011 (with 2006，2007 absent)

	Refrigerator (10000)	Air Conditioner (10000)	Washing Machine (10000)	Television (10000)	Personal Computer (10000)	Integrated Circuit (10000)	Mobile Phone (10000)
North-China							
2003	172.31	348.01	30.82	853.74	658.31	83966.82	
2004	230.23	580.68	10.30	786.06	688.49	119963.16	9001.75
2005	232.75	704.09	11.73	905.00	683.83	177978.07	15459.55
2008	277.75	713.38	57.35	1462.16	698.90	24.13	29928.18
2009	150.02	547.44	43.45	819.39	847.39	25.39	30010.39
2010	150.61	594.82	54.70	1004.38	942.94	35.32	36688.67
2011	218.80	721.30	29.35	1030.40	1088.10	41.20	35480.50
East-China							
2003	1777.03	4120.68	1776.83	4390.12	2550.16	1286937.27	
2004	2396.40	5391.53	2183.80	5627.28	3820.28	1788837.27	13859.59
2005	2318.04	5387.86	2860.88	6562.46	7398.18	2277461.51	14253.00
2008	3920.67	6497.20	3804.39	6567.52	12966.24	362.10	23887.71
2009	5158.66	6550.31	4439.01	8157.64	17276.19	355.61	29958.95
2010	6227.24	8884.71	5596.91	9451.24	23262.91	534.48	61086.98
2011	7365.00	11397.70	5995.77	9908.84	25207.33	585.91	73436.11
Central-China							
2003	190.64	122.32	106.20	158.37	2.52	7.70	
2004	288.73	215.57	102.69	164.20	0.51	6.25	453.21
2005	324.94	284.70	91.01	177.00	0.42	14.00	586.90
2008	356.90	511.56	108.61	109.16	1.42	0.01	368.11
2009	374.39	527.07	105.06	67.56	87.38	0.01	831.52
2010	532.04	743.83	151.30	32.67	189.26	0.01	456.38
2011	652.20	809.50	210.50	12.70	836.50	0.01	2803.50
West-China							
2003	102.58	229.85	50.61	1139.17	5.71	112189.14	
2004	118.02	458.44	52.06	751.26	3.13	205779.94	30.03
2005	111.33	387.91	71.90	638.77	2.46	244275.56	54.91
2008	201.58	508.79	260.81	894.24	0.00	30.90	1780.02
2009	247.40	453.41	386.11	854.20	4.11	33.39	1123.56
2010	385.83	664.11	444.81	1341.74	189.35	82.69	1595.33
2011	463.20	984.00	480.32	1279.40	4905.00	92.40	1537.60

Data resource: China Statistical Year Book

1.2 ICT diffusion in China

We don't intend to analyze the detail of consumers' behavior change, which is more or less beyond scopes of our study, even it could be definitely helpful from the perspective of prediction for each kind of EEE's demand then the related environmental problem, relying on numerous micro-econometric methods developed in preliminary works： Worapon Kiatkittipong et al. （2008） discussed the environmental optimization of the trade-off between the purchasing a replacement and repairing the old mal-functional one; Lauren Darby and Louise Obara (2005) studied consumers' behavior about the wastes' disposal of EEE; the collection of small items for recycling and most are disposed of via household refuse collections requires adequate infrastructure (Cooper and Mayers, 2000)； the majority of household waste management research has focused on the activity of recycling (see, for example, Tonglet et al., 2004; Mattson et al., 2003; Williams and Kelly, 2003; McDonald and Oates, 2003; Salhofer and Isaac, 2002; Coggins, 2001; Perrin and Barton, 2001; Thomas, 2001; Evison and Read, 2001; Read, 1998, 1999).

ICT diffusion is much more difficult to be estimated. This concept has not direct compatible statistical term for data entry in China Statistical Year Book. As we insist to find valuable information about the use of ICT product by a general spatial view at a national wide level, the winding way offers an opportunity for us to achieve this goal. In China Statistical Year Book, we have the data of regional breakdowns of ownership of electronic and electric appliances per 100 households and the data of regional breakdowns of sampling number of household and the sampling ratio，the two terms' product give the quantity of main ICT products owned in different region of China. The result is represented in the figure below.

Table IV.2 presents the calculated results categorized by product (in columns) and by region (North-China, East-China, Central-China and West-China) grouped by every year (in rows). For each product, we compare the evolution of the owned quantity of different region in obtaining the results figured out as below.

From figure IV.4 to figure IV.10, we have the first impression that the indicator for all products is absolutely higher in East-China than in the other three regions. This reflects the reality that East-China steps far ahead of other regions in the diffusion for all ICT products. Furthermore, we also find an impressing phenomenon that the gap between East-China and the rest is getting enlarged considerably for PC, AC, FT and MP. The West-China finds itself always at the bottom during this period for WM, Ref, TV and PC; this region finally surpasses slightly North-China and Central-China in the last year for AC. The three regions except the east one have kept almost the same level for all products.

Dynamically, we observe that this indicator moves smoothly in all regions for all products except in East-China for PC, AC, FT and MP. We are able to say that the market seems more or less saturated and the competition is getting intensified in the all regions for WM, Ref and TV; controversially, the market of PC, AC, FT and MP in East-China seems very active, we estimate that the reasons could be: firstly, the mass migration to this region from all the rest regions of China; secondly, if the first one is real, the needs for AC per unit of household is higher than WM, Ref and TV in term of unit; thirdly, the PC, FT and MP are products with more inventive factors, and the design changes rapidly in pushing consumers to purchase these products of new generation much more frequently that other products and consumers often have habit to keep old ones when they buy new ones.

Table IV.2 Main EEEs owned by households according to different region in China from 2003 to 2011 (with 2006，2007 absent)

Year	Region	Washing Machine (10000)	Refrigerator (10000)	Color TV Set (10000)	Computer (10000)	Air Conditioner (10000)	Fixed Telephone (10000)	Mobile Pphone (10000)
2003	North-China	7381.500	6313.584	7713.015	1770.892	994.136	981.325	1052.209
	East-China	14087.469	12834.176	17753.577	6143.220	6118.463	6164.862	7844.617
	Central-China	6135.117	5378.356	6755.926	1619.050	1116.489	1049.207	829.714
	West-China	7806.148	6768.328	8698.053	1844.606	1055.886	999.457	898.172
2004	North-China	7563.138	6631.431	8209.970	2373.953	1434.061	1462.233	1957.982
	East-China	14503.709	13425.141	19102.168	7674.532	8583.925	8757.108	12742.726
	Central-China	6272.555	5563.109	7144.037	1921.545	1506.443	1426.076	1430.840
	West-China	8218.613	7238.337	9518.248	2584.500	1832.712	1732.315	2054.930
2005	North-China	7837.762	6924.311	8528.877	3287.620	2239.602	2240.528	3565.694
	East-China	15513.244	14409.779	21160.245	10767.441	13731.400	14223.987	23084.644
	Central-China	6344.449	5714.782	7319.882	2631.995	2410.581	2164.523	2803.849
	West-China	8474.302	7484.378	9862.443	3167.640	2395.013	2205.568	3105.283
2008	North-China	8300.819	7649.061	8945.146	4724.653	3043.819	2635.498	4582.001
	East-China	15866.090	15352.405	22577.765	16063.681	23570.946	22023.972	42070.877
	Central-China	6319.083	5776.584	7122.963	3362.105	3440.926	2446.116	3796.737
	West-China	8431.143	7489.181	9242.384	4419.060	3321.320	2619.482	4489.070
2009	North-China	8465.196	7957.109	9398.197	5490.906	3696.025	3217.280	6067.423
	East-China	16375.169	32017.178	42969.920	29911.481	36690.567	33723.189	66206.295
	Central-China	6474.246	5997.287	7575.797	3971.126	4371.872	3094.058	5117.259
	West-China	8667.688	7886.037	9961.237	5347.999	4113.702	3194.181	5785.428
2010	North-China	8337.787	7935.968	9458.057	6048.836	4334.538	3755.852	7445.709
	East-China	16111.719	16007.103	24463.413	20813.964	34002.402	31347.233	64518.815
	Central-China	5920.961	5594.608	7135.250	4007.716	4613.572	3215.406	5488.992
	West-China	8309.287	7679.029	9813.810	5803.491	4557.255	3450.384	6640.647
2011	North-China	8798.887	8407.819	9718.796	7161.188	5352.820	4056.172	8328.314
	East-China	17066.896	17057.287	25878.705	24854.079	43271.026	34828.058	76697.946
	Central-China	6357.961	6039.874	7604.798	5408.926	7164.357	4023.398	7763.213
	West-China	8929.761	8405.821	10320.130	7053.399	5769.933	3811.698	7896.150

Data resource: China Statistical Year Book

Figure IV.4 Dynamic evolution of Washing Machine (WM) owned by households according to different region in China 2003 - 2011 (with 2006，2007 absent)

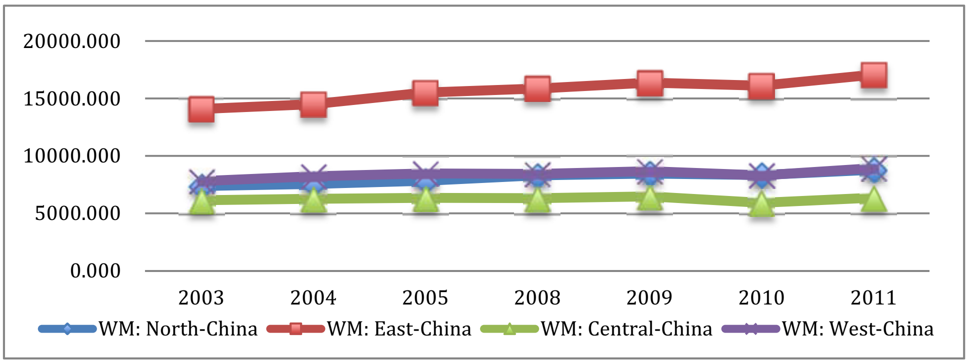


Figure IV.5 Dynamic evolution of Refrigerator (Ref) owned by households according to different region in China 2003 - 2011 (with 2006，2007 absent)

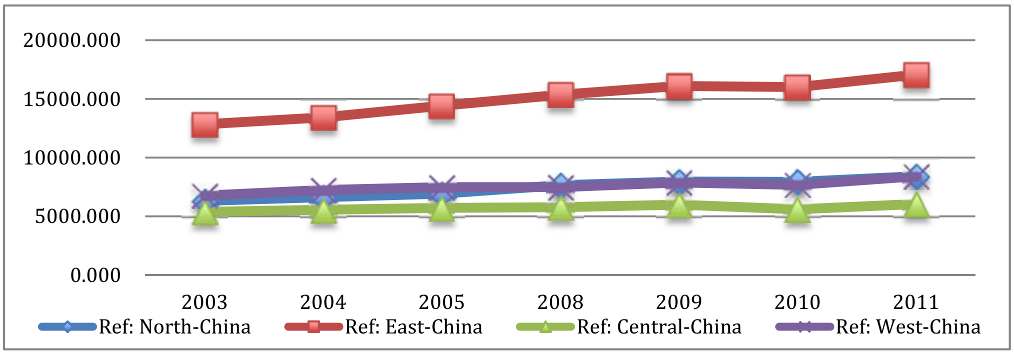


Figure IV.6 Dynamic evolution of Television (TV) owned by households according to different region in China 2003 - 2011 (with 2006，2007 absent)

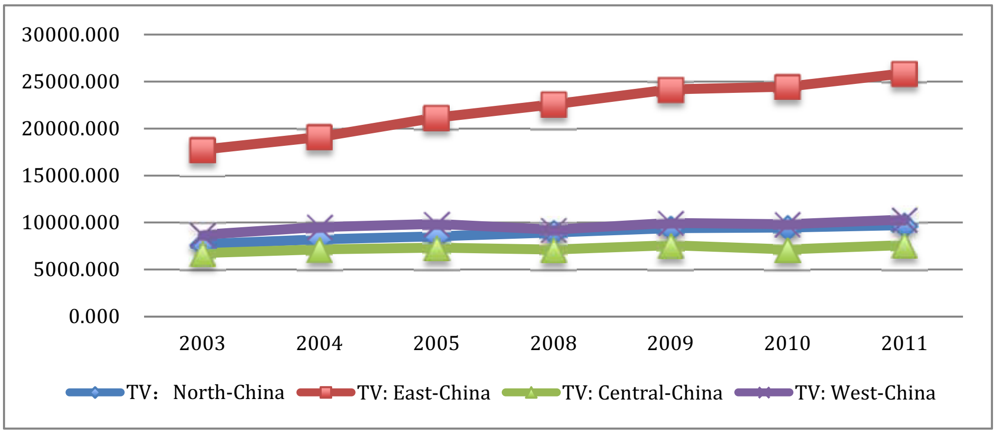


Figure IV.7 Dynamic evolution of Personal Computer (PC) owned by households according to different region in China 2003 - 2011 (with 2006，2007 absent)

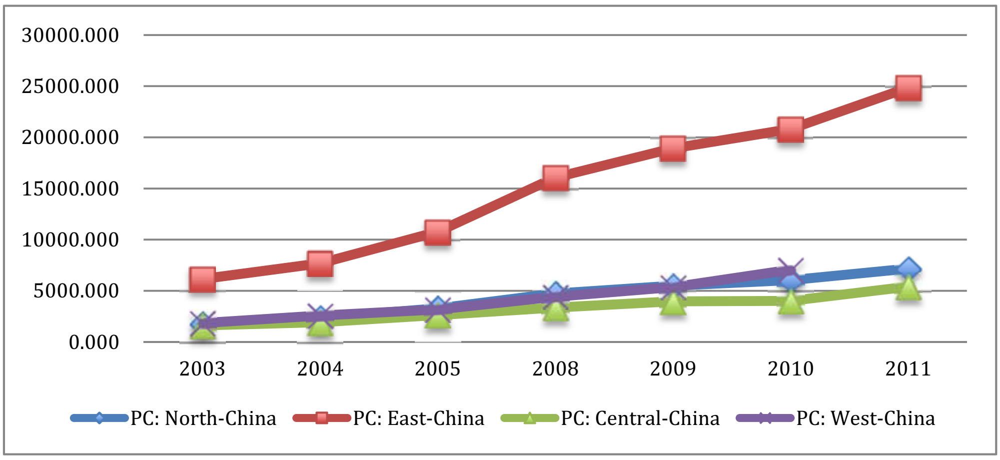


Figure IV.8 Dynamic evolution of Air Conditioner (AC) owned by households according to different region in China 2003 - 2011 (with 2006，2007 absent)

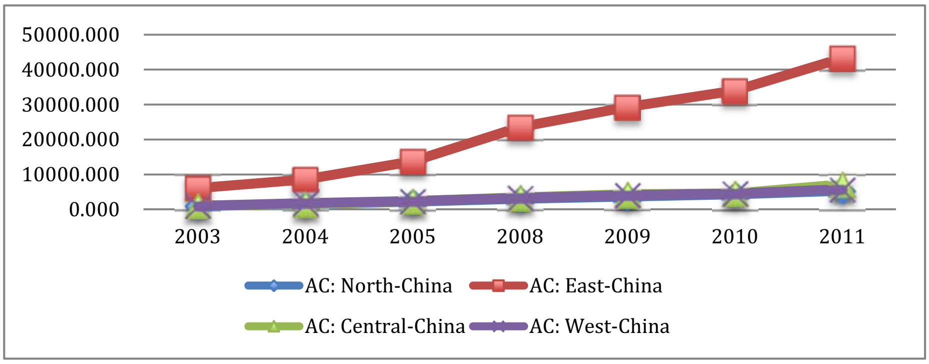


Figure IV.9 Dynamic evolution of Fixed Telephone (FT) owned by households according to different region in China 2003 - 2011 (with 2006，2007 absent)

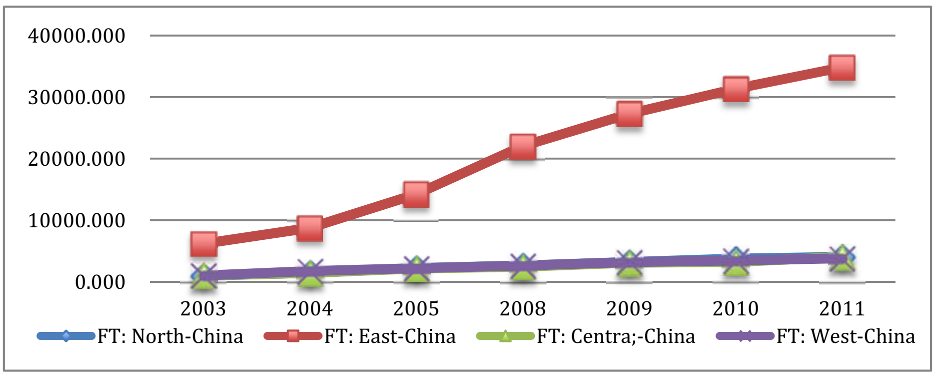
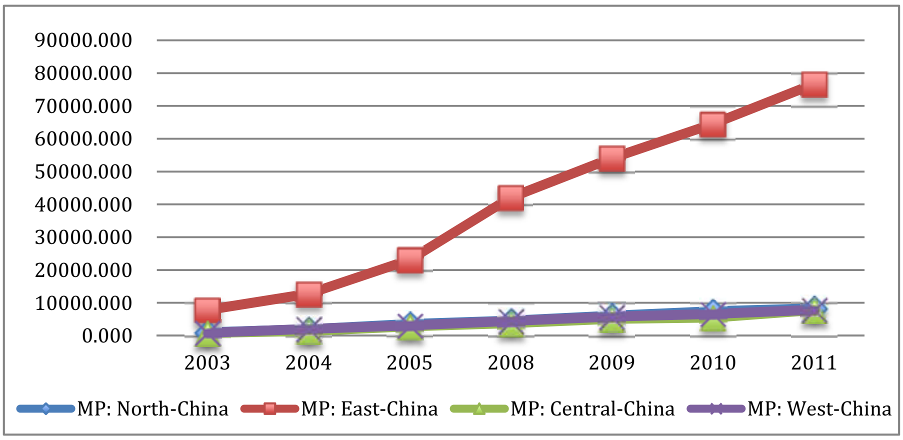


Figure IV.10 Dynamic evolution of Mobile Phone (MP) owned by households according to different region in China 2003 - 2011 (with 2006，2007 absent)



1.3 Environmental impacts analysis - LCA together with spatial factor

We have paid great attention on ICT industry's development in China from both production aspect and diffusion side. The evident fact is shown in front of us without any doubt that East-China leads in both production and diffusion among the four regions we have classified, and West-China stay as bottom in both production and diffusion for most cases.

One interesting question confusing us is that if we could estimate ICT industry's environmental impact in each region under the frame of LCA with help of the earlier analysis from both production and diffusion.

For the intention to respond to the question above, we create the concept of spatial environmental balance (SEB) similar to the national balance of import and export. For SEB, the equilibrium condition has specific sense:

$Y_{ij}= C_{ij}$, where i represents one kind of product, j represents one region……….(IV.1)

Y_{ij} indicates the production of product i in region j, and C_{ij} indicates the consumption of product i in region j. (IV.1) is a general equilibrium condition for SEB: this equality indicates that statistically we consider the whole life cycle of product i starts and end (cradle-to-grave) in region j for a certain quantity, without excessive environmental impact from any part of the life cycle. It's natural that one can doubt the differentiation between the products flowing into this region and the products flowing out of this region for the same kind of product *i*, but we argue that the environmental impact issued from the production process of the flowed out products of region *j* could be compensated by the environmental impact issued from the production process of the products flowed into region *j* from the rest regions; the environmental impact issued from the use of the products flowed into region *j* could be compensated by the environmental impact issued from the use of the flowed out products of region *j* to the rest regions. Otherwise, we have the discussion for the inequalities presented as below:

$$Y_{ij} > C_{ij} \quad \text{(IV.2)}$$

$$Y_{ij} > C_{ij} \quad \text{(IV.3)}$$

For the case of (IV.2), there is a surplus of production, and then region *j* becomes deficit on the environmental impact issued from the production process but gains benefit from the environmental impact issued from the use and end life. If the deficit is more than the benefice in term of absolute value, then the region is deficit on SEB, vice versa (for the (IV.3)). The result could be various according to categories of product and the percentage of LCA results of relative part of life cycle respectively.

In our study, we generalize the time of the life cycle in SEB. Though, there may be argument that the environmental impact issued from the use of life cycle and the end life is realized through and after the period of use.

The ex ante SEB the ex post SEB are alternative measures for estimation: the ex ante SEB takes account of the production and the diffusions' environmental impact based on the statistic of the same year without time gap, yet the ex post SEB takes account of the production's environmental impact based on the statistic of the current year and the diffusions' environmental impact based on the statistic of *t* years before, where *t* corresponds to the life of use of the ICT product in question. Considering the statistically feasibility and attribution of the responsibility to the original place and time, we use the approach of ex ante SEB.

By studying the consistency of LCA, Anders S. G. Andrae & Otto Andersen (2010) realized valuable collection of data about some important ICT products' LCA results according to different research sources. The limit is that the data is only available for PC, TV and MP in their comparative analysis that could be compatible with the data we have from China Statistical Year Book. Therefore, we focus on the three products for the SEB analysis in our study.

- PC

From table IV.3 and figure IV.11, we observe that the SEB fluctuates around neutral value in all regions except East-China where we see the evident increasing trend during the mentioned period. But we also find that among the three regions, SEB in West-China started a considerable rise in 2011.

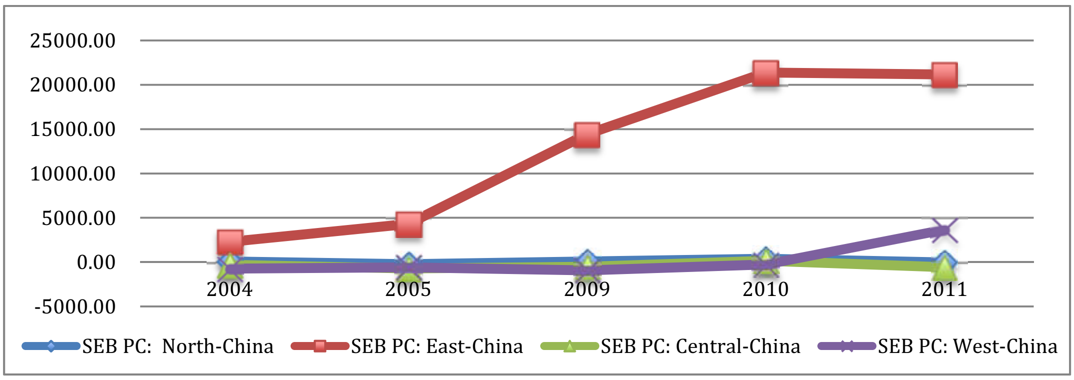
As SEB finds itself always as inequality for PC, so we are interested to estimate this SEB quantitatively in order to determine if the region looses (deficit) or gains (benefice) for PC's environmental impact.

Table IV.3 SEB for PC according to regions (10000 units)

Region	2004	2005	2009	2010	2011
North-China	85.43	-229.84	81.14	385.01	-24.25
East-China	2288.97	4305.27	14410.20	21378.61	21167.22
Central-China	-301.99	-710.03	-521.64	152.67	-564.71
West-China	-736.76	-580.68	-924.83	-266.14	3655.09

Data resource: China Statistical Year Book

Figure IV.11 Trend of SEB for PC according to regions



For quantifying the SEB we create in our study, it's necessary to refer to existing LCA results for PC in preliminary works. As Anders et al. mentioned in their study that published LCAs for PC occasionally give conflicting messages. Therefore, it could have different quantified SEB results for PC in the same region according to different LCA results of PC.

In the research of Anders et al., the summary of life cycle CO_2e emissions is offered for PC. As we cannot have the data about the weight of PC with CRT screen and PC with LCD screen, so we use the each LCA results measured on CO_2e emissions for estimating SEB of the region.

Table IV.4 Summary of life cycle CO_2 emissions of PC

Device and technology, nation, reference, system boundary	**Kg CO_2e/piece**	**% Production and transports**	**% Use and End-of-life**
Desktop PC, CRT screen, Europe, Atlantic Consulting and IPU (1998), cradle-to-grave	650	29	71
Desktop PC, CRT screen, Europe, IVF (2007b), cradle-to-grave	660	12	88
Desktop PC, LCD screen, Europe, IVF (2007c), cradle-to-grave	340	22	78.3
Desktop PC, LCD screen Switzerland, Ecoinvent database (2008d, f, g, h, i, j, k, m, n), cradle-to-grave	3, 300	97	3. 1
Desktop PC, CRT screen Switzerland, Ecoinvent database (Ecoinvent database, 2008d, e, f, g, h, i, j, k, l), cradle-to-grave	1, 300	36	64. 2
Desktop, US, Apple (2009), cradle-to-grave	870	49	51

In table IV.4 we have 6 LCA results according to different studies for PC with CRT screen and PC with LCD screen. We matches these LCA results to the data we obtained in China Statistical Year Book for the same products, then we get the SEB results for each region across the mentioned years. By data arrangement and calculation, we have SEB measured on 10 000 tons of CO_2e (SEB on 10 000 tons of CO_2e) for PC in each region as presented in table IV.5.

In table IV.5, the results of SEB/tons of CO_2e for PC are grouped according to different research resources, and the comparison of dynamic trends of four regions are figured out for each group, presented by from figure IV.12 to figure IV.17.

As mentioned in the work of Anders et al., the LCA studies occasionally give conflicting messages for laptop and desktop computers. Just in table IV.4, we note that the result from "*Switzerland, Ecoinvent database (2008d, f, g, h, i, j, k, m, n)*" conflicts impressively with other results on both absolute value of CO_2 emissions and distribution of weights between the usage and end-of-life stage and the production and transport stage of product's life cycle.

Table IV.5 Summary of SEB measured on 10 000 tons of CO_2e emissions of PC according to regions

Desktop PC, CRT screen, Europe, Atlantic Consulting and IPU (1998), cradle-to-grave

Region	2004	2005	2009	2010	2009
North-China	−23.3	62.7	−22.2	−105.1	6.6
East-China	−624.9	−1175.3	−3934.0	−5836.4	−5778.6
Central-China	82.4	193.8	142.4	−41.7	154.2
West-China	201.1	158.5	252.5	72.7	−997.8

Desktop PC, CRT screen, Europe, IVF (2007b), cradle-to-grave

	2004	2005	2009	2010	2009
North-China	−42.9	115.3	−40.7	−193.1	12.2
East-China	−1148.1	−2159.5	−7228.2	−10723.5	−10617.5
Central-China	151.5	356.2	261.7	−76.6	283.3
West-China	369.6	291.3	463.9	133.5	−1833.4

Desktop PC, LCD screen, Europe, IVF (2007c), cradle-to-grave

	2004	2005	2009	2010	2009
North-China	−16.4	44.0	−15.5	−73.7	4.6
East-China	−438.2	−824.1	−2758.4	−4092.3	−4051.8
Central-China	57.8	135.9	99.9	−29.2	108.1
West-China	141.0	111.2	177.0	50.9	−699.7

Desktop PC, LCD screen Switzerland, Ecoinvent database (2008d, f, g, h, i, j, k, m, n), cradle-to-grave

	2004	2005	2009	2010	2009
North-China	264.7	−712.2	251.4	1193.0	−75.2
East-China	7092.8	13340.7	44652.9	66245.9	65590.8
Central-China	−935.8	−2200.2	−1616.4	473.1	−1749.9
West-China	−2283.0	−1799.4	−2865.8	−824.7	11326.0

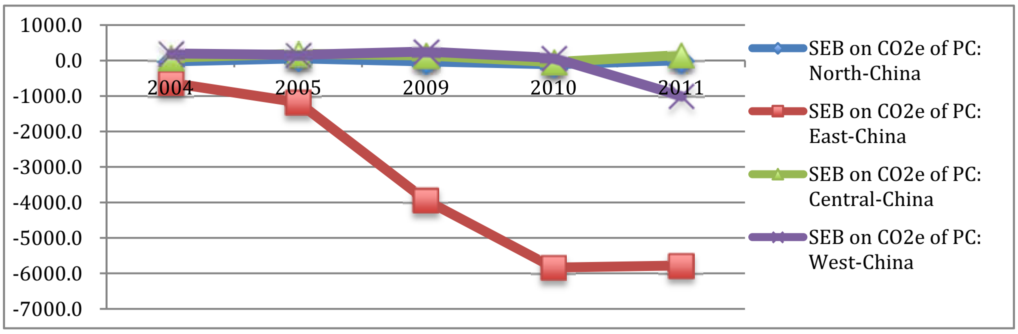
Desktop PC, CRT screen Switzerland, Ecoinvent database (Ecoinvent database, 2008d, e, f, g, h, i, j, k, l), cradle-to-grave

	2004	2005	2009	2010	2009
North-China	−31.3	84.3	−29.7	−141.1	8.9
East-China	−839.1	−1578.3	−5282.8	−7837.4	−7759.9
Central-China	110.7	260.3	191.2	−56.0	207.0
West-China	270.1	212.9	339.0	97.6	−1340.0

Desktop, US, Apple (2009), cradle-to-grave

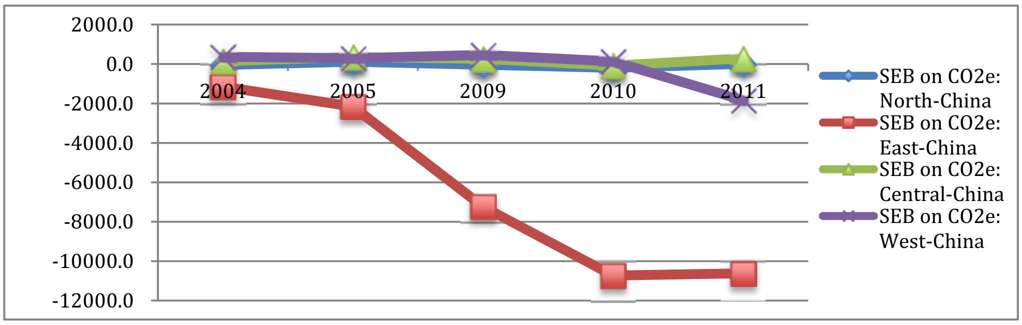
	2004	2005	2009	2010	2011
North-China	−1.5	4.0	−1.4	−6.7	0.4
East-China	−39.8	−74.9	−250.7	−372.0	−368.3
Central-China	5.3	12.4	9.1	−2.7	9.8
West-China	12.8	10.1	16.1	4.6	−63.6

Figure IV.12 Trend of SEB measured on 10 000 tons of CO_2e for PC according to regions - 1



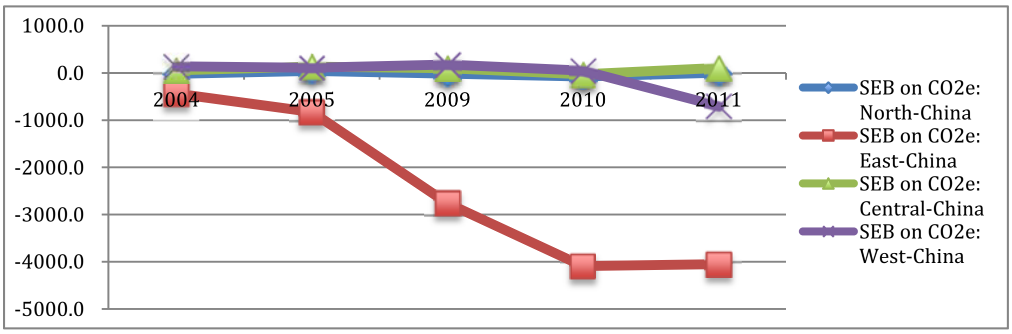
Based on "LCA result of desktop PC, CRT screen, Europe, Atlantic Consulting and IPU (1998), cradle-to-grave"

Figure IV.13 Trend of SEB measured on 10 000 tons of CO_2e for PC according to regions - 2



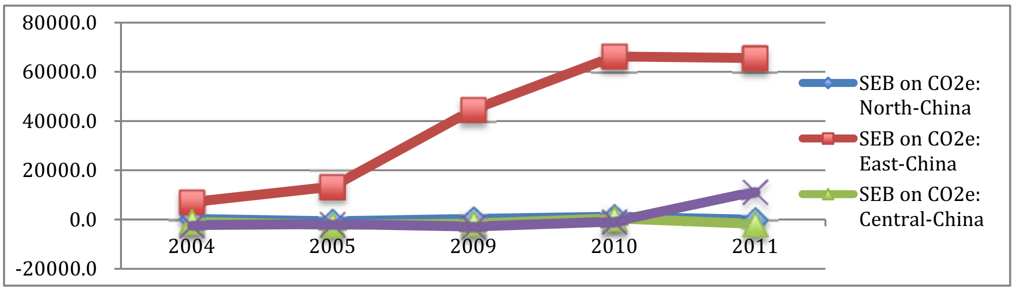
Based on "LCA result of desktop PC, CRT screen, Europe, IVF (2007b), cradle-to-grave"

Figure IV.14 Trend of SEB measured on 10 000 tons of CO_2e for PC according to regions - 3



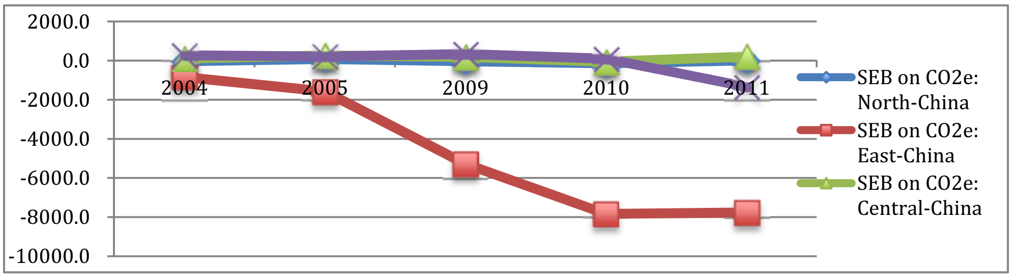
Based on "LCA result of desktop PC, LCD screen, Europe, IVF (2007c), cradle-to-grave"

Figure IV.15 Trend of SEB measured on 10 000 tons of CO_2e for PC according to regions - 4



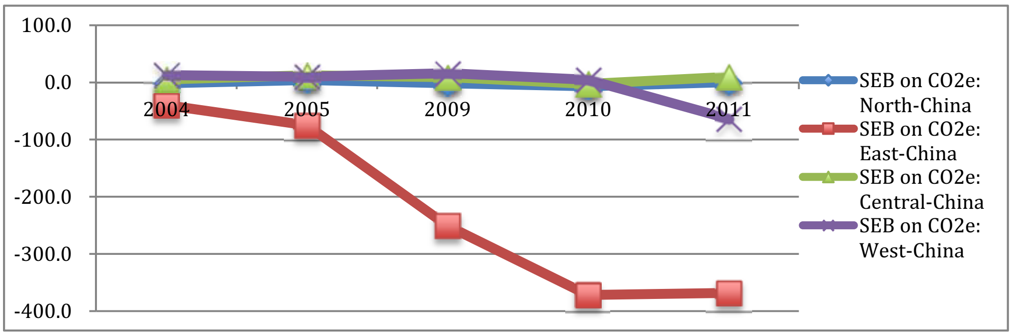
Based on "LCA result of desktop PC, LCD screen Switzerland, Ecoinvent database (2008d, f, g, h, i, j, k, m, n), cradle-to-grave"

Figure IV.16 Trend of SEB measured on 10 000 tons of CO_2e for PC according to regions - 5



Based on "LCA result of desktop PC, CRT screen Switzerland, Ecoinvent database (Ecoinvent database, 2008d, e, f, g, h, i, j, k, l), cradle-to-grave"

Figure IV.17 Trend of SEB measured on10 000 tons of CO_2e for PC according to regions - 6



Based on "LCA result of desktop, US, Apple (2009), cradle-to-grave"

From figure IV.12 to figure IV.17 except figure IV.15, we observe that the SEB CO_2e

for PC runs around the equilibrium in North-China, Central-China and West-China, and it appeared a considerable decline in West-China compared to the two first ones. SEB on CO_2e for PC is negative and falls seriously in East-China since 2004 and this trend stops to continue since 2010. In figure IV.15, we have the totally inverse situation. This conflict comes from the fact that from "*Switzerland, Ecoinvent database (2008d, f, g, h, i, j, k, m, n)*", the estimated percentage of CO_2e emissions generated in production and transport stage in the total CO_2e emissions from the total life cycle of PC is much more important than this percentage for use and end-of-life stage, which is completely opposite to other mentioned studies' results.

From the results above, we conclude that:

- If the CO_2e emissions of production and transport weights more than the CO_2e emissions of use and end-of-life, East-China is the region where there is a great environmental deficit with increasing trend since 2004 that decelerates in 2010; the rest regions balance around the equilibrium level over the same period, but West-China meeting a notable decline of SEB since 2010;
- If the CO_2e emissions of production and transport weights less than the CO_2e emissions of use and end-of-life, East-China is the region where there is a great environmental benefit with increasing trend since 2004 that decelerates in 2010; the rest regions balance around the equilibrium level over the same period, but West-China meeting a notable rise of SEB since 2010.

We prefer the first scenario than the second one, as the first one matches better the real environmental situation since recent years. The environmental problem has been the most concerned issue in Chinese society. People are losing patience and confidence on government's measures to environmental protection. More and more serious environmental accidents explode which are strictly related to industrial activities. Since end of 2012, there is a caner geographical distribution map of China that spreads on internet widely, in which we see almost the same scenario as we obtained in our study: the east region has been the region the most touched by liver cancer. Although this map is not officially recognized in China, it's still mostly recognized among Chinese netizens. This information seems valuable to our study of

SEB on CO_2e, because these diseases could be linked to the manufactories intensively implemented in East-China. We expect that this complements to the SEB on CO_2e that is not complete for concluding exact LCA results quantitatively.

- TV

From table IV.6 and figure IV.18, we observe that the SEB fluctuates around neutral value in all regions except East-China where we see the evident increasing trend during the mentioned period. And we also find that the evolution of SEB for PC in the three regions seem to have highly correlation just for the mentioned years.

As in the case for PC, SEB finds itself always as inequality for TV, so we are interested to estimate this SEB quantitatively in order to determine if the region looses (deficit) or gains (benefice) for TV's environmental impact.

Table IV.6 SEB for TV according to regions (10000 units)

	2004	2005	2009	2010	2011
North-China	289.11	586.09	366.34	944.52	769.66
East-China	4278.69	4504.38	6561.88	9161.35	8493.55
Central-China	-223.91	1.16	-385.27	473.22	-456.85
West-China	-68.93	294.57	135.35	1489.17	773.08

Data resource: China Statistical Year Book

Figure IV.18 Trend of SEB for TV according to regions (10000 units)

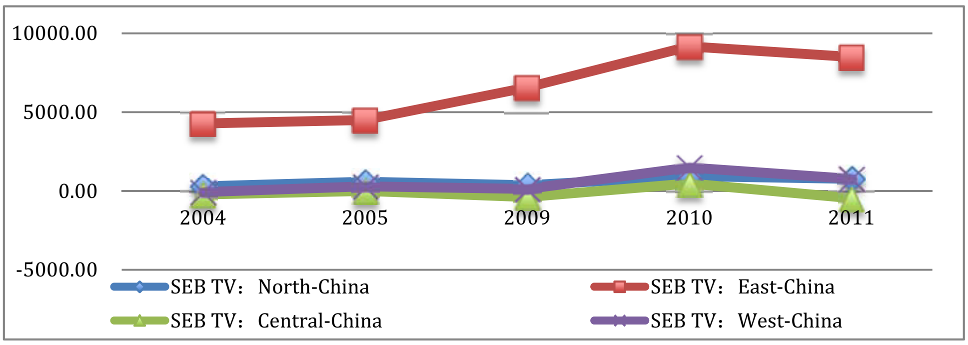
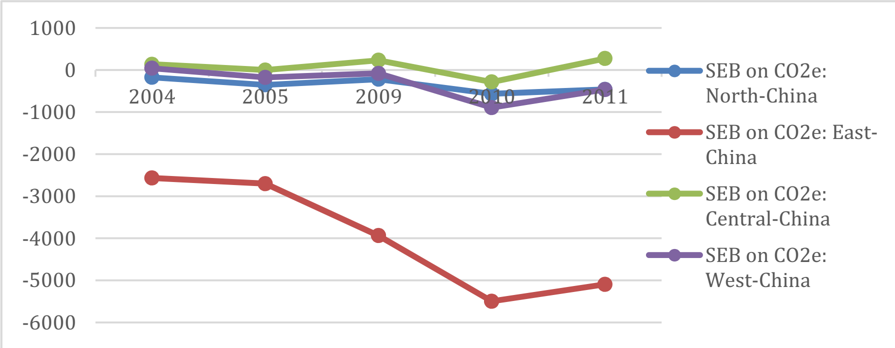
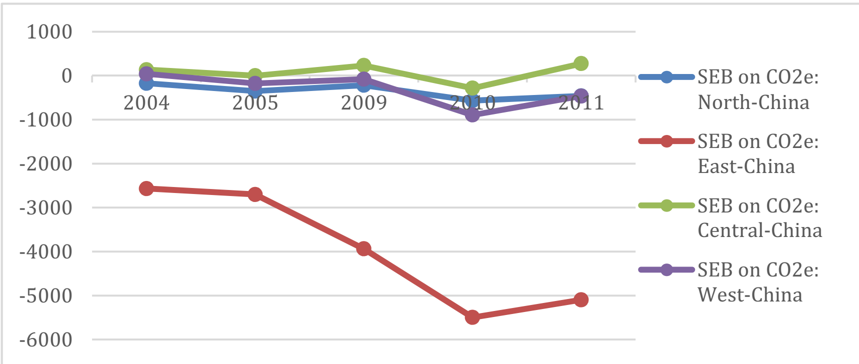


Figure IV.19 Trend of SEB measured on 10 000 tons of CO_2e for TV according to regions - 1



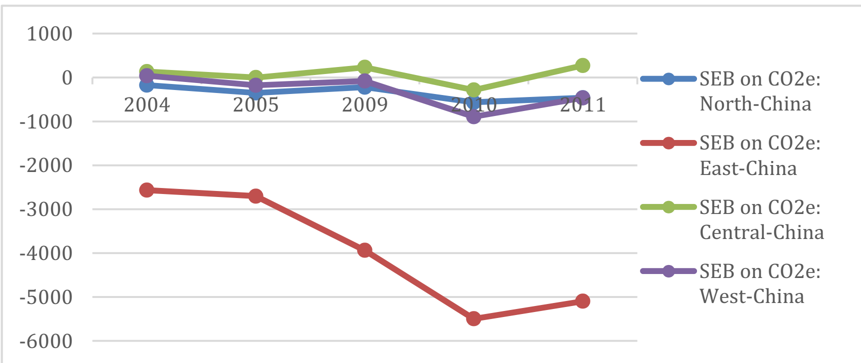
Based on "TV, CRT, Japan, Aoe (2003), cradle-to-grave"

Figure IV.20 Trend of SEB measured on 10 000 tons of CO_2e for TV according to regions - 2



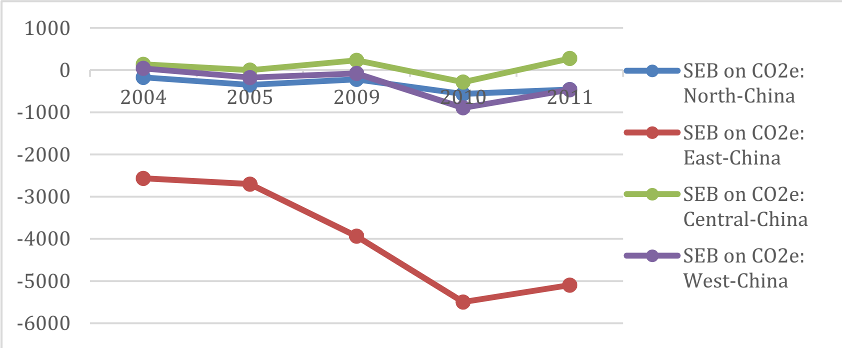
Based on "TV, PDP, Japan, Aoe (2003), cradle-to-grave"

Figure IV.21 Trend of SEB measured on 10 000 tons of CO_2e for TV according to regions - 3



Based on "TV, LCD, Japan, Aoe (2003), cradle-to-grave"

Figure IV.22 Trend of SEB measured on 10 000 tons of CO_2e for TV according to regions - 4



Based on "TV, CRT, China, Feng and Ma (2009), cradle-to-grave"

From figure IV.18 to figure IV.22, we observe that the SEB CO_2e for TV runs around the equilibrium in North-China, Central-China and West-China. SEB on CO_2e for TV is negative and falls seriously in East-China since 2004 and rise again since 2010. These results for TV seem similar to the first scenario in the case of PC, that matches well the reality in China. The tiny difference is that in stead of getting deteriorated in West-China since 2010 for PC, there is no sign of the same trend for TV manufacture in this region, and we observe the rise of SEB on CO_2e from 2010 to 2011 in this region as in all the rest regions.

It should be mentioned that there exist evident consistency among results based on the four referred researches, as Andrae et al. (2010) found in their study that the different LCA results are consistent for TV and MP (see the SEB on CO_2e for MP later).

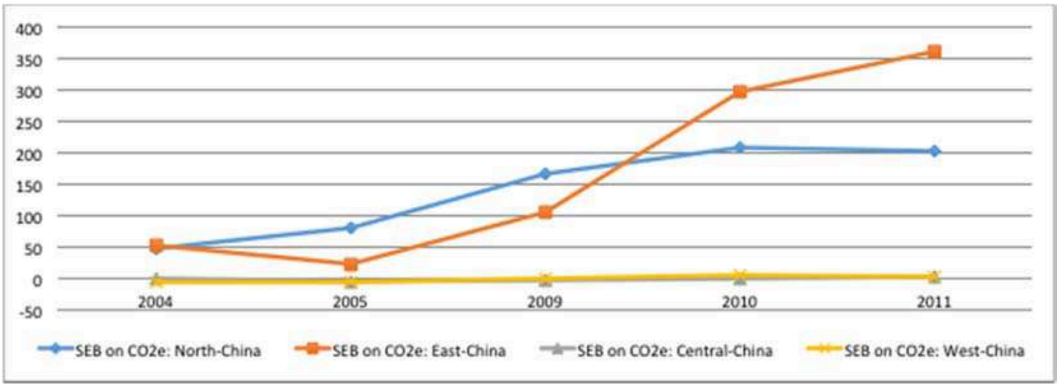
- MP

Table IV.7 SEB for MP according to regions (10000 units)

	2004	2005	2009	2010	2011
North-China	8095. 98	13851. 84	28524. 97	35310. 38	34597. 89
East-China	8961. 48	3911. 08	17958. 38	50639. 61	61256. 98
Central-China	-147. 92	-786. 11	-489. 00	84. 65	529. 28
West-China	-1126. 73	-995. 44	-172. 80	740. 11	282. 10

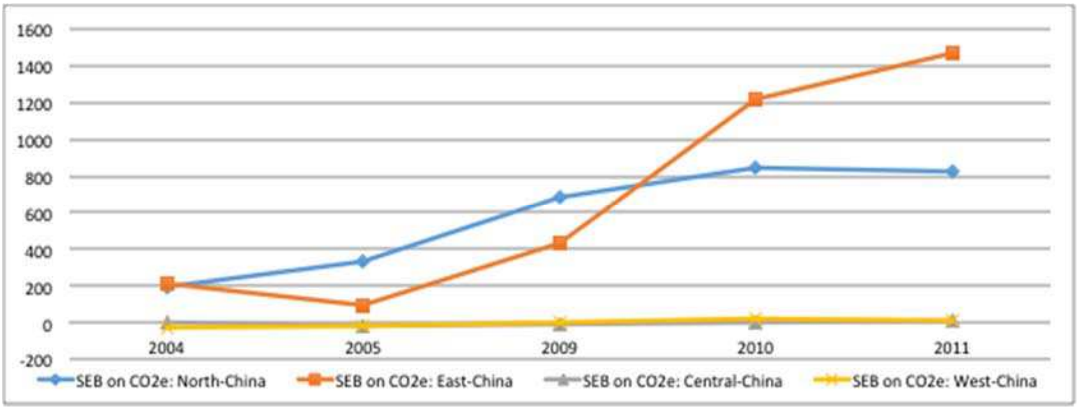
Data resource: China Statistical Year Book

Figure IV.23 Trend of SEB measured on 10 000 tons of CO_2e for MP according to regions - 1



Based on "Handheld mobile phone, global, PE International (2008), cradle-to-grave"

Figure IV.24 Trend of SEB measured on 10 000 tons of CO_2e for MP according to regions - 2



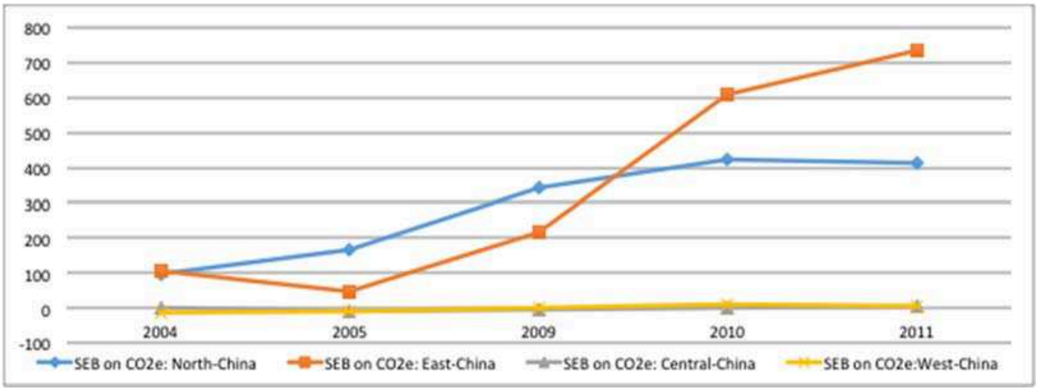
Based on "3G mobile phone, Finland, Nokia (2005), cradle-to-grave"

From figure IV.23 to figure IV.25, we observe the consistent results that the SEB CO_2e for MP runs around the equilibrium in South-China and Central-China. SEB on CO_2e for MP is negative increases in East-China and North-China， and the this SEB on CO_2e for MP in East-China exceeds that in North-China since 2010.

These results for MP seem different to the first scenario in the case of PC. The rise of environmental impact in North-China and East-China could be explained by the double effect that the production exceeds much more than the need in the north and in the east, and that the environmental impact from production process weights much more important than the environmental impact from the use and the end of life for MP.

The second point matches also proved by recent work of Jinglei Yu et al. (2010). This result is compatible with the real situation that the production of MP is mostly concentrated in the north region and the east region, and in the central and west regions, both the consumption evolution and the production stay behind the two first regions to great extent.

Figure IV.25 Trend of SEB measured on 10 000 tons of CO_2e for MP according to regions - 3



Based on "Handheld mobile phone, global, PE International (2008), cradle-to-grave"

Section2. Case study: Chongqing

Chongqing is the fourth and the newest independent municipality of China since 1997, and the only one located in West-China. As already discussed in precedent section, it's obvious that West-China is late for the ICT industry's development compared with other regions (especially East-China). Chongqing is facing an arduous task of industry upgrading and optimizing (J.F Zhang & W. Deng, 2010).

For Chinese central government, to designate Chongqing as the fourth independent municipality is a key strategy to change the serious unbalanced development between retarded inland regions and the advanced costal regions, and Liu Yang (2011) finds that environmental protection investment plays an important role for the improvement of city environmental quality in the case study of Chongqing. One clue has already emerged in the figure IV.2, in telling that the gap between the inland retarded regions (especially West-China) and the advanced costal region, the East-China, started to close since 2011. This phenomenon is easy to be associated with the global economic crisis exploded since 2008: as traditionally, ICT manufacture in China is strongly characterized by its export business mode, consequently these ICT producers have heavily been impacted by this crisis because of the weakened oversea market. China's central government has been very aware of this serious situation, and the natural reflection is to stimulate the consumption and the capital investment in the inland region, where we expect the great potential growth in the future that could help China's economy to survive from the crisis.

In this section, we zoom our study on Chongqing. The analytical method similar to that of China in precedent section will be used here (from both production side and diffusion side), considering that the geographical factor here is only part of the national wide geographical analysis already studied in precedent section.

Chongqing Statistical Year Book is the principal data resource we refer to, in order to compact with the analysis at the national wide level.

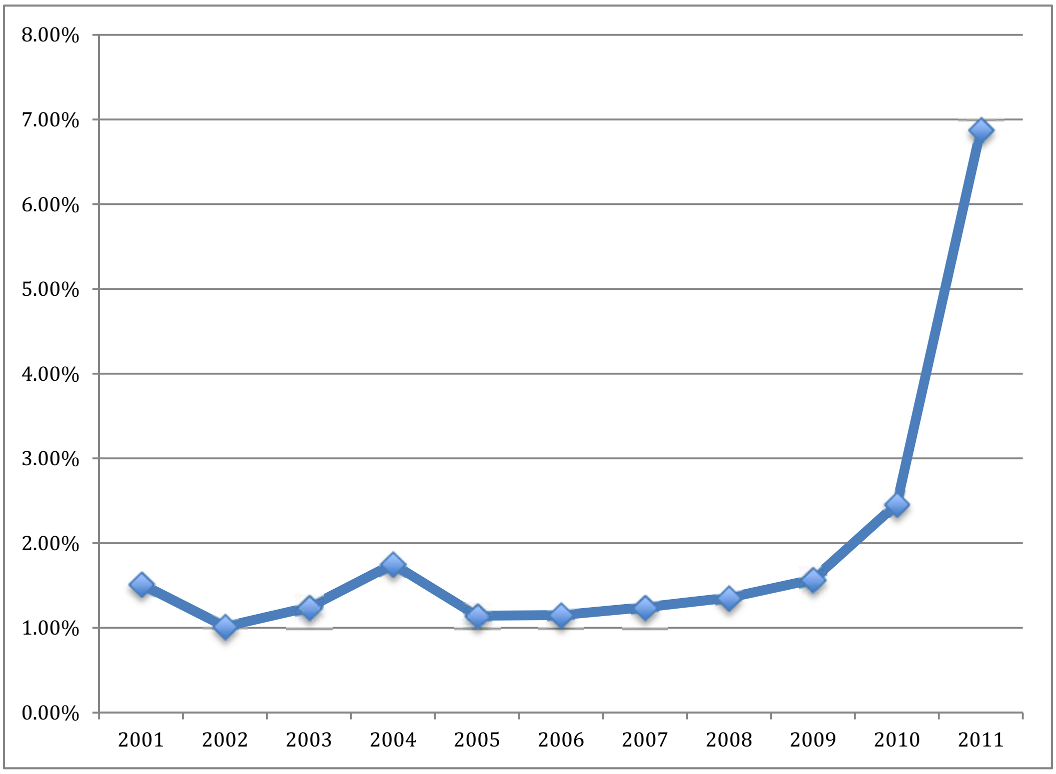
2.1 ICT production in Chongqing

As in section 3, we use the share of ICT industry in GDP as important indicator to describe the overall development of ICT industry in Chongqing. In this section, Chongqing Statistical Yearbook is the principal data resource. As China Statistical Year Book, this resource is not so accurate as we desired because of some artificial factor, but we consider that this resource is not fatally bad and it reflects at least the general situation in Chongqing as the most official one that we possess.

In table IV.8, we have the data of important indictors of ICT industry for Chongqing. From these statistics, we observe three important things:

First, the importance of ICT industry in term of number of enterprises experienced a curve under the form "U" (see figure IV. 27). This could be explained by ICT industrial reform Chongqing experienced over this period. A decline of number of ICT enterprises happened in the early period is accompanied by the wave that series of less competitive state-owned enterprises closed down, and the rise of this indicator which happened since recent years is accompanied by introducing giant international ICT manufacturers in Chongqing to a large scale；

Figure IV. 26 share of GIOV of ICT manufacture in GIOV of overall industry of Chongqing



Data resource: Chongqing Statistical Year Book

Second, the importance of ICT industry in term of employees experienced accelerated increase through this period. The share of average employment of ICT and other electronic products manufacture in the overall average employment of Chongqing increases considerably, this could be explained by the movement of labors from closed enterprises to the new established ones, and the expansion of this industry since recent years;

Third, share of IOV of ICT and other electronic products manufacture in GIOV of Chongqing stays stable for the most part of this period, but meets impressive rise since last two years. This trend is compatible with the two precedent observations, which indicates a new expansion of ICT industry in the overall industry development of Chongqing.

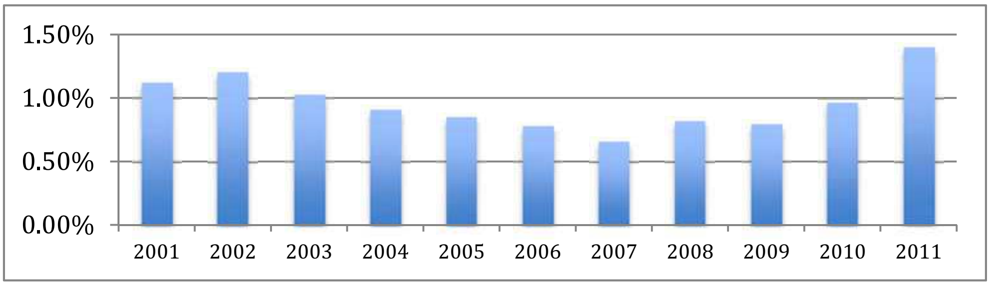
Table IV.8 Important indicators of ICT manufacture in Chongqing

		Number of Enterprises (unit)	Share of Number of Enterprises of ICT and other Electronic Products Manufacture / Chongqing (%)	Average Employment (10 000 persons)	Share of Average Employment - ICT and other Electronic Products Manufacture/Chongqing (%)	GIOV (10000 Yuan)	Share of IOV of ICT and other Electronic Products Manufacture/ Chongqing（%）
2001	Chongqing	2054		84.19		10728325	
	ICT and other Electronic Products Manufacture	23	1.12%	0.81	0.96%	162873	1.52%
2002	Chongqing	2072		82.01		12283741	
	ICT and other Electronic Products Manufacture	25	1.21%	0.77	0.94%	124800	1.02%
2003	Chongqing	2243		84.33		15889928	
	ICT and other Electronic Products Manufacture	23	1.03%	0.70	0.83%	197441	1.24%
2004	Chongqing	2634		90.05		21427260.7	
	ICT and other Electronic Products Manufacture	24	0.91%	0.7	0.78%	375809.6	1.75%
2005	Chongqing	2946		92.42		25258684	
	ICT and other Electronic Products Manufacture	25	0.85%	0.77	0.83%	288897	1.14%
2006	Chongqing	3214		96.84		32142340	
	ICT and other Electronic Products Manufacture	25	0.78%	1.04	1.07%	370055	1.15%
2007	Chongqing	3942		108.27		43632489	
	ICT and other Electronic Products Manufacture	26	0.66%	1.26	1.16%	542121	1.24%
2008	Chongqing	4741		117.16		55992570	
	ICT and other Electronic Products Manufacture	39	0.82%	1.42	1.21%	758899	1.36%
2009	Chongqing	6412		137.28		67729015	
	ICT and other Electronic Products Manufacture	51	0.80%	2.02	1.47%	1064372	1.57%
2010	Chongqing	7130		146.56		91435532	
	ICT and other Electronic Products Manufacture	69	0.97%	2.87	1.96%	2251443	2.46%
2011	Chongqing	4778		145.76		118470581	
	ICT and other Electronic	67	1.40%	5.93	4.07%	8154357	6.88%

	Number of Enterprises (unit)	Share of Number of Enterprises of ICT and other Electronic Products Manufacture / Chongqing (%)	Average Employment (10 000 persons)	Share of Average Employment - ICT and other Electronic Products Manufacture/Chongqing (%)	GIOV (10000 Yuan)	Share of IOV of ICT and other Electronic Products Manufacture/ Chongqing（%）
Products Manufacture						

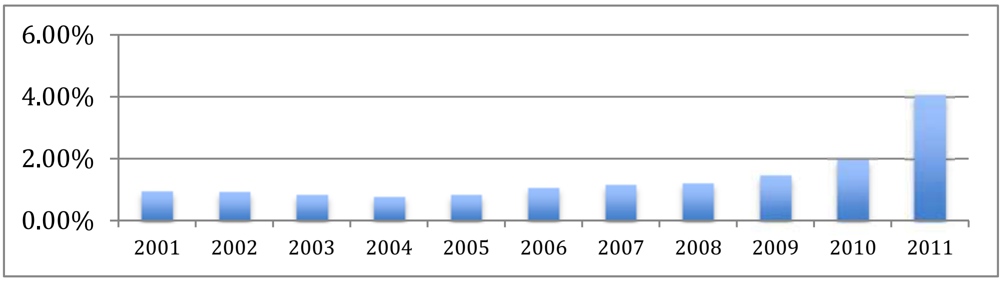
Data resource: Chongqing Statistical Year Book

Figure IV. 27 Share of ICT manufacture in Chongqing - Number of Enterprises



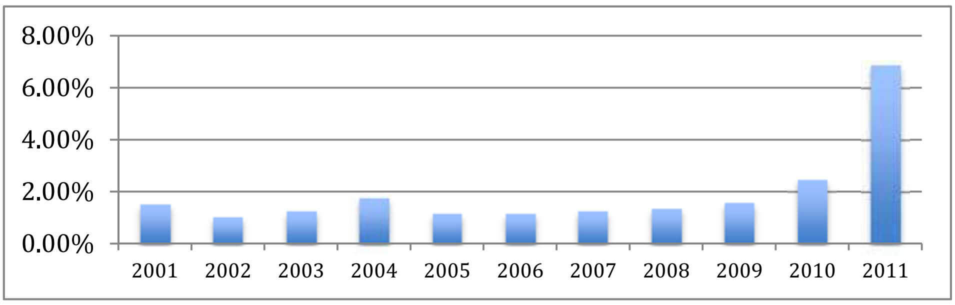
Data resource: Chongqing Statistical Year Book

Figure IV. 28 Share of ICT manufacture in Chongqing - Average Employment (10 000 persons)



Data resource: Chongqing Statistical Year Book

Figure IV. 29 Share of ICT manufacture in Chongqing - GIOV



Data resource: Chongqing Statistical Year Book

In figure VI.27, we observe a trend under form of slight U: the number of ICT enterprises stagnates from 2001 to 2007 (see table VI.2), yet its weight in the overall indictor of Chongqing decreasing during the same period; from 2008 to 2011, the absolute value (see table VI.2) and the weight both meet considerable rise, especially for the 2011.

In figure VI.28 and figure VI.29, we observe that the weight in terms of employment and GIOV present almost the same trend: stable for the most part of the period from 2001 to 2011, but ascending considerably for the last years. This phenomenon corresponds well to the national background analyzed in section3, in which we observe the evident change for the geographically unbalanced situation of the ICT industry's development in China since the economic crisis exploded in 2008. The ICT industry is becoming the new engine of Chongqing's growth.

Table IV.9 Main EEEs' output in Chongqing from 2005 to 2011

Product	2005	2006	2007	2008	2009	2010	2011
TV (10000 units)	42.60	40.77	31.26	10.72	38.16	65.87	85.05
PC (10000 units)	N/A	N/A	N/A	3	0.21	189	2548
AC (10000 units)	N/A	N/A	N/A	N/A	N/A	573	867

Data resource: Chongqing Statistical Year Book

As the SEB analysis developed in section1, we prepare for this analysis in Chongqing here by offering the data of the main EEE's production in Chongqing measured by 10000 units.

In table IV.6, the production of TV has doubled from 2005 to 2011; AC has increased by almost 50% in the last year; but the most remarkable phenomenon is that the production of PC has met impressive rapid growth since 2010, from 2100 units to 1890000 in 2010 and then to 25480000 units in 2011. This situation reveals the fact that the PC manufacture moved in Chongqing since recent years, and this must be oriented by strong governmental strategic measures, in order to upgrade Chongqing's industrial structure from the heavy industry mainly driven economy to light industry.

2.2 ICT diffusion in Chongqing

As in the analysis at the national wide level, ICT diffusion is also more complicated for estimating. The same way will be used in the analysis of Chongqing. We refer to the winding way to achieve this goal. In Chongqing Statistical Year Book, we have ownership of major electronic and electric household appliances per 100 urban households at year-end and the data of regional breakdowns of sampling number of household and the sampling ratio， the product of the two terms equals the quantity of correspondent ICT products owned in Chongqing.

Seven main EEEs owned by households are enumerated in the table above. The measure is the units of products owned by every 100 households in average in Chongqing, from 2001 to 2011 (the data of air conditioner is non available in 2005). Together with figure VI.9, we distinguish three trends: first, this indicator decreases during this period; second, this indicator almost stagnates at the same level during this period; third, this indicator increases considerably during this period. Under this mentioned classification, we find that among these six main EEEs owned by households, indicator for fixed phone decreases for the most part of this period, especially from 2003 to 2011 (from 95.67 to 65.86); indicator for television, refrigerator and washing machine reflects a stable trend for the most part of this period (around 150 for television, around 100 for refrigerator and washing machine); indicator for air conditioner, personal computer and mobile phone shows considerable increase during the whole period (from 81.33 to 164.31 for air conditioner, from 13.67 to 76.07 for personal computer and from 83.67 to 164.31 for mobile phone) .

Table IV.10 Ownership of Major Durable Consumer Goods Per 100 Urban Households at Year-end in Chongqing

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Refrigerator	99.67	98.67	98.92	98.00	99. 67	102	105.00	100.13	100.68	101.89	101.17	101.86
Washing Machine	94.67	97.00	98.19	97.67	99. 33	102. 33	103.67	95.10	96.82	98.46	97.23	97.83
Television	132.00	138.67	142.17	150.67	153.33	155.33	164.33	149.92	145.42	149.39	147.33	149.12
Air Conditioner	81.33	85.67	106.89	126.67	152.33	N/A	174.33	164.30	166.52	172.95	158.35	164.31

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Personal Computer	13.67	17.33	25.33	34.67	43.67	51.33	70.00	63.57	65.27	72.96	69.03	76.07
Fixed Telephone	18.33	34.33	53.94	97.67	96.00	94.33	95.00	91.21	86.46	86.26	83.20	65.86
Mobile Phone	83.67	87.00	94.64	95.67	128.33	154.33	187.00	172.29	179.46	188.66	190.48	207.11

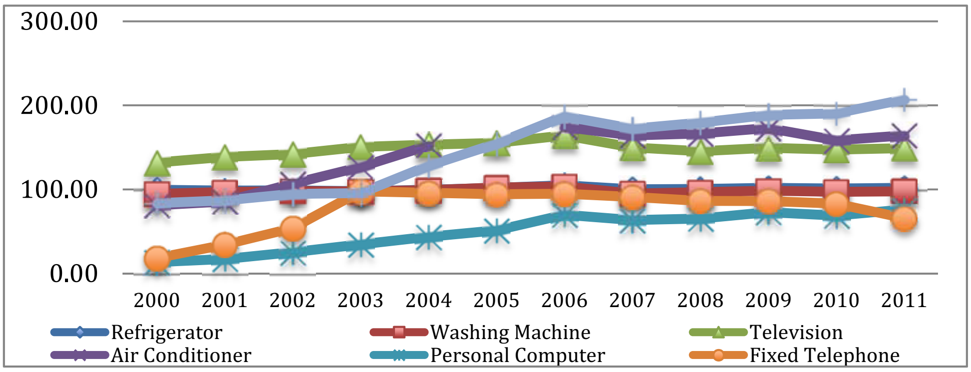
Data resource: Chongqing Statistical Year Book

The evolution of these most important EEEs consumed by household reflects the change of consumers' behavior about EEE consumption for the last decade in Chongqing.

We focus in this research on the flux of these EEEs possession per 100 households, in order to offer a general estimation of the evolution of these products' possession intensity for preparing the overall estimation of the ICT's environmental impact of Chongqing by accounting the environmental impact balance from both the production side and the diffusion side.

For now, we are capable to see that from the dynamic view, for the average units owned by 100 households, fixed phone contributes positive environmental effect, television, refrigerator and washing machine contribute neutral environmental effect and air conditioner, personal computer and mobile phone contribute negative environmental effect to the EEE's environmental impact balance in Chongqing.

Figure IV. 30 Dynamic evolution of Ownership of Major Durable Consumer Goods Per 100 Urban Households at Year-end



Data resource: Chongqing Statistical Year Boo k

2.3 Environmental impacts analysis

Here we continue to use the method used in section 1 in of this part, to calculate the spatial environmental balance (SEB) of Chongqing for the main EEE from which we can find available data in Chongqing Statistical Yearbook: Laptop and TV.

- Laptop

We apply the same way as the case at the national level in calculating laptop industry's overall spatial environmental balance in Chongqing. Firstly, we calculate the SEB of laptop in Chongqing by subtracting the annual variation of units of laptop owned by residents in Chongqing from the annual production for selected years; secondly, we use the LCA results of laptop from different research sources to obtain the CO_2 emissions results of different scenarios (measured on 10 000 tons of CO_2e), by multiplication (kg CO_2 e/piece × SEB obtained in first step), distribution (to distribute the precedent product to production & transport phase and use & end of life phase according to their respective weight according to different research source) and subtraction (to subtract the CO_2 emissions of use & end of life phase from the CO_2 emissions production & transport phase). Then we obtain the final result of laptop presented in table IV.11.

Table IV.11 SEB measured on 10 000 tons of CO_2e for PC in Chongqing according to different LCA results

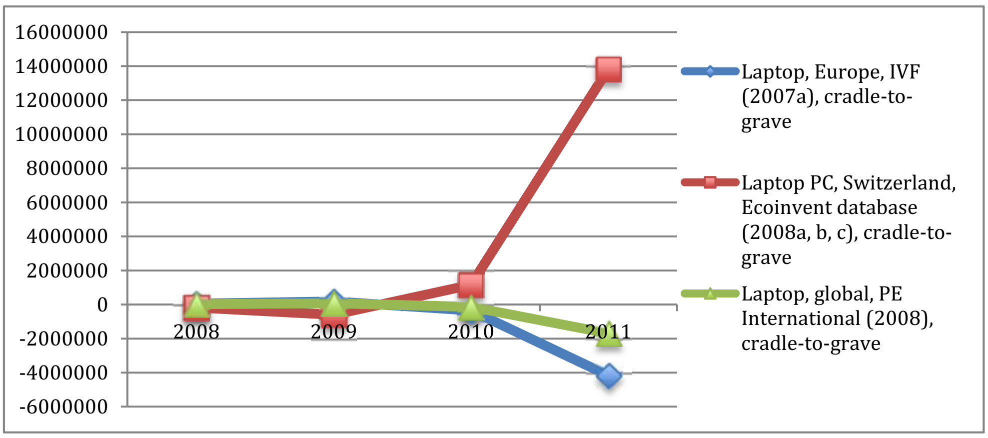
Research Sources	2008	2009	2010	2011
Laptop, Europe, IVF (2007a), cradle-to-grave	52292.82007	180552.9591	-347516.583	-4169716.046
Laptop PC, Switzerland, Ecoinvent database (2008a, b, c), cradle-to-grave	-173450.6432	-598878.1415	1152681.664	13830578.06
Laptop, global, PE International (2008), cradle-to-grave	21225.3	73285.24	-141055	-1692460

The result in table IV.11 presents a contrasting view and it is visualized in figure IV.31. This shock could be explained by two principal reasons: firstly, the inconsistency among the referred LCA results for laptop as mentioned by Andrea & Otto; secondly, the remarkable magnitude difference between these quantitative LCA results measured on CO_2e per unit od product.

If we take into account the LCA result that the CO_2 emissions through the production & transport phase weight over the CO_2 emissions through the use & end of life phase (*Laptop PC, Switzerland, Ecoinvent database (2008a, b, c), cradle-to-grave*), Chongqing gains environmental benefice in 2008 and 2009 (period when consumption is more important than production), but starts to have environmental deficit for laptop since 2010 and this environmental deficit balloons in 2011 (period when production becomes more important than consumption).

If we take into account the LCA result that the CO_2 emissions through the production & transport phase weight lighter than the CO_2 emissions through the use & end of life phase (*Laptop, Europe, IVF (2007a), cradle-to-grave* & *Laptop, global, PE International (2008), cradle-to-grave*), Chongqing has environmental deficit for laptop in 2008 and 2009 (period when consumption is more important than production), but starts to gain environmental benefice since 2010 and 2011 (period when production becomes more important than consumption).

Figure IV. 31 SEB measured on 10 000 tons of CO_2e for Laptop for Chongqing according to different LCA results



- TV

As for laptop industry's overall spatial environmental balance in Chongqing, we apply the two steps of calculation for SEB on 10 000 tons of CO_2e for TV in this city: firstly, we calculate the SEB of TV in Chongqing by subtracting the annual variation of units of TV owned by residents in Chongqing from the annual production for selected years; secondly, we use the LCA results of TV from different research sources to obtain the CO_2 emissions results of different scenarios (measured on 10 000 tons of CO_2e), by multiplication (kg CO_2 e/piece × SEB obtained in first step) and distribution (to distribute the precedent product to production & transport phase and use & end of life phase according to their respective weight according to different research source) and subtraction (to subtract the CO_2 emissions of use & end of life phase from the CO_2 emissions production & transport phase). The final result of TV is presented in table IV.12. As we don't have accurate data about respective share of TV with CRT screen, of TV with PDP screen and of TV with LCD screen in overall TV production neither in overall TV consumption in Chongqing, so we ignore this detail which should not influence the qualitative results of SEB on CO_2 emissions, considering the consistency between the referred LCA results studied in the work of Andrea & Cotton.

We observe the consistency to great extent in table IV.12 and in figure IV.32, which matches the consistency between the mentioned LCA results. Furthermore, we also see interesting regular fluctuation of SEB on CO_2 emissions above and below the neuter line, with the positive value and the negative value one following the other year by year. We consider that this phenomenon may matches the economic cycle for TV market in Chongqing, as the demand and the supply cross each other every year around the market equilibrium point. This tells that if a market cycle for one product is regular and if the LCA results are consistent, the SEB may be compatible with the economic cycle of this product by fluctuating up and down around the neutral line.

Table IV.12 SEB measured on 10 000 tons of CO_2e for TV in Chongqing according to different LCA results

Research Sources	2008	2009	2010	2011
TV， CRT， Japan， Aoe (2003)， cradle-to-grave	-147451.764	302163.6	-142402.146	64399.206
TV， PDP， Japan， Aoe (2003)， cradle-to-grave	-165145.9757	338423.232	-159490.4035	72127.11072
TV， LCD， Japan， Aoe (2003)， cradle-to-grave	-118944.423	243745.304	-114871.0644	51948.69284
TV， CRT， China， Feng and Ma (2009)， cradle-to-grave	-98669.80541	202197.809	-95290.76937	43093.80201

Figure IV. 32 SEB measured on 10 000 tons of CO_2e for TV for Chongqing according to different LCA results

Section3. Conclusions

In this part, we studied the ICT development in China and in Chongqing from both the production and the diffusion.

At the national level, the share of ICT industry's GOV in China's GDP has slightly fallen through the period, as the share of GIOV in China's GDP has also experienced the slight decrease to almost the same extent. Geographically, East-China is the outstanding region for ICT production, and West-China is the most left behind region according to three used indicators. Yet we observe the sign that the gap between the West and more developed regions is closing. This phenomenon indicates the eventual trend that the environmental impact issued from the production process starts to move from the costal regions to the west inland regions in the coming period.

For PC, we have inconsistent environmental impact in sourcing to inconsistent LCA results. East-China earns environmental benefice if the LCA result determines that through product's life cycle, the environmental impact of the production & transport phase exceeds the environmental impact of use & end of life phase; East-China looses environmental dividend if the LCA result determines that through product's life cycle, the environmental impact of the production & transport phase is lower than the environmental impact of use & end of life phase. The other regions fluctuate around the neutral line except that the gap between the west and the east starts to close since last few years; for TV, the evolution of SEB on CO_2 emissions is consistent for the four regions, and East-China is the outstanding region that looses environmental dividend to large extent; for MP, the SEB on CO_2 emissions varies also consistently for the four regions. East-China and North-China are the two regions where we find the environmental deficit to large extent, whereas the rest regions have their environmental balance walking around equilibrium.

In Chongqing case study, it's evident that from the production side, for the recent decade, Chongqing has lingered at the low level for most of the time, but met impressive growth since the last few years, especially for laptop production. From the diffusion side, we presented the evolution of the indicator of "*Ownership of Major Durable Consumer Goods Per 100 Urban Households at Year-end*". We find that for the seven main ICT and other electronic & electric durable consumer goods, this indicator of PC, MP and AC has experienced stable increase, and this indicator for the rest stays stable even decreases through the period.

Based on the discussion of the ICT development in Chongqing, by relying on the available data for both production and diffusion, we analyzed the environmental gain and loss for this city with same way used in the analysis at the national level. As Chongqing's ICT production is concentrated on laptop and TV, so we deployed the analysis for these two products.

We found that the result for laptop is contrasting in referring to different LCA results we referred for laptop. This city could gain environmental benefice for laptop if we take into account the LCA result that the CO_2 emissions through the production & transport phase weight lighter than the CO_2 emissions through the use & end of life phase, and this city could have environmental deficit for laptop in 2008 and 2009 (period when consumption is more important than production), but starts to gain environmental benefice since 2010 and 2011 (period when production becomes more important than consumption).

We observe the interesting regular fluctuation of SEB on CO_2 emissions above and below the neuter line, with the positive value and the negative value one following the other year by year.

Based on these analysis and observations in this part, we find that two factors alternatively influence the region's environmental balance: the geographical distribution of key parts of product's life cycle, and the reference of LCA results.

Even we observe the inconsistency in the case of PC, but we can still find general consistent result for the evolution of ICT industry's spatial environmental balance (SEB) in China, the movement of this industry from the costal developed regions to the distressed inland regions also induce the SEB's movement in similar way for most cases, but the direction could be inverse according to some contradictory LCA result for some products.

This finding has sense for policy-making. The social planner should take into account the geographical factor by dynamic view into their strategy of policy-making.

PART V - COMPREHENDING THE TREND OF POLICY-MAKING RELATED TO ICT PRODUCTS' ENVIRONMENTAL PROBLEMS

As mentioned in hypothesis 12 in part I, we assume that social planner's goal is to reduce the ICT industry's environmental impacts through ICT product's whole life cycle. The scope of the relative policy-making should cover all parts of product's life cycle according to related environment impacts. From the analysis of ICT product's life cycle in part III, we observed the distribution of product's environmental impacts among different parts of the life cycle. We generalize the most important impacts into two principle categories: the directly emitted hazardous wastes and the indirectly emitted green house gas (GHG) measured as tons of CO_2 equivalent (tCO_2e), the later being strictly linked to energy consumption, for production, transport, use and wastes disposal. It's evident that if we close eye on one of the two, then eventually the strategy of policy-making will be misguided.

The knowledge about the institutional system aids understanding the environmental strategy of policy-making. North (1990) frames institutional change as ongoing interactions between organized economic activities, knowledge and institutional framework including both formal and informal constraints. Levy and Spiller (1994, 1996) extend this theory to analysis of regulation and point out the importance of institutional endowment, which often plays a critical role in committing economic/political actors to regulatory policies. This approach has been widely applied to explain differences in performance and practices in telecommunications (e.g., Cherry &Wildman, 1999; Gutierrez &Berg, 2000; Zhang, 2002).

Pieter Verdegem et al. (2011) offered an integrated approach on technology acceptance research by bridging the gap between a market and a policy-oriented point of view for ICT industry. Policy discourse concerned with sustainable development has called the environmental efficiency of modern production and consumption practices into question (Meadows et al., 1972; Weizacker et al., 1998; Perman et al., 1999; Hawken et al., 2000). Actions to de-carbonize economies, improve the efficiency of resource use and minimize potential pollutants have become key elements of policy and law to promote sustainable development (Berkout, 2002; Tietenberg, 2003; Dti, 2003; Segger and Khalfan, 2004; Hawkins and Shaw, 2004). Yet，in preliminary works, the wasted electric and electronic equipment (WEEE) occupied the predominant topic in analyzing ICT product's LCIA under the EPR principle. Annika Gottberg et al. (2006), studied the impact of WEEE regulations system under EPR frame on the European lighting sector; Kingand Burgess (2005) and Lindhqvist (2000) determine that policy measure to deal with the WEEE problem is to adopt the extended producer responsibility (EPR) principle; Deepali Sinha Khetriwal, Philipp Kraeuchi, Rolf Widmer, (2009) examined the decade-long experience of Switzerland in using EPR to manage the e-waste; A few pioneering studies are the Carnegie Mellon study published by Matthews et al. (1997) on estimating e-waste; a Mclaren et al. (1999) study on a pilot cell phone take back scheme in the UK; and Jung and Bartel (1999) study analyzing the feasibility of taking back and recycling computers in San Jose, California；Tojo (1999) does an in-depth study of the Japanese regulation for household appliances, also comparing the Japanese law with several European counterparts; Lifset (1993) takes the EPR movement as manufacturer take back or product stewardship.

We observe that one important factor is wildly looked down or ignored in these works is the economic geographic factor that we studied just now in the precedent part, which is difficult to be standardized and integrated into the LCIA, and often it contributes considerable uncertainty to LCIA results.

In this part, we check the environmental policy system concerning ICT industry in China by referring to the LCIA analysis studied in part III, in order to figure out the trend of policy-making strategy on this issue, before to comments. As Vedung (1998) points out, no uniform and generally accepted classification of policy instruments is found in the literature of public policy, our study deploys the analysis of the relevant policies through enlarged view in stead of being limited in the regulations system uniquely focused on the end of life management.

Section 1. Social planner/planners - different administrative departments involved in regulating ICT products' environmental problems

Different administrative departments are involved in regulating ICT industry's environmental problem, directly or indirectly. The way in which one relative department makes policy depends a lot on its principal endowed function. Different departments could approach ICT industry's environmental problems from different perspectives in conducting different strategies of policy-making, and these strategies could be consistent if the overall political organization is efficient enough, or inconsistent if it is sub-efficient or even completely inefficient.

To have an explicit view of the social planners' profile is necessary for understanding how relative policy-making system functions, and then it's expected to find out to which extent the consistency of different departments' policy-making strategies issued from their proper perspective reaches, in perceiving the eventual conflicts in their thinking of how to treat ICT industry's environmental problems that may cause the inefficiency of the policy-making. These conflicts may come from different regulations or different understandings and ways of implementing the same regulation. In the following, we offer a relative brief presentation of the main functions of key administrative departments involved in. In stead of being comprehensive, these presentations focus only on the subject of combating ICT industry's environmental problems.

- National Development and Reform Commission (NDRC)

  One of NDRC's main functions about the ICT industry's environmental problem is: *to promote the strategy of sustainable development; to undertake comprehensive coordination of energy saving and emission reduction; to organize the formulation and coordinate the implementation of plans and policy measures for recycling economy, national energy and resource conservation and comprehensive utilization; to participate in the formulation of plans for ecological improvement and environmental protection; to coordinate the solution of major issues concerning ecological building, energy and resource* *conservation and comprehensive utilization; to coordinate relevant work concerning environment-friendly industries and clean production promotion.*[14]

- Ministry of Industry and Information Technology (MIIT)

  The seventh principle function of MIIT is about the issue of debating ICT industry's environmental problem:

  Develop and organize the implementation of national policies and plans for energy conservation and comprehensive utilization of resources, cleaner production for industries and communications, participate in the promoting plans for energy conservation and comprehensive utilization of resources, cleaner production, organize and coordinate the application of related key model projects and new products, new technology, new equipment and new material.[15]

- Ministry of Environmental Protection (MEP)

  All of the main functions of MEP are related to ICT industry's environmental issue is as following:

  1. *Develop and organize the implementation of national policies and plans for environmental protection, draft laws and regulations, and formulate administrative rules and regulations for environmental protection. Organize the development of environmental function zoning, organize the development of various kinds of environmental protection standards, criteria and technical norms; organize the development of the plan for pollution prevention and control in key regions and river basins as well as environmental protection plan for drinking water source areas;...*
  2. *Take charge overall coordination, supervision and management of key environmental issues….*
  3. *Shoulder and materialize the responsibility for achieving national target on emission reduction….*
  4. *Take charge putting forward recommendations on the scale and direction for fixed assets investment in the field of environmental protection and*

14 See: http://en.ndrc.gov.cn/mfndrc/default.htm
15 See: http://www.miit.gov.cn/n11293472/n11459606/n11459642/11459720.html

arrangement of national financial budget; review and check the fixed-asset investment projects under national plan and annual plan in accordance with its terms of reference identified by the State Council; cooperate with relevant departments to do well the implementation and supervision work. Take part in, guide and facilitate the development of circular economy and environmental protection industry; take part in climate change activities.

5. *Shoulder the responsibility for preventing and controlling environmental pollution and damage at source. Conduct environmental impact assessment as entrusted by the State Council on major economic and technical policies, development programs and major economic development plans; put forward suggestions on environmental impacts to draft laws and regulations relevant to environmental protection; review and approve environment impact statements of key development regions and projects.*
6. *Take charge supervision and management on the prevention and control of environmental pollution. Develop and carry out the management system for pollution prevention and control of water, air, soil, noise, light, odor, solid wastes, chemicals and vehicle emissions; it and relevant departments supervise and administrate environmental protection of drinking water source areas; organize and guide comprehensive environmental control activities in urban and rural areas.*
7. *Guide, coordinate and supervise ecological conservation....*
9. *Take charge the work on environmental monitoring and information release. Develop environmental monitoring systems and norms; organize the implementation of the monitoring of environment quality and pollution sources. Organize investigation, assessment, prediction and early warning of environmental quality; organize the development of and administrate national environmental monitoring network and national environmental information network; establish and practice environment quality publication system, make public comprehensive national environment report and key environmental information.*

11. *Carry out international cooperation and exchanges on environmental protection; study and put forward recommendations on relevant issues in international environment cooperation; organize and coordinate the implementation of international environmental conventions, take part in handling of foreign environmental protection affairs.*
12. *Organize, guide and coordinate environmental publicity and communications work; develop and organize the implementation of the outlines for publicity and communications of environmental protection; carry out the publicity and education on the development of conservation culture and environment-friendly society; promote the participation of the public and social organizations in environmental protection.*
13. *Undertake other affairs delivered by the State Council.*[16]

- General Administration of Quality Supervision, Inspection and Quarantine (GAQSIQ)

  The relative mains functions of GAQSIQ are:

  Quality Management *- In accordance with the Law on Product Quality of the People's Republic of China and the corresponding Regulations for Implementation, AQSIQ organizes the implementation of state policies and measures on quality advancement, provides macroscopical guidance to quality work all over the country, ..., organizes the introduction of advanced expertise and scientific methods of quality management, undertakes the formulation of the rules on quality supervision for major engineering equipment,…*

  Supervision and Management of Certification and Accreditation - *In compliance with the Regulations of the People's Republic of China on Certification and Accreditation, CNCA takes the responsibilities as follows:*

  To develop, promulgate and implement the state laws, regulations and rules concerning certification and accreditation, safety license, hygiene registration and conformity assessment, to coordinate and guide certification and

[16] See: http://english.mep.gov.cn/About_SEPA/Mission/200803/t20080318_119444.htm

accreditation across the nation,...

To draft the catalogue of products subject to compulsory certification and Safety License System, to work out and promulgate certification marks, conformity assessment procedures and technical requirements, to organize the implementation of compulsory certification and Safety License System. ...

To supervise and standardize certification business according to relevant laws, supervise and administer intermediary services and technical evaluation behaviors, to be responsible also for the qualification screening of, and supervision over certification bodies, and to accept, investigate and handle complaints related to certification and accreditation….

To administer and coordinate international cooperation activities in the field of certification and accreditation in the name of government, to participate in the activities of international organizations of certification and accreditation, and to sign agreements and protocols related to conformity assessment.

Management of Standardization - *In line with the Standardization Law of the People's Republic of China and the Regulations for the Implementation of the Standardization Law of the People's Republic of China, SAC undertakes the following responsibilities:*

To draft and revise the state laws and regulations on standardization, to formulate and implement the policies on standardization, to formulate the national administrative rules on standardization and develop relevant systems, and to organize the implementation of laws, rules and systems on standardization;

To formulate the development programs on standardization of China, to organize, coordinate and draft the programs on the development and revision of national standards, to be responsible for the examination, approval, numbering and publication of national standards;

To be responsible for coordinating and administering national technical committees of standardization concerned, coordinating and guiding sectoral and local standardization work, and to be responsible for registration of sectoral and *local standards.*

To participate in activities of the International Organization for Standardization (ISO), International Electro-technical Commission (IEC) and other international and regional standardization organizations; to be responsible for organizing the activities of Chinese National Committee for ISO and IEC. To be responsible for managing the participation of domestic sectors and local regions in activities of international and regional standardization organizations, signing and implementing international cooperation agreements; and to administer the work of national systems of organizational entity codes and commodity bar codes.

- Ministry of Commerce People's Republic Of China (MOFCOM)

  The relative mains functions of GAQSIQ are:

  2. To promote the structural adjustment of the circulation industry, to guide the reform of enterprises of circulation, the business development of commercial services and communities, to propose the political proposals for promoting the development of middle and small business enterprises, and to push the standardization and development of circulation industry, chain business, commercial franchising，logistics, e-commerce and other modern circulation businesses.

  18. Undertake other affairs delivered by the State Council.[17]

- Ministry Of Finance (MOP)

  The main functions of MOP concerning relative economic policy and funds management concerning ICT industry's environmental issue are:

  4. *Shoulder the responsibility of managing the non-tax revenue, the governmental funds, and the administrative undertaking charges. …*

  5. *Undertake other affairs delivered by the State Council.*[18]

To better understand the corresponding perspective of relative administrative department, we borrow the Extended Producers Responsibility (EPR) models expounded by Lindhqvist (2000) and later discussed extensively in literature are

17 See: http://www.mof.gov.cn/zhengwuxinxi/benbugaikuang/

18 See: http://www.mof.gov.cn/zhengwuxinxi/benbugaikuang/

outlined below (Langrova, 2002; Oh and Thompson, 2006 ; Milojkovic and Litovski, 2005) in order to clarify the functions of these involved departments surrounding policy-making on the issue of debating ICT industry's environmental problem, even though the EPR is in latter discussion.[19]

• **Liability** – this refers to the responsibility for proven environmental damages caused by the product in question. The extent of the liability is determined by legislation and may embrace different parts of the life cycle of the product, including usage and final disposal. Under the EPR frame, producer is thus responsible for the environmental damage caused by the product in question.

• **Economic responsibility** – The expenses, for example, for the collection, recycling or final disposal of the products. These expenses could be paid directly by the producer or by a special fee. Under the EPR principle, the producer will cover all of part of these expenses.

• **Physical responsibility** – the manufacturer is involved in the physical management of the products and/or their effects. This can range from merely developing the necessary technology, to managing the total "take-back" system for collecting and management/disposal of the products.

• **Ownership** – This means the ownership of products throughout their life cycle, which could be linked to the environmental problems of the product. In the case of EPR, the producer assumes both physical and economic responsibility. In this scenario, the product appears to be leased by the consumer, in which the consumers purchase the 'use' of the product.

• **Informative responsibility** – The responsibility for providing information about the product or its effects at the various stages of its life cycle. That is the producer will provide information on components or material list to reduce the cost of third-party involvement in post-consumer recycling.

[19] Though the EPR models are studied mainly for the Waste Electrical and Electronic Equipment (WEEE), we generalize these models as responsibilities issue from ICT industry's environmental problems in this section, because our focus on here is to study the consistency of social planners' policy-making strategies, and the analysis for the first step is to try to find out the distribution of the related departments on these related responsibilities.

We project the main relative concerned administrative departments on the models above according to their presented functions in obtaining the matrix in table 1.1.

In table 1.1, we observe that under the policy based on EPR principle, MIIT and MEP focus on liability, NDRC, MIIT, MEP and MOF aim at the economic responsibility, NDRC, MIIT and MEP work on the physical responsibility together, MIIT and MEP take the ownership as the content of their domain, and MIIT, MEP and GAQSIQ focus on the information responsibility.

The fact that several departments concern the same responsibility could be the source of divergence of policy-making strategy that may eventually result the inefficiency of laws' implementation.

Table V. 1 Distribution of departments on different responsibilities

	Liability	**Economic responsibility**	**Physical responsibility**	**Ownership**	**Informative responsibility**
NDRC	□	□	□		
MIIT	□	□	□	□	□
MEP	□	□	□	□	□
GAQSIQ					□
MOF		□			
MOFCOM		□		□	

For liability, NDRC's concern is more macroscopical than the concern of MIIT and MEP: NDRC's perspective mainly lies on the whole nation's economy, especially at the level of industrial sector and of the whole nation, in order to make the strategy at the national level; for MIIT, the priority is to improve ICT industry's competitiveness in integrating the eco-design and environmental management into producer's economic activities, like material selection, production process, end-life management, etc.; for MEP, the principal concern is the environmental issue, in belittling the eventual economic impact on ICT industry due to environmental policy. Therefore, the NDRC's perspective on ICT industry's environmental problems could be compact with MIIT and MEP without conflict, yet the divergence on the liability could eventually emerge between MIIT and MEP: MIIT pays considerable attention on ICT manufacturer's competitiveness on the manufacturing chain and the economic interest of ICT manufacturer for debating this industry's environmental problems in taking measures to regulate ICT industry's related activities in order to control its external impact on environment, as MEP concentrates on the environmental issue in keeping other issues aside. The divergence emerges for the policy-making when MIIT and MEP implement the same related law: MIIT emphasizes policy's implementation in integrating industry's concern as MEP emphasizes the environmental.

For economic responsibility, four departments are concerned: NDRC, MIIT, MEP and MOF. For this responsibility, NDRC deals with this issue by taking macroscopical measure, as MIIT seeks funds principally from deposit-refund system among manufacturers in order to incite them to improve the eco-design level and the environmental management level, MEP seeks funds from MOF to subsidy manufactures for their pollution control through the production process, and recycler's activities for the wastes disposal. Therefore, NDRC and MOF's perspectives are compatible with these of MIIT and MEP, but the divergence emerges once again between MIIT and MEP: MIIT back the idea that the manufacturer takes the economic responsibility through the most parts of ICT product's life cycle, yet MEP prefer to link the economic responsibility of different part of life cycle to the directly related agent, in stead of generalizing the economic responsibility through all parts of ICT product's whole life cycle to manufacturer. This divergence could conduct the efficiency of the way of charging the economic burden.

The situation of physical responsibility is mostly compatible with this of economic situation. MOF is absent here, as NDRC, MIIT and MEP are involved together in this issue. NDRC still plays the role as the macroscopical planner in coordinating the other two departments for working on the physical responsibility. The divergence still exists between MIIT and MEP for this issue: MIIT consider manufacturer as responsible for the physical activities as developing necessary technology for reducing the environmental impacts through manufacturing process and developing take-back system for the end-life management; MEP, similarly as in precedent cases, still prefer to separate the physical responsibilities in different parts of life cycle for different direct related agent. This eventually causes dispute as the two work together for establishing related regulations according to laws.

For ownership, MOFCOM, MIIT and MEP are involved. MOFCOM's priority is how to promote the business activities in implementing related regulations, and consequently it supports the take-back system developed by manufacturer. For this point, MOFCOM's perspective is compact with this of MIIT, but with division： MOFCOM push the take-back activities principally through retailers, in order to advance business prosperity at the same time, especially with the Old-for-New scheme[20]; as MIIT opposes this way strongly in considering that the returned products flow does not efficiently enter into the regulated recycle system, and manufacturer's motivation of improving the eco-design and environmental management including the end life management, because the interest from recycling and reuse is separated from manufacturer's efforts. Whereas MEP still prefers the traditional system of ownership, in tracing back the environmental problems through manufacturing process to the direct ownership, the manufacturer, and the environmental problems at the end of life to specific recyclers.

For informative responsibility, MIIT, MEP and GAQSIQ are involved. MIIT's attention is on building the system of material use information release, such as the bill of material (BOM), and the carbon footprint; MEP's key concern is the release of pollution information during the manufacturing process, for which manufacturer is considered as responsible, and the release of information about the hazardous substances contented in WEEE, for which recycler should be responsible as before; GAQSIQ's perspective for informative responsibility is technical one, and the release of environmental information is highly integrated into the information of quality standard system. The release of environmental information of the end-life

[20] Consumers get no more than 10% of the market price of the new product when they decide to dispose of an old appliance or product and buy a new one.

management is absent in GAQSIQ's view concerning the informative responsibility. Consequently, MIIT and MEP's division emerges at the point of whether manufacturer takes the whole informative responsibility for the manufacturing process and for the end-life management; GAQSIQ's attention is only on the technical aspect of ICT product where only the producer should shoulder the responsibility.

From the analysis above, we conclude that for all the presented responsibilities for the issue of ICT industry's environmental problems, NDRC and MOF have the macroscopical strategy for relevant policy-making, as NDRC focuses on developing plans and MOF focuses on affording necessary funds. The two involved social planners' perspectives are compatible with those of other involved ones. Yet, divisions emerge mostly among MIIT, MEP and MOFCOM: MIIT and MOFCOM support working on the policy-making under the EPR principal in order to stimulate producers' relevant activities to integrated their environmental efforts into the efforts for improving their competitiveness, in considering that MOFCOM's intention is biased against MIIT's on implementing the take-back system for reason that the first one's priority is to promote the business activities of circulation industry, as the latter one's key concern lies on producers' interest and the whole ICT industry's competitiveness; yet MEP prefers to working on the environmental issue with the directly linked agent for each part of life cycle in stead of charging all responsibilities to producer, this could be explained by the traditional administrative mode of MEP, and the existed wastes disposal system already established in China and supervised by MEP.

These divisions are potential reasons that could induce conflicts among the mentioned social planners by causing inefficiency for policy-making. The inefficiency could happen for the fact that different social planners emphasize on different parts of life cycle for policy-making, or, they reach the coordination in costing considerable time and social resources.

Section 2. Domestic regulations about ICT products' environmental problems

In section1, the analysis of the involved social planners' perspectives on the relevant responsibilities according to different parts of ICT product's life cycle could be considered as the upstream analysis of the trends of policy-making, from which we observe the ex-ant condition for social planners' policy-making strategy.

In this section, we deploy the downstream analysis for policy-making - analysis of social planner's strategy for policy-making based on present relevant laws and regulations issued in China.

This downstream analysis tends to scan domestic laws and regulations according to different parts of ICT product's life cycle, in order to find out the trends of the policy-making in China in subject of ICT industry's environmental problems with preparation for the next analysis of the reaction of ICT manufacturers vis-à-vis the relevant policy system.

2.1 Domestic laws involving the issue of ICT industry's environmental problems

China has enacted laws to protect environment, to limit pollution and to promote sustainable development. We present firstly the laws covering the issue of ICT industry's environmental problems.

- *Recycling Economy Law of the People's Republic of China* (released on 29/08/2008, implemented on 01/01/2009).
  - Concerned domains: all economic activities in China, including ICT industry.
  - Main purposes: waste reduction, reuse and recycling.
- *Law of the People's Republic of China on Promoting Clean Production* (released on 29/02/2012, implemented on 07/01/2012).
  - Concerned domains: any units or individuals engaged in activities relating to production or provision of services and their corresponding management agencies.
  - Main purposes: promote cleaner production, increase the efficiency of the utilization rate of resources, reduce and avoid pollutant-producing, protect and improve environment, ensure the health of human beings and promote the sustainable development of the economy and society.

- *Energy Conservation law of the People's Republic of China* (released on 28/10/2007, implemented on 04/01/2008).
    - Concerned domains: all economic activities that produce or consume energy.
    - Main purposes: enhance management over energy use, adopt technically feasible, economically reasonable, environmental and society-acceptable measures, in order to reduce energy consumption, losses and pollutant discharge, curb waste and utilize energy effectively and reasonably in the course of production to consumption.
- *Law of the People's Republic of China on prevention of environmental pollution caused by solid waste* (released on 29/12/2004, implemented on 04/01/2005).
    - Concerned domains: all environmental pollution caused by solid waste in the territory of the People's Republic of China.
    - Main purposes: prevent the pollution of caused by solid waste, ensure the good health of the public, and promote the development of socialist modernization, accordingly establish following laws.
- *The Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution* (released on 29/04/2000, implemented on 09/09/2000).
    - Concerned domains: national economic and social development plans of different administrative levels.
    - Main purposes: take measures to control or gradually reduce, in a planned way, the total amount of the main atmospheric pollutants discharged in local areas.
- *Law of the People's Republic of China on Prevention and Control of Water Pollution* (last version released on 28/02/2008, implemented on 06/01/2008).
    - Concerned domains: surface and ground water bodies including rivers, lakes canals, irrigation channels and reservoirs in the territory of the People's Republic of China.
    - Main purposes: prevent and control water pollution, protect and improve the environment, maintain the safety of drinking water, and promote sustained economic and social development.

- *Law of the People's Republic of China on Prevention and Control of Pollution from Environmental Noise* (released on 29/10/1996, implemented on 03/01/1997).
  - Concerned domains: the noise in industrial production， construction， traffic and transportation, and social life which disturbs the living environment in the neighborhood.
  - Main purposes: prevent and control environmental noise pollution, protect and improve the living environment, safeguard human health and promote economic and social development.
- *Law of the People's Republic of China on Product Quality* (last version released on 07/08/2000, implemented on 09/01/2000).
  - Concerned domains: all production and marketing activities within the territory of the People's Republic of China. Products processed and manufactured for the purpose of marketing. This law is not applicable to construction projects. However, the construction materials, structural components and fittings and equipment those fall within the category.
  - Main purposes: The law has been formulated with a view to reinforcing the supervision and regulation of product quality, improving the quality of products, clarifying the liabilities for product quality, protecting the legitimate rights and interests of consumers and safeguarding the social and economic order.
- *Law of the People's Republic of China on Work Safety* (last version released on 07/06/2002, implemented on 01/11/2002).
  - Concerned domains: work safety in units that are engaged in production and business activities (hereinafter referred to as production and business units) within the territory of the People's Republic of China.
  - Main purposes: This Law is enacted for enhancing supervision and control over work safety, preventing accidents due to lack of work safety and keeping their occurrence at a lower level, ensuring the safety of people's lives and property and promoting the development of the economy.

- *Code of Occupational Disease Prevention of PRC* (last version released on 27/10/2001, implemented on 01/05/2002).
    - Concerned domains: the occupational-disease-prevention activities within the territory of PRC. "Occupational disease " hereunder refers to the diseases incurred to the laborers of enterprises; institutions and private business units resulted from contacting with powder dust, radioactive substances, and other poisonous and harmful substances in the work.
    - Main purposes: this code is enacted in accordance with the provisions of the Constitution in a bid to prevent, control and eradicate occupational diseases, prevent occupational diseases, protect the health and rights of laborers and boost economic development.

2.2 Domestic regulations and rules focusing on the issue of ICT industry's environmental problems

To well implement the laws mentioned earlier, relevant regulations and rules are made.

- *Technical Policies of Pollution Prevention and Control for Waste Household Appliances and Electronic Products* (released on 24/08/2006).
    - Concerned domains: waste electronic and electrical products.
    - Main purposes: reduce waste of household electronic and electrical products, enhance resource reuse efficiency, and control the environmental pollution during the reuse process and the disposal process.
    - Processes involved in the product's life cycle: product's end life.
- *Regulations for Management of Recycling Disposal of Waste Electronic and Electrical Equipment* (released on 25/02/2009, implemented on 01/01/2011).
    - Concerned domains: waste electronic and electrical products.
    - Main purposes: regulate the recovery and disposal of waste electronic and electrical products, facilitate comprehensive utilization of resources and circular economy development, protect the environment, and safeguard

human health.

- *Electronic Information Products Pollution Prevention Regulations* (released on 28/02/2006, implemented on 01/03/2007).
    - Concerned domains: electronic ICT products.
    - Main purposes: implement the electronic information products pollution prevention regulations from the beginning, reduce the environmental pollution and the public damage generated by the electronic ICT products after use, in order to realize clean production and sustainable development, protect human health and safeguard properties, and enhance the efficiency of utilization of resources.
- *Energy Efficiency Standards Implementation Rules*（1989-2003）
    - Concerned domains: household appliances, lighting, and commercial & industry equipment.
    - Main purposes: develop and implement mandatory “reach” energy efficiency standards for main industrial equipment, household appliances, office equipment, lighting equipment and vehicles.
- *China Energy Label* (implemented on 01/01/2005).
    - Concerned domains: the label that provides the information on energy-efficiency level of energy-consuming products.
    - Main purposes: strengthen administration of energy conservation, promote energy-saving technologies and upgrade energy efficiency.
- *Regulations on the Safety Administration of Dangerous Chemicals* (released on 01/2011, implemented on 10/2010)
    - Concerned domains: production, operation, storage, transportation, and use of dangerous chemicals and disposal of the wasted dangerous chemicals in the territory of the People’s Republic of China.
    - Main purposes: to strengthen the control over safety of dangerous chemicals, guarantee the people’s life and property safety, and protect the environment, these Regulations are hereby enacted.
- *Administrative measures of the collection and use of the fund for waste electrical*

and electronic equipment's disposal (released on 21/05/2012, implemented on 01/12/2011)

- Concerned domains: producers, importers and their agents of electric and electronic equipment (EEE) should meet the obligation to pay their contribution to the fund. EEE producers here include the own-brand manufacturers and contract manufacturers; the products involved in the first group include television, refrigerator, household air conditioner, washing machine and personal computer.
- Main purposes: to build up the specific system WEEE take-back and disposal, in order to scale up and industrialize the management of WEEE recycling, for purpose of environmental protection.

- *Regulations for environmental information transparency* (released on 08/02/2007, implemented on 01/05/2008)
  - Concerned domains: the governmental environmental information includes the environmental information recorded and kept by environmental authorities in their duties; the enterprise's environmental information recorded and kept by enterprise through its production activities and other environmental related activities.
  - Main purposes: to develop and specify the environmental information release by environmental authorities and enterprises, to protect the right of every citizen, corporate and other organization to access to environmental information.

2.3 Results

We just presented the relevant generic and specific laws and regulations related to the issue of ICT industry's environmental problems. Based on the content of these legislative documents, we construct a series of statistical analysis, in order to have a clear and general view of relevant social planners' strategy for policy-making. These statistical analysis are strongly linked to the life cycle structure presented earlier in section 3 of part III. We mention that the analysis of the generic laws is distinguished from these of the specific regulations, considering the factor of homogeneity of analysis.

All the statistics in the following are based on the presented legislative documents mentioned in 2.1 and 2.3 of this section. And we continue to use the notation proposed in part III for different parts of life cycle: A, B, C, D, E.

- Statistic on EEPLC and ERPLC for relevant laws

This statistic describes the frequency of relevant laws & regulations' "appearance" in each part of ICT product's life cycle. The word "appearance" is used here for the fact that the laws or regulations are related to correspondent part of life cycle with its partial provisions or the whole of it. This statistic here is used to partially explain to which extent the policy-making pay attention to each mentioned part of life cycle on the issue of the environmental effects and the environmental reaction, according to the existing legislative documents' content.

In figure V.1, we see that in general view, the relevant laws take greatest attention on the environmental impact linked to the production process part of life cycle (A) with 10 appearances, and the environmental effect generated at the end-life of life cycle (E) takes the second place with 8 appearances.

In figure V.2, the dynamic trend of the frequency is figured out according to the year of these laws' implementation. From this figure, it's not evident to get the consistent result, but, we observe that the frequency on E takes relatively most important place through time, by occupying the peak twice (in 2000 and in 2008), and staying at the highest place for the last appearances (once in 2012); the frequency on A stays relatively stable by never touching the bottom line.

In figure V.3, we observe that relevant laws take the predominant attention on eventual environmental reaction in the production process part of life cycle (A) with 10 appearances, and the eventual environmental reaction at the end-life of life cycle (E) takes the second place with 6 appearances. The eventual environmental reaction by through the use of ICT product is the least considered in these laws with only 3 appearances.

In figure V.4, the trend of the frequency is demonstrated by dynamic way according to the time of these laws' implementation. From this figure, like in figure V.2, it's not evident to get the consistent result, but, we observe that the frequency on A takes relatively most important place through time, by occupying the peak twice (in 2000 and in 2008), and staying relatively stable by never touching the bottom line and taking the highest place for the last appearances (once in 2012); the eventual environmental reaction in the part of transport (B) and in the part of use (C) are relatively less important considered by these laws.

Figure V. 1 Frequency of relevant laws' appearance in EEPLC

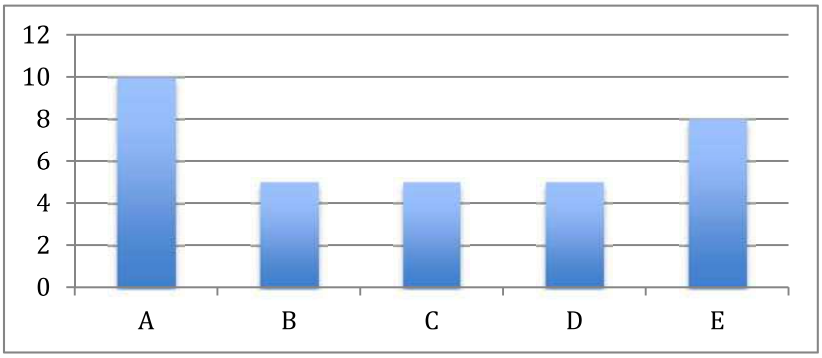


Figure V. 2 Dynamic trend of frequency of relevant laws' appearance in EEPLC

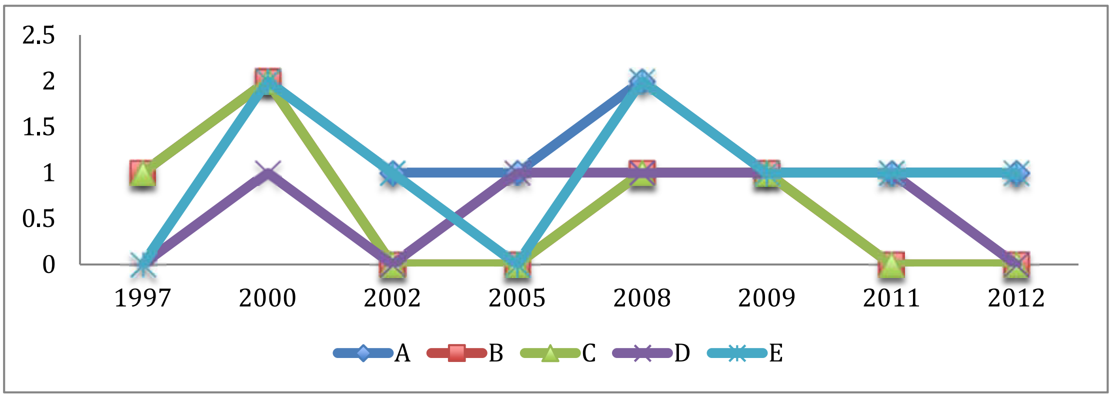


Figure V. 3 Frequency of relevant laws' appearance in ERPLC

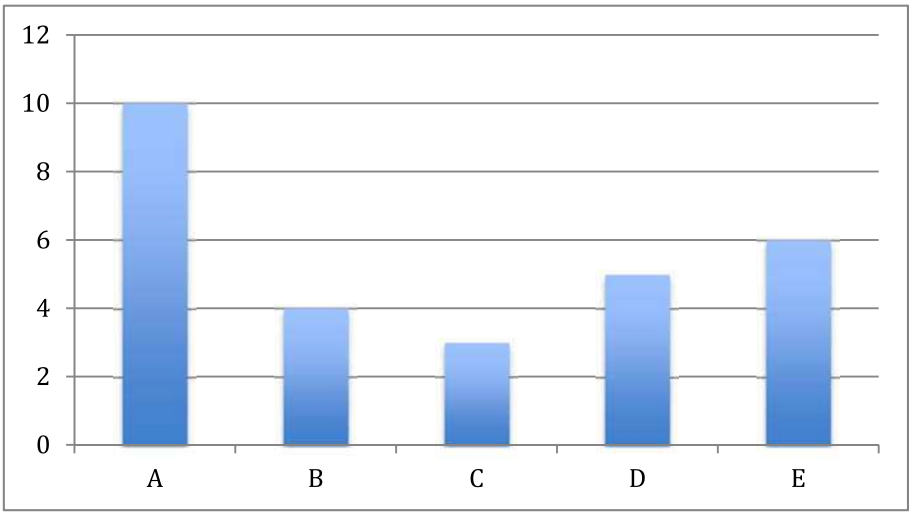
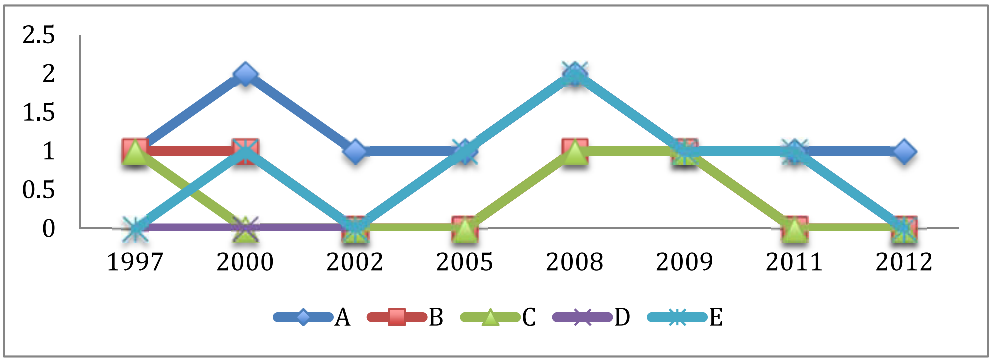


Figure V. 4 Dynamic trend of frequency of relevant laws' appearance in ERPLC



- Statistic on EEPLC and ERPLC for specific regulations

In figure V.5, we see that from the overall view, the relevant specific regulations take the most attention on the environmental effect generated at the end of life cycle (E) with 6 appearances, and the environmental effect generated during the production process (A) takes the second place with 5 appearances.

In figure V.6, the trend of the frequency is demonstrated by dynamic way according to the time of these specific regulations' implementation. From this figure, it's not evident to get the consistent result, but, we observe that the frequency of E takes relatively most important place through time, by staying consistently at first place since 2006, and taking the peak for the last appearances (twice in 2011); the frequency of C decreases from 1 to 0 in 2006 without rising again in the following years.

In figure V.7, we observe that it's obvious that these regulations consider the environmental reaction by producer is the most important by having the frequency of 8 appearances in part A of life cycle which is largely more than the frequency of appearances in part E which takes the second place with only 2 appearances. We also observe that the use of ICT product (part C) is totally ignored by these regulations by having no frequency.

In figure V.8, it's evident that the evolution of the frequency on part A keep stable and take a rise for the last time in occupying the peak in 2011. The trend of the frequency on part E is also similar with this on part A, by staying null since 2003, and then climbing to 1 for 2010 in keeping the same position in 2011.

Figure V. 5 Frequency of relevant specific regulations' appearance in EEPLC

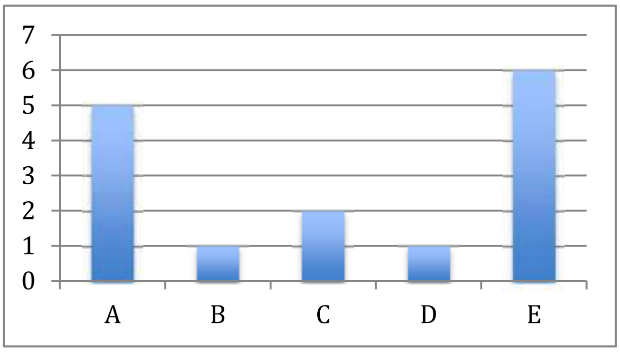


Figure V. 6 Dynamic trend of frequency of relevant specific regulations' appearance in EEPLC

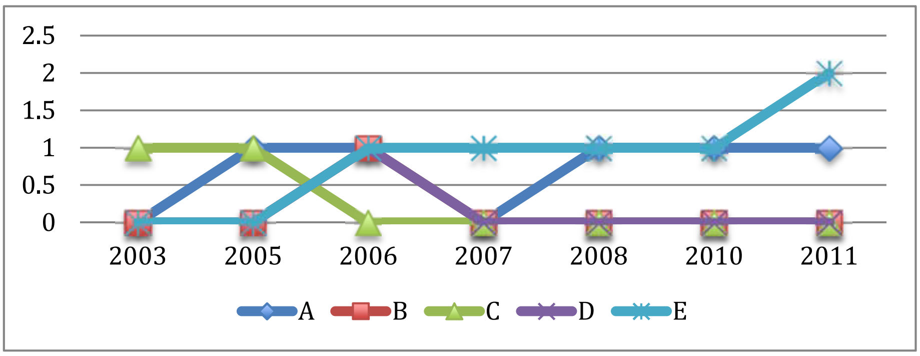


Figure V. 7 Frequency of specific regulations' appearance in ERPLC

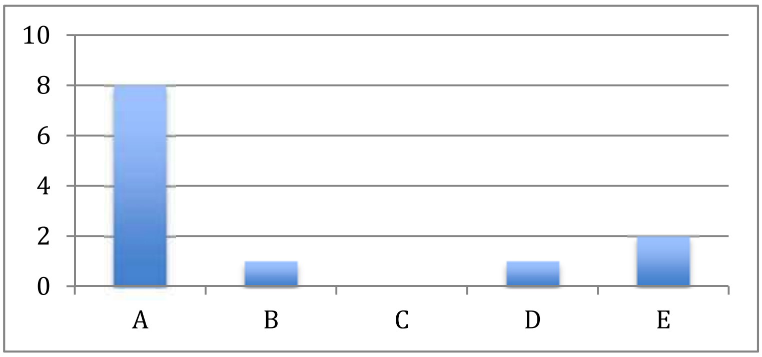
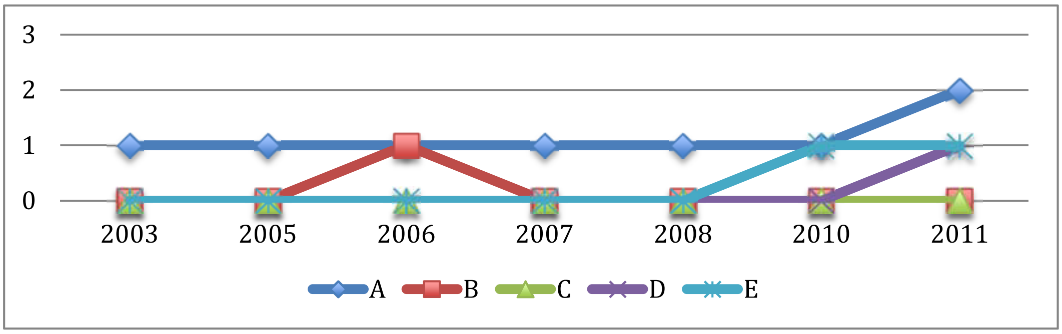


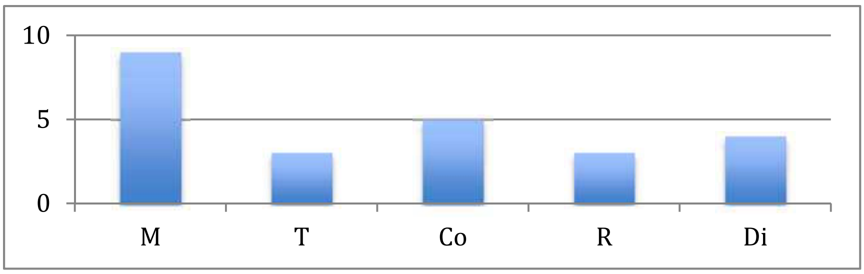
Figure V. 8 Dynamic trend of frequency of relevant specific regulations' appearance in ERPLC



- Statistic on liability

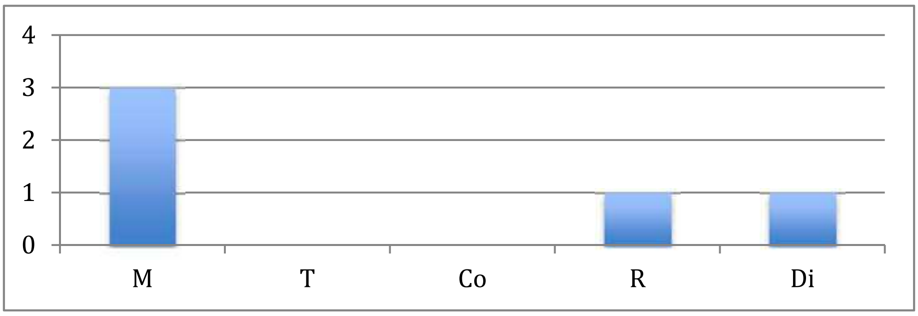
This statistic describes to which extent the generic laws and specific regulations pay attention to each mentioned environmental actor (EA) according to the frequency of these legislative documents' appearances concerning these EAs for liability. This statistic here is based on the existing legislative documents' content.

Figure V. 9 Frequency of relevant laws' appearance concerning each EA on liability



In figure V.9, we observe that manufacturer (M) is the most mentioned EA in these laws on the issue of liability by having 9 indications in these laws. Consumer takes the second place by having 5 indications in these laws.

Figure V. 10 Frequency of relevant regulations' appearance concerning each EA on liability



In figure V.10, we observe that manufacturer (M) is still the most mentioned EA in these regulations on the issue of liability by having 9 indications. Recycler and disposer take the second place by having only one indication; transporter and consumer are untouched by these regulations.

- Statistic on economic responsibility

This statistic describes to which extent the generic laws and specific regulations pay attention to each mentioned environmental actor (EA) according to the frequency of these legislative documents' appearances concerning these EAs for economic responsibility. This statistic here is based on the existing legislative documents' content.

In figure V.11, we observe that manufacturer (M) is the most mentioned EA in these laws on the issue of economic responsibility by having 4 indications in these laws. Disposer takes the second place by having 3 indications in these laws. Transporter, consumer and recycler are untouched in this case.

In figure V.12, we observe that manufacturer (M)'s place is predominant over all other EAs that have no frequency in these regulations on the issue of economic responsibility by having 1. This is due to the regulation that clearly attributes the economic responsibility of the WEEE to producer, "*Administrative measures of the* *collection and use of the fund for waste electrical and electronic equipment's disposal*", which is just implemented in 2011.

Figure V. 11 Frequency of relevant laws' appearance concerning each EA on economic responsibility

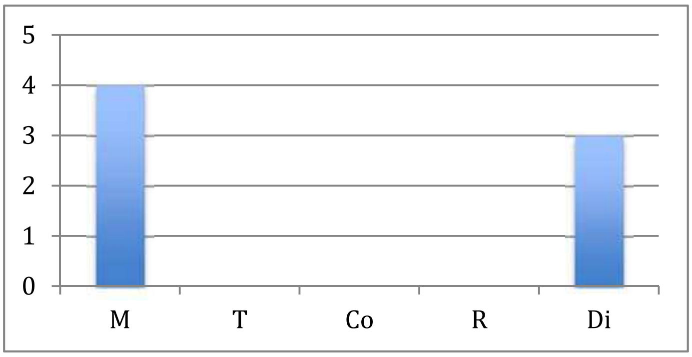
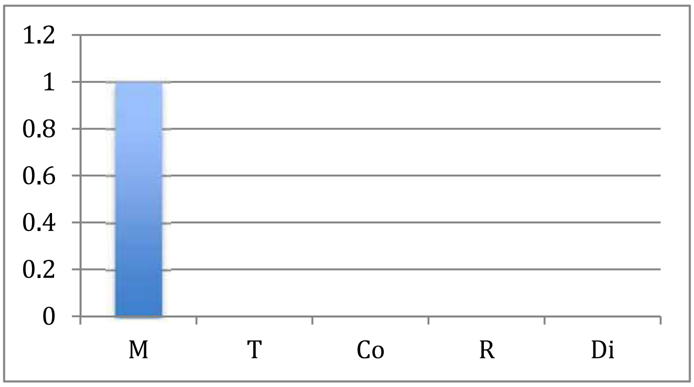


Figure V. 12 Frequency of relevant regulations' appearance concerning each EA on economic responsibility

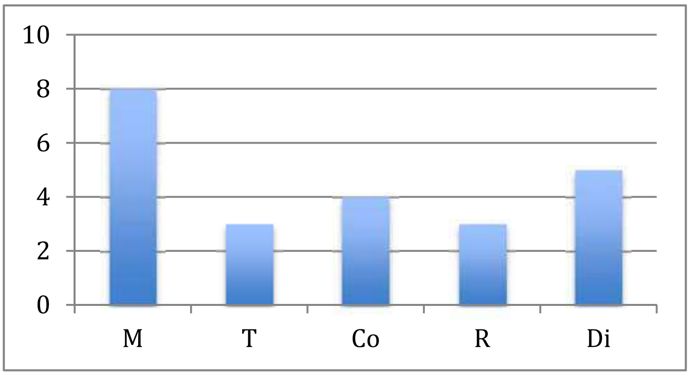


- Statistic on physical responsibility

This statistic describes to which extent the generic laws and specific regulations pay attention to each mentioned environmental actor (EA) according to the frequency of these legislative documents' appearances concerning these EAs for physical responsibility. This statistic here is based on the existing legislative documents' content.

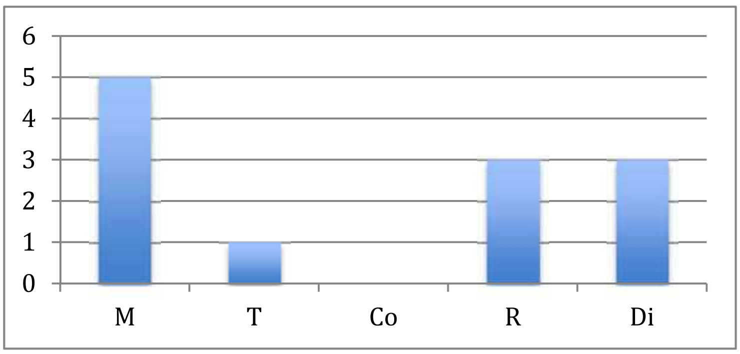
In figure V.13, we observe that manufacturer (M) is the most mentioned EA in these laws on the issue of physical responsibility like always by having 8 indications in these laws. Disposer takes the second place by having 5 indications in these laws. Though transporter, consumer and recycler are relatively less regarded in this case, but still have non-null results (3, 4, 3 respectively).

Figure V. 13 Frequency of relevant laws' appearance concerning each EA on physical responsibility



In figure V.14, we observe that manufacturer (M) is the most mentioned EA in these regulations once again on the issue of physical responsibility by having 5 indications. Recycler and disposer take the second place by having three indications everyone; one for transporter and no frequency for consumer in these regulations for this case.

Figure V. 14 Frequency of relevant regulations' appearance concerning each EA on physical responsibility

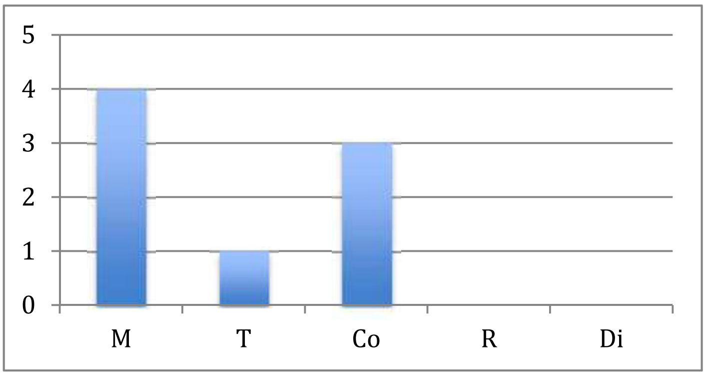


- Statistic on ownership

This statistic describes to which extent the generic laws and specific regulations pay attention to each mentioned environmental actor (EA) according to the frequency of these legislative documents' appearances concerning these EAs for ownership. This statistic here is based on the existing legislative documents' content.

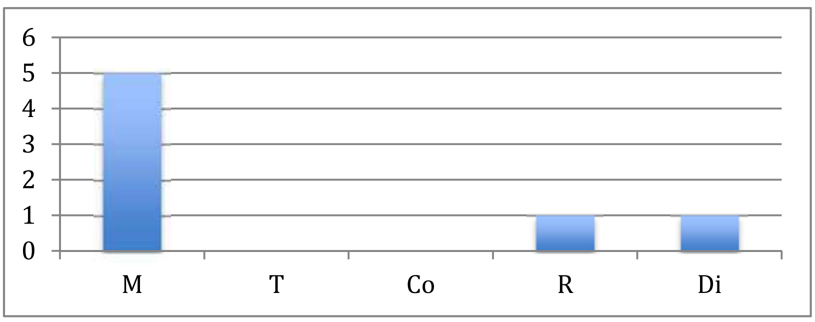
In figure V.15, we observe that manufacturer (M) is the most mentioned EA in these laws on the issue of ownership by having 4 indications in these laws. Consumer takes the second place by having 3 indications in these laws. Transporter has one frequency. Disposer and recycler are untouched in this case.

Figure V. 15 Frequency of relevant laws' appearance concerning each EA on ownership



In figure V.16, we observe that manufacturer (M) is the most mentioned EA in these regulations once again on the issue of ownership by having 5 indications. Recycler and disposer take the second place by having one indication everyone; transporter and consumer are untouched in this case.

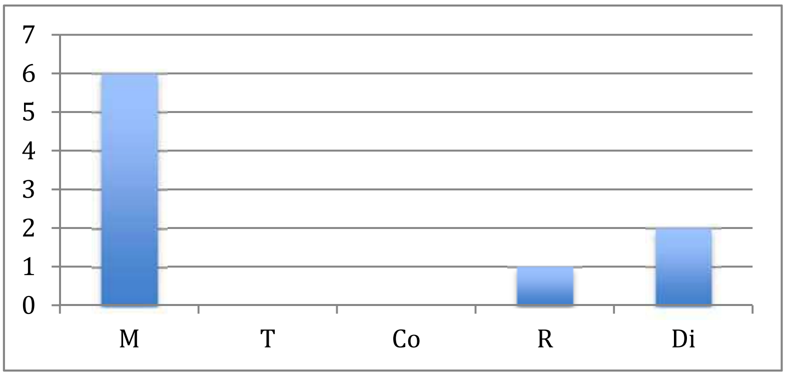
Figure V. 16 Frequency of relevant regulations' appearance concerning each EA on ownership



- Statistic on informative responsibility

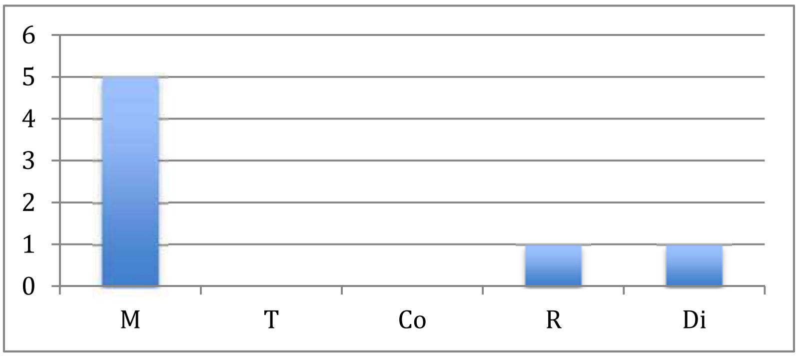
This statistic describes to which extent the generic laws and specific regulations pay attention to each mentioned environmental actor (EA) according to the frequency of these legislative documents' appearances concerning these EAs for informative responsibility. This statistic here is based on the existing legislative documents' content.

Figure V. 17 Frequency of relevant laws' appearance concerning each EA on informative responsibility



In figure V.17, we observe that manufacturer (M) is the most mentioned EA in these laws on the issue of informative responsibility by having 6 indications in these laws. Disposer takes the second place by being mentioned twice, recycler is mentioned once. Consumer and transporter are untouched in this case.

Figure V. 18 Frequency of relevant regulations' appearance concerning each EA on informative responsibility



In figure V.18, we observe that manufacturer (M) is the most mentioned EA in these regulations once again on the issue of informative responsibility by having 5 indications. Recycler and disposer take the second place by having one indication everyone; transporter and consumer are untouched in this case.

Section3. Conclusions

In practicing the upstream analysis on the main functions of administrative departments that considered as social planners about the issue of ICT industry's environmental problems, we observe that hypothesis 12 mentioned in part I is broken by the constraint of China's political administration system' complexity and repetitions of functions from different departments. This analysis shows the inconsistency existing among policy-making strategies by different departments about solving the environmental problems of ICT industry. This objective inconsistency coming from the shortage of political administration system could have impact on the condition that social planners make the policy as one.

By extending relevant responsibilities that originally focused on producer to the scope of all parts of product's life cycle, we find that NDRC and MOF's perspective is compatible with the perspective of other departments in most cases for their key positions: one for comprehensive policy planning and the other for general fund planning; divergence of policy-making strategy emerges between MIIT and MEP for liability, economic responsibility, physical responsibility and informative responsibility, by contributing these responsibilities to different economic agents with their attention to respective different part of life cycle; MOFCOM also has different strategy with MIIT for policy-making about the economic responsibility.

After the upstream analysis, we deployed the downstream analysis, which studies the relevant domestic laws and regulations' partial even full content according to different parts of life cycle and different responsibilities to check the eventual inconsistency of policy-making.

By the policy-making downstream analysis, we find that:

- For laws

Generally, social planners focus mostly on environmental impact generated during production process, and secondly on this generated during the end of life. Dynamically, we observe that since recent years the end of life attracts more attention of social planners with environmental problems due to the wastes becoming more important concern. About the environmental reaction, the policy-making strategy is revealed to be more pragmatic that the greatest attention is attributed to the production process. The use phase and the transport are the less considered in these laws making.

These findings tell that the production process is the phase the most considered in subject of environmental impact and environmental reaction for laws making, and end of life is the phase where we observe the increasing attention in subject of environmental impact. It may be expected that the end of life will be paid more attention in the future as the part of life cycle where policy makers intend to emphasize on related agents' environmental reaction to improve the environmental management.

- For specific regulations

Regulations are made in frame of laws and drafted as actionable. The study on these relevant regulations could reveal the of policy-making's core information. By statistical results, we find the different phenomenon compared to the case of laws: the end of life takes the most important place in subject of environmental impact from both general perspective and dynamic perspective, and the negligible place in subject of environmental reaction from both general perspective and dynamic perspective.

- For relevant responsibilities

In this study we find that laws are more active than specific regulations concerning all the correspondences between responsibilities and environmental actors. This could be explained that the specific regulations' drafting meets more difficult considering their role. Manufacturer is primarily focused as the liable for all these responsibilities in the contents of laws and regulations; the remarkable point is that manufacturer is taken as unique liable for the economic responsibility in these mentioned specific regulations.

This matches well to the trend of policy-making principle toward the extended producer's responsibility (EPR).

PART VI - ICT PRODUCERS' ENVIRONMENTAL REACTIONS - ATTITUDES AND ACTIONS

After discussing the environmental impact of ICT products through the life cycle, the ICT industry's development in China and the analysis of social planners' strategy of policy-making by the upstream view and the downstream view, we are stepping into the analysis of producers' environmental reactions to see how the policies impact on producers' attitudes and activities according to social planners' strategy concluded in part V.

According to Cui and Forssberg (2003), the production of electrical and electronic equipment (EEE) is one of the fastest growing areas; Petrus Kautto and Matti Melanen (2004) studied the responses from producers to WEEE policy in Finland，and R. Casagrandi, G. Guariso (2009) found that frequency of occurrence of many information technologies increased at significantly higher rates in the environmental studies than in the general sciences.

In this part, we study producers' environmental reactions based on this survey under the frame of series of workshops of Switch-Asia program. A questionnaire is established and distributed to enterprises during workshop, and reoccupied after formation.

Questions are posed to interviewed enterprises about their attitudes and activities on environmental issues. These questions are organized by following product's life cycle, and by considering related responsibilities.

In our study, we intend to analyze the correlation between enterprises' geographical (location information of headquarters, R&C center, main target market and production plants) and economical force's information (position in production chain), and, their attitudes and activities about environmental problems. Although the questionnaire does not require these enterprises' geographical and economical force's information, we still dig these information from their website. The related geographical information of these surveyed enterprises includes: headquarters location, R&D

location and production plant location. The geographical zones are recognized as: North-China, East-China, Central-China, West-China and South-China.

In this part, firstly we deploy the analysis in a general view: to study these interviewed enterprises' attitudes on the importance of different environmental measures by ordering them, and to analyze enterprises' investment on environmental improvement; secondly, we advance the research on enterprises' attitudes and activities in respect of different parts of ICT product's life cycle.

Section 1. General discussion

1.1 Analysis of correlation between environmental measures' ordering and ICT enterprises' geographical situation - general attitude

In the questionnaire, surveyed enterprises are required to order the importance of different environmental measures: **a.**to set up the overall environmental management system; **b.**to reduce the hazardous substance contented in product; **c.**to promote eco-design; **d.**to debate the discharge of "three wastes" (waste gas, waste water and waste residues); **e.**to develop green marketing; **f.**to promote energy-saving; **g.**to develop new energy exploration; **h.**to develop waste recycling; **i.**to develop comprehensive use of resources. The order decreases from 1 to 9, indicating that the number increases with order decreasing.

Among the 68 focused enterprises, 39 enterprises have ordered the 9 environmental measures and the result is presented in the following table. It's also found that the domestic operators are the focal companies within the Chinese ICT supply network, which is compatible with the result in work of Lei Yu et al. (2008).

Table VI. 1 Enterprises' ordering for 9 environmental measures

Enterprise	a	b	c	d	e	f	g	h	i
1	1	2	3	4	5	6	7	8	9
2	5	1		3		2			4
3	4			2		1		5	3

Enterprise	a	b	c	d	e	f	g	h	i
4	4	1	5	3		2		6	
5	6	1		4		2	3		5
6	1								
7	5	1	6	4	7	2	3	8	
8									
9	1	5	7	2		4	6		3
10	5	1	7	3	6	2		8	4
11					2		1	3	
12	5	2	7	8	6	1	9	4	3
13	3	2	4		8	1	5	6	7
14			2		3	1			
15	4		5	2	6	1			3
16						1		2	
17		1	4	3		2		5	
18						1			
19						1			
20		1		3			2		
21	4	1	5	6		2		7	3
22	1	5	2	6	8	7	8	4	3
23	1	8	2	5	3	4	9	6	7
24	1	3				2			
25	7	2	8	1	9	5	4	3	6
26	1	4	3	8	2	7	5	9	6
27	1	5	8	2	9	4	7	3	6
28	1	7	3	4	6	5	2	8	
29		3	2	4		1			
30	1	4	7	3	9	2	6	8	5
31	1	6	4	2	7	5	8	9	3
32	1	7	2	6	5	3		8	4
33	1	2	4	3				5	
34	3	1	2	6	9	5	7	8	4
35	7	1	8	2	6	3	4	9	5
36						1			
37	1			4		3		5	2
38	1								
39	7	1	3	8	6	2	5	9	4

We are mostly interested in finding out the eventual relationship between the ordering of these measures and enterprise's geographical information. Here, we focus on enterprises' headquarters location and production plants location. For each environmental measure, we study the correlation between the order given by each enterprise and the spatial distribution of location of enterprise's headquarters and of production plant. The geographical order is defined as: East-China (including Beijing)=1; South-China =2; Central-China=3; West-China=4; North-China=5. This order respects the scale of region's economic development level: the East-China is the most developed region, and West-China and North China are far behind.

We made two kinds of correlation study, one between the order given by enterprises for each measure and the location of enterprises' headquarters, the other one between the order given by enterprises for each measure and the location of enterprises' production plant. The study of correlation between the order given by enterprises for each measure and the location of enterprises' R&D center is absent because of the lack of enough related information.

Most of the 18 results (9×2) demonstrate very weak correlation, but 4 among them appear the correlation with significance lower than 10%, and 2 of them with significance lower than 5%.

Table VI. 2 Correlation between order for "*to develop waste recycling*" and headquarters location

		Headquarters	Waste-Rec
Headquarters	Pearson correlation	1	.368*
	significance (two sides)		.070
	N	39	25
Waste-Rec	Pearson correlation	.368*	1
	significance (two sides)	.070	
	N	25	25

Note: Waste-Rec = waste recycling; *. At confidence level of 0.1

Result from table VI.2 tells that the ICT manufacturer decrease the order of "to develop waste recycling" as environmental measure when headquarters is situated farther inside from the costal region of Mainland China, the correlation rate is about 0.37. In other words, the ICT enterprises with headquarters situated in regions economically more developed will pay more attention on the waste recycling than those with headquarters situated in regions economically left behind.

Table VI. 3 Correlation between order for "*to develop comprehensive use of resources*" and headquarters location

		Headquarters	Comp-use
Headquarters	Pearson correlation	1	.411*
	significance (two sides)		.058
	N	39	22
Comp-use	Pearson correlation	.411*	1
	significance (two sides)	.058	
	N	22	22

Note: Comp-Reuse = comprehensive use; *. At confidence level of 0.1

Table VI. 4 Correlation between order for "*to promote energy-saving*" and production plants location

		Production	Energy-Saving
Production	Pearson correlation	1	.406*
	significance (two sides)		.019
	N	39	33
Energy-Saving	Pearson correlation	.406*	1
	significance (two sides)	.019	
	N	33	33

*. At confidence level of 0.05

In table VI.3, we obtain the result that presents the positive correlation with rate of about 0.41 and the significance level lower than 10%. This result indicates the eventual positive relation between enterprise's ordering for "*to develop comprehensive use of resources*" and headquarters location. This means that ICT enterprises with headquarters situated in more economically developed regions pays more attention on comprehensive use of resources than those with headquarters situated in regions economically left behind.

Table VI. 5 Correlation between order for "*to develop waste recycling*" and

production plants location

		Production	Waste-Rec
Production	Pearson correlation	1	.408*
	significance (two sides)		.043
	N	39	25
Waste-Rec	Pearson correlation	.408*	1
	significance (two sides)	.043	
	N	25	25

*. At confidence level of 0.05

Table VI.4 and table VI.5 gives the correlation results with the confidence level 5% that is higher than the results with headquarters with confidence level 10%.

Table VI.4 tells that the ICT manufacturer decrease the order of "to promote energy-saving" as environmental measure when production plants are situated farther inside from the costal region of Mainland China, the correlation rate is about 0.4. In other words, the ICT enterprises with production plants situated in regions economically more developed will pay more attention on energy-saving than those with production plants situated in regions economically left behind.

In table VI.5, we obtain the result that presents the positive correlation with rate of about 0.41 and the significance level lower than 5%. This result indicates the eventual positive relation between enterprise's ordering for "*to promote wastes recycling*" and production plants location. This means that ICT enterprises with production plants situated in more economically developed regions pays more attention on comprehensive use of resources than those with production plants situated in regions economically left behind.

1.2 Analysis of correlation between environmental measures' ordering and ICT enterprises' environmental investment - general action

In the questionnaire, enterprises are required to tell the share of investment on each measure for environmental improvement in the total environmental investment. These investments according to different measures include: **p.** investment on equipment for pollution control; **q.** investment on eco-design; **r.** investment on standard authentication and formation; **s.** investment on green marketing; **t**. investment on establishing products recycling system. The order of regions is identic with that in 1.1

for the analysis here. 17 enterprises among 68 interviewed ones offered available data. The result is given in the following table.

Similar to the analysis in 1.1, we made two kinds of correlation study, one between the weight of investment on environmental measure and the location of enterprises' headquarters, the other one between the weight of investment on environmental measure and the location of enterprises' production plant. The study of correlation between the weight of investment on environmental measure and the location of enterprises' R&D center is absent because of the lack of enough related information.

Most of the 10 results (5×2) demonstrate very weak correlation, but 2 among them appear the correlation with significance lower than 10%.

Table VI. 6 Enterprises' investments share of 5 environmental measures in total environmental investment

Enterprise	p(%)	q(%)	r(%)	s(%)	t(%)
1	88.4	0	0.4	0	11.2
2	11	64	2	1	22
3	30	50	5	5	10
4	91.5	0	8.5	0	0
5	10.3	47.2	2.1	7	26.5
6	0	45	20	25	0
7	10	70	5	10	5
8	41	20	10	20	9
9	4	2	0.5	0.5	0
10	39	10	10	8	15
11	58	15	10	4	11
12	30	20	10	10	30
13	30	0	10	0	5
14	20	30	30	10	10
15	32.1	0	8.3	0	0
16	20	20	10	20	20
17	30	30	20	10	10

In table VI.7, we observe that there exists negative correlation rate about -0.43 between the weight of investment on standard authentication and formation and enterprises' production plants' location. This result indicates the eventual trend that the more inside of the Mainland China the production plants are situated, the less the enterprises invest on standard authentication and formation.

In table VI.8, we observe that there exists negative correlation rate about -0.45 between the weight of investment on green marketing and enterprises' production plants' location. This result indicates the eventual trend that the more inside of the Mainland China the production plants are situated, the less the enterprises invest on green marketing.

Table VI. 7 Correlation between investment on "*investment on standard authentication and formation*" and headquarters location

		Production	Standard-Authentication & formation
Production	Pearson correlation	1	-.433*
	significance (two sides)		.083
	N	17	17
Standard- Authentication & formation	Pearson correlation	-.433*	1
	significance (two sides)	.083	
	N	17	17

*. At confidence level of 0.1

Table VI. 8 Correlation between investment on "*investment on green marketing*" and production plants location

		Production	Green Marketing
Production	Pearson correlation	1	-.451*
	significance (two sides)		.069
	N	17	17
Green Marketing	Pearson correlation	-.451*	1
	significance (two sides)	.069	
	N	17	17

*. At confidence level of 0.1

1.3 Surveyed enterprises' attitudes and activities about environmental information release

There are 7 questions about these 68 surveyed enterprises' attitudes and activities about environmental information release.

- Attitude:

- Does your company consider the eco-information transparency as one of company's social responsibilities?
- Does your company support the right of the citizen to access to environmental information?
- Does your company support the legislation to guarantee the right of the citizen to access to environmental information?
- Does your company agree with open and transparent system of environmental information?
- Does your company consider that the environmental policies are enough open in China?

- Action:

- Does your company release the environmental information?
- What is the way for your company's environmental information release?

We mention that for the last question, we consider that the release of environmental information on internet website is the active way and we note it as "yes" indicating its positive sense, and, the release of environmental information by traditional way (especially official way) or even no release is the passive way and we note it as "no" indicating its negative sense. We sum the answers by obtaining the following statistic.

From the figure above, we observe that the situation is almost optimist. For each question, the positive answer overwhelms the negative answer among these ICT enterprises. For the questions on attitudes, enterprises show a considerable increase in their negative answer for the last one - "*Does your company consider that the environmental policies are enough open in China?*". For this question, we consider the statistic of the 22 enterprises' position in the production chain for the negative answer is of some value, and we detail it as follow.

Figure VI. 1 Statistic of enterprises' attitudes and activities about environmental information release

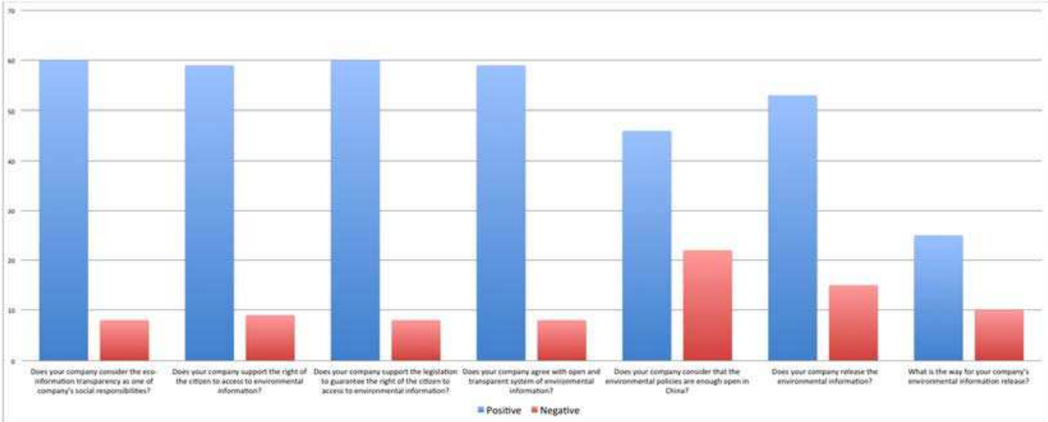


Figure VI. 2 Statistic of enterprises' attitudes about the openness of Chinese environmental policies - weight according to position on production chain

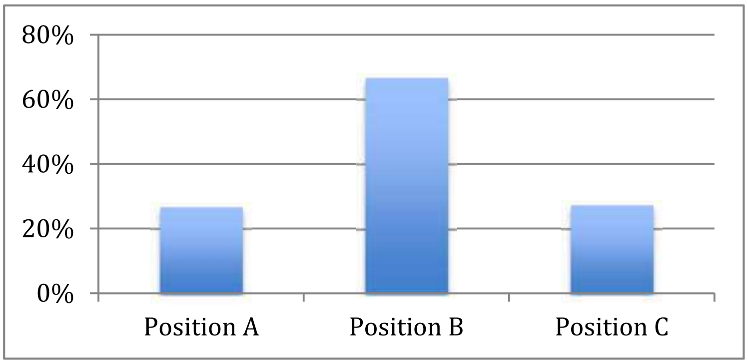
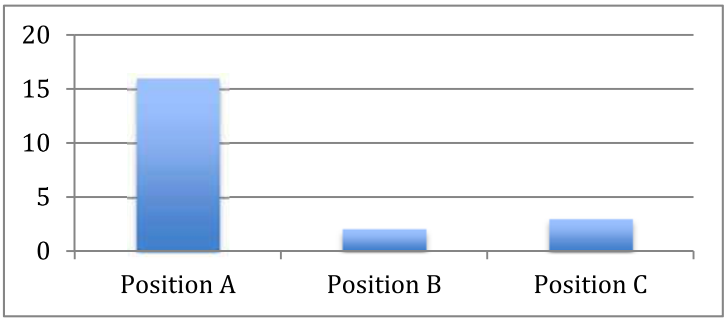


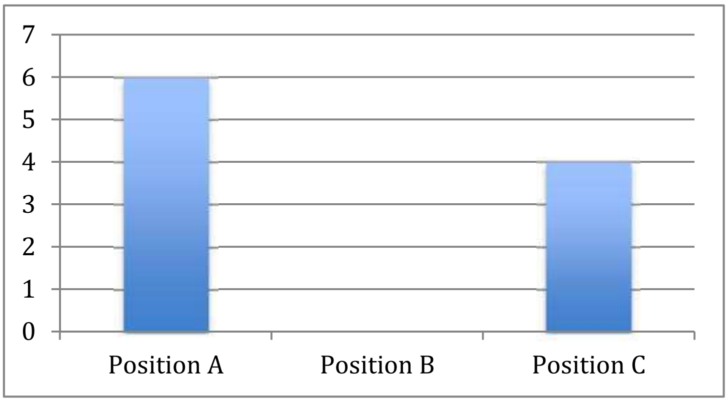
Figure VI. 3 Statistic of enterprises' attitudes about the openness of Chinese environmental policies - units according to position on production chain



In figure VI.2 and figure VI.3, we note position A for the brand manufacturer (BM), position B for the original equipment manufacturer (OEM), and position C for the production material supplier (PMS) observe that from the absolute units, most of the enterprises giving “no” are the BM being on the downstream of the production chain (position A); but from the weight, we see that the OEM takes the most important place (2 on 3 or about 67%), as BM and PMS present the same proportion for this “no”. This phenomenon could at least tell one thing: the PMSs on the downstream of the production chain are the least important group holding negative impression for the openness of Chinese environmental policies. The reason may be that the PMSs are in the passive position to be controlled by various environmental standards conducted from BM or OEM.

For the questions on activities, we detail the statistic according to these surveyed enterprises’ position on the production chain and the geographically related information.

Figure VI. 4 Statistic of enterprises that release environmental information by conservative way - units according to position on production chain



From figure VI.3, it’s evident that among the enterprises that chose to release environmental information by conservative way, most are brands and suppliers, we don’t observe OME in this case.

We summarize the statistics above in table VI.9, together with related geographical information.

In table VI.9, we note that among the 43 available responses, most of them give the positive response, and no foreign brand chooses the conservative way to release environmental information; unique oversea market are few focused for all these responders; all responders' headquarterss and R&D centers are mainly located in more developed regions, as production plants are more proportionally distributed for the responders of "open" than for those of "conservative". These results reveals one important information that ICT enterprises implementing part of their production plants in regions falling behind could be those more open for releasing environmental information.

Table VI. 9 Statistic - the way of information release

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Open	25	21	1	3	
Conservative	8	4	0	4	
Response	Brand Nationality		Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Open	20	5	7	3	11
Conservative	8	0	6	1	1
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Open	14	8	0	1	0
Conservative	5	2	1	0	0
Response	R&D location				
	East-China	South-China	Central-China	West-China	North-China
Open	7	7	0	0	0
Conservative	6	1	1	0	0
Response	Production location				
	East-China	South-China	Central-China	West-China	North-China
Open	12	13	4	7	4
Conservative	4	2	3	0	0

1.4 Conclusions for the general analysis

In this section, we analyzed the correlation between environmental measures' ordering and ICT enterprises' geographical situation that is considered as the general analysis of enterprises' attitudes toward the environmental management, and the correlation between investment on environmental measures and ICT enterprises' geographical situation that is considered as the general analysis of enterprises' action on the environmental measures.

By the available results, we find the consistency between the two analyses for some environmental measures. For attitude, enterprises with headquarters and production plants situated in economically more developed regions are more aware about the waste recycling, comprehensive use of resources and energy saving than enterprises with headquarters and production plants situated in regions economically left behind; for action, enterprises with headquarters and production plants situated in economically more developed regions investment more on standard authentication & formation and green market than enterprises with headquarters and production plants situated in regions economically left behind.

From the perspective of product's life cycle, these results reflect the fact that for attitude, enterprises are more aware about the end part (waste recycling), the upstream (comprehensive use of resources) and the use part (energy saving) of product's life cycle if their headquarters and production plants are situated in economically more developed regions; for action, enterprises prefer to invest on standard authentication & formation and green marketing, if, the production plants are situated in economically more developed regions.

The observation from the analysis on attitude reveals the information that enterprises may be expected to do more environmental efforts on upstream of production process, end of life, and energy saving in the future. This phenomenon matches well the present action they are applying, investing more on standard authentication & formation and green marketing, which could be considered as preparation for their intention we just observed.

For the information release, we observe the optimistic situation in general view. More ICT manufacturers choose the open way to release their environmental information, especially with those who install part of their production plants in less developed inner regions. This could also be possible that enterprises express their attitudes in very general view.

In the following, we continue to analyze the data collected with the survey from perspective of relevant responsibilities and different parts of product's life cycle, under geographical condition.

Section 2 Analysis from perspective of different parts of life cycle

2.1 Material purchase

In this part, we study the statistic of ICT enterprises' environmental management at the source - the control on the material selection. Three questions are posed to enterprises: First, does manufacturer possess the management system for green supply chain in the purchase stage? Second, does the present material management system satisfy RoHS of EU? Third, does the present material management system satisfy the REACH of EU?

Table VI. 10 Statistic - Does Manufacturer possess the management system for green supply chain in the purchase stage

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Yes	48	47	1	7	
No	13	7	2	3	
Response	Brand Nationality		Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Yes	42	6	23	6	17
No	13	0	7	2	4
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Yes	31	14	0	1	0
No	7	3	1	1	1
Response	R&D location				
	East-China	South-China	Central-China	West-China	North-China
Yes	24	10	0	0	0
No	8	5	1	2	0

Response	Production location				
	East-China	South-China	Central-China	West-China	North-China
Yes	28	21	8	10	5
No	7	5	3	3	2

In table VI.10, 51 among the 68 interviewed enterprises give their responses. Most of these responses are positive (48 for Yes versus 13 for No); the concentration on position A appears for both positive responders and negative responders (47 for Yes and 7 for No), with negative responders less concentrated on position A; all foreign enterprises are positive responders (6 for Yes); domestic market is still the main focused one for both positive and negative responders; the evident concentration on economically more in developed regions for both positive responders and negative responders is embodied by both headquarters and R&C center' location; yet, the geographical distribution of production plants are more balanced among the developed regions and distressed regions for both responders.

Table VI. 11 Statistic - Does the present material management system satisfy RoHS of EU

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Yes	45	44	1	7	
No	13	7	1	4	
Response	Brand Nationality		Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Yes	40	5	23	6	16
No	13	0	9	1	3
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Yes	27	14	1	1	0
No	8	3	0	1	1
Response	R&D location				
	East-China	South-China	Central-China	West-China	North-China
Yes	21	10	1	0	0

Response					
No	10	4	0	2	0
Response	Production location				
	East-China	South-China	Central-China	West-China	North-China
Yes	26	20	8	9	5
No	9	5	2	3	2

In table VI.11, 58 among the 68 interviewed enterprises give their responses. Most of these responses are positive (45 for Yes versus 13 for No); the concentration on position A appears for both positive responders and negative responders (37 for Yes and 11 for No); all foreign enterprises are positive responders (5 for Yes); domestic market is still the main focused one for both positive and negative responders; the evident concentration on economically more in developed regions for both positive responders and negative responders is embodied by both headquarters and R&C center' location; yet, the geographical distribution of production plants are more balanced among the developed regions and distressed regions for both responders.

Table VI. 12 Statistic - Does the present material management system satisfy REACH of EU

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Yes	38	37	1	5	
No	19	11	2	5	
Response	Brand Nationality		Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Yes	33	5	19	6	12
No	19	0	11	2	6
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Yes	24	12	1	0	0
No	12	4	0	1	1
Response	R&D location				
	East-China	South-China	Central-China	West-China	North-China
Yes	17	9	1	0	0

No	14	6	0	2	0
Response	Production location				
	East-China	South-China	Central-China	West-China	North-China
Yes	24	19	7	8	5
No	10	6	2	3	2

In table VI.12, 57 among the 68 interviewed enterprises give their responses. Most of these responses are positive (48 for Yes versus 13 for No); the concentration on position A appears for both positive responders and negative responders (47 for Yes and 7 for No), with negative responders less concentrated on position A; all foreign enterprises are positive responders (6 for Yes); domestic market is still the main focused one for negative responders, and for positive responders, their market is more international; the evident concentration on economically more in developed regions for both positive responders and negative responders is embodied by both headquarters and R&C center' location; yet, the geographical distribution of production plants are more balanced among the developed regions and distressed regions for both responders.

From the statistic just presented, we observe the consistency among the three statistics: positive response dominates these responders, especially for the foreign brands, this means that generally ICT manufacturers manifest active actions at the source, by establishing BOM system and respecting European RoHS and REACH. These enterprises' headquarters and R&D center are mostly situated in more developed regions, and their production plants' geographical distribution is more balanced by arranging considerable part in distressed regions.

2.2 The use phase of life cycle - energy saving

For the question "does the products have been authenticated by Chinese Energy-Saving Standard", 44 among the 68 interviewed enterprises have given clear responses. Among these responders, most of them are situated on position A of the production chain, as few are situated on position B; all foreign brands have given

"Yes"; unique domestic market and international market are the main focused for both positive and negative responders; in this case, both positive and negative responders' headquarters and R&D centers are mainly concentrated in economically more developed regions, as their production plants have more proportional distribution among these regions, and positive responders have important numbers of production plants situated in West-China (10).

In table VI.14, we observe that for the question "does the products have been authenticated by any Energy-Saving Standard out of China", 43 among the 68 interviewed enterprises have given clear responses. Among these responders, most of them are situated on position A of the production chain, as few are situated on position B; all foreign brands have given "Yes"; unique domestic market and international market are the main focused for both positive and negative responders; in this case, both positive and negative responders' headquarters and R&D centers are mainly concentrated in economically more developed regions, as their production plants have more proportional distribution among these regions, and positive responders have important numbers of production plants situated in West-China (8).

Table VI. 13 Statistic - Have products been authenticated by Chinese Energy-Saving Standard

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Yes	33	27	2	4	
No	11	6	0	4	
Response	Brand Nationality		Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Yes	28	5	19	2	11
No	11	0	5	1	5
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Yes	22	7	0	1	1
No	6	3	1	1	0
Response	R&D location				
	East-China	South-China	Central-China	West-China	North-China

Yes	18	8	0	1	0
No	7	1	1	1	0
Response	Production location				
	East-China	South-China	Central-China	West-China	North-China
Yes	21	16	6	10	5
No	6	3	2	2	1

Table VI. 14 Statistic - Have the products been authenticated by any Energy-Saving Standard out of China

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Yes	29	23	2	4	
No	14	10	0	3	
Response	Brand Nationality		Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Yes	23	6	14	2	12
No	14	0	8	1	5
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Yes	17	9	0	0	1
No	10	2	1	1	0
Response	R&D location				
	East-China	South-China	Central-China	West-China	North-China
Yes	15	10	0	1	0
No	9	1	1	1	0
Response	Production location				
	East-China	South-China	Central-China	West-China	North-China
Yes	17	16	4	8	4
No	8	4	4	3	2

2.3 Production process

For this part of life cycle, the questionnaire posed one question "does manufacturer take the pollution control measurements through the production process" to interviewed enterprises, and almost all of them have given their response (67of 68).

In table VI.15, we observe that most responders are positive, 55 "Yes" against 12 "No"; both kinds of responders are concentrated on the position A of production chain;

all foreign brands are positive responders; important part of positive responders focus uniquely on the domestic market, and negative responders target markets are proportionally allocated; once again, headquarters and R&D centers are mostly situated in more developed regions for both positive and negative responders, as great part of production plants of both the two appear in distressed regions.

From statistic in table VI.13 and in table VI.14, consistency is found for the enterprises' activities about product's energy saving which has environmental impact on the use stage. Most of these enterprises' products are authenticated by Chinese energy saving standard and foreign energy saving standard. Headquarters and C&D centers of both positive and negative responders are concentrated in economically more developed regions, but considerable part of their production plants are located in distressed regions, especially in West-China.

Table VI. 15 Statistic - Does manufacturer take the pollution control measurements through the production process?

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Yes	55	52	1	9	
No	12	7	2	2	
Response	Brand Nationality		Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Yes	49	6	31	6	17
No	12	0	6	2	4
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Yes	36	15	1	1	0
No	6	4	0	1	1
Response	R&D location				
	East-China	South-China	Central-China	West-China	North-China
Yes	30	10	1	0	0
No	7	6	0	2	0
Response	Production location				
	East-China	South-China	Central-China	West-China	North-China

Yes	33	22	9	10	5
No	6	6	2	3	2

Situation is positive for this stage of life cycle: most of these interviewed enterprises respect relevant regulations by making pollution control through production process. Just as for precedent cases, most of them have their brain - headquarters and R&D centers - situated in more developed regions, as their arms - production plants - are situated more proportionally among regions.

2.4 Marketing

In this part of life cycle, the only one posed question in the questionnaire is “does manufacturer orient consumers' attention on product's environmental quality”. 63 of the 68 interviewed enterprises give available response.

Table VI. 16 Statistic - Does manufacturer orient consumers' attention on product's environmental quality?

Response	Number of Manufacturers	Position on production chain			
		A	B	C	
Yes	50	46	1	8	
No	13	8	2	2	
Response	Brand Nationality		Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Yes	44	6	26	6	17
No	13	0	7	2	4
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Yes	31	14	1	1	1
No	6	5	0	1	1
Response	R&D location				
	East-China	South-China	Central-China	West-China	North-China
Yes	27	9	1	0	1
No	7	7	0	2	0
Response	Production location				

	East-China	South-China	Central-China	West-China	North-China
Yes	29	20	9	10	5
No	6	7	2	3	2

In table VI.16, we observe that most responders are positive, 50 “Yes” against 13 “No”; both kinds of responders are concentrated on the position A of production chain; all foreign brands are positive responders; both positive responders and negative responders have great part of them focusing on the unique domestic market are proportionally statistically allocated; once again, headquarters and R&D centers are mostly situated in more developed regions for both positive and negative responders, as great part of production plants of both the two appear in distressed regions.

Situation is positive for this stage of life cycle: most of these interviewed enterprises pay attention to green marketing. Similar to precedent results, most of them have their brain - headquarters and R&D centers - situated in more developed regions, whereas their arms - production plants - are situated more proportionally among regions.

2.5 Eco-design

Eco-design is key issue for today’s ICT innovation and policy-making. This part of life cycle is like the design of gene, which decide crucially product’s environmental impact through its life cycle. Two related questions are posed in questionnaire: “does manufacturer put environmental impact factor into product's design” and “Does manufacturer put energy-saving factor into product's design”.

In table VI.17, 67 of the 68 interviewed enterprises give response. We observe that most responders are positive, 56 “Yes” against 11 “No”; most of both kinds of responders are situated on the position A of production chain; all foreign brands (6) are positive responders; the unique domestic market, the unique oversea market and international market are proportionally focused by both positive responders and negative responders; once again, headquarters and R&D centers are mostly situated in economically more developed regions for both positive and negative responders, whereas great part of production plants of both the two appear in distressed regions.

Situation is positive for this stage of life cycle: most of these interviewed enterprises pay attention to integrating the environmental factor into product's design. Similar to precedent results, most of them have their brain - headquarters and R&D centers - situated in more developed regions, as their arms - production plants - are situated more proportionally among regions.

In table VI.18, all of the 68 interviewed enterprises give response. We observe that most responders are positive, 52 "Yes" against 16 "No"; most of both kinds of responders are situated on the position A of production chain; all foreign brands (6) are positive responders; the unique domestic market, unique oversea market and international market are proportionally focused by both positive responders and negative responders; similar to precedent case, headquarters and R&D centers are mostly situated in economically more developed regions for both positive and negative responders, whereas great part of production plants of both the two appear in distressed regions.

Table VI. 17 Statistic - does manufacturer integrate environmental impact factor into product's design?

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Yes	56	44	2	10	
No	11	5	2	3	
Response	Brand Nationality		Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Yes	50	6	29	7	17
No	11	0	4	3	4
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Yes	35	16	1	1	1
No	6	3	0	1	1
Response	R&D location				
	East-China	South-China	Central-China	West-China	North-China
Yes	30	11	1	0	1
No	7	5	0	2	0

Response	Production location				
	East-China	South-China	Central-China	West-China	North-China
Yes	33	23	10	10	5
No	6	5	2	3	2

Situation in this case is consistent with the precedent case, being positive for this stage of life cycle: most of these interviewed enterprises pay attention to integrating energy saving factor into product's design. Similar to precedent results, most of them have headquarters and R&D centers situated in more developed regions, as their production plants situated more proportionally among regions.

Table VI. 18 Statistic - Does manufacturer put energy-saving factor into product's design?

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Yes	52	41	2	9	
No	16	8	2	5	
Response	Brand Nationality		Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Yes	46	6	26	8	17
No	16	0	10	2	4
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Yes	31	16	1	1	1
No	11	3	0	1	1
Response	R&D location				
	East-China	South-China	Central-China	West-China	North-China
Yes	26	11	1	0	1
No	12	5	0	2	0
Response	Production location				
	East-China	South-China	Central-China	West-China	North-China
Yes	29	23	10	10	5
No	11	5	2	3	2

2.6 End of life

End of life is stage of ICT product’s life cycle that attracts more and more attention of policy maker. The trend of policy is to accentuate producer’s end of life management in order to stimulate the eco-design at the source. In the questionnaire, 5 questions are offered to interviewed enterprises, and the related statistics are presented in the following.

production chain; 4 foreign brands are positive responders and 1 foreign brand gives “No”; the unique domestic market, unique oversea market and international market are proportionally focused by both positive responders and negative responders; headquarters and R&D centers are mostly situated in economically more developed regions for both positive and negative responders, whereas great part of production plants of both the two appear in distressed regions，especially for negative responders. This table tells the fact that generally, it’s positive for making measures about used product’s recycling and disposal, and as before, geographically, these enterprises’ headquarters and R&D centers are located mostly in economically more developed regions, and their production plants are partly implemented in distressed regions.

Table VI. 19 Statistic - Does manufacturer build measures for used products' recycling and disposal?

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Yes	30	23	1	6	
No	19	16	1	3	
Response	Brand Nationality		Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Yes	26	4	17	4	9
No	18	1	11	1	7
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Yes	20	8	1	0	0
No	10	5	0	2	1
Response	R&D location				

	East-China	South-China	Central-China	West-China	North-China
Yes	19	6	1	0	0
No	10	6	0	2	0
Response	Production location				
	East-China	South-China	Central-China	West-China	North-China
Yes	17	11	3	3	1
No	9	8	3	7	4

In table VI.20, all of the 68 interviewed enterprises give response. We observe that most responders are negative responders with 55 “No” against 13”Yes”; most of both kinds of responders are situated on the position A of production chain; 4 foreign brands are positive responders and 1 foreign brand gives “No”; the unique domestic market, unique oversea market and international market are proportionally focused by both positive responders and negative responders; headquarters and R&D centers are extremely concentrated in economically more developed regions, especially no headquarter neither R&D center is situated in the three regions falling behind; whereas, great part of production plants of negative responders appear in distressed regions, yet it’s remarkable that no production plants of positive responders appears in these distressed regions.

Table VI. 20 Statistic - Does manufacturer build recycling system in China?

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Yes	13	7	2	4	
No	55	42	2	10	
Response	Brand Nationality		Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Yes	13	0	7	2	4
No	49	6	30	7	17
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Yes	10	2	0	0	0
No	32	17	1	2	2
Response	R&D location				
	East-China	South-China	Central-China	West-China	North-China

Yes	7	2	0	0	0
No	31	14	1	2	1
Response	Production location				
	East-China	South-China	Central-China	West-China	North-China
Yes	8	2	0	0	0
No	32	26	12	13	7

This table tells the fact that it's not optimistic for the action of building the recycling system by manufacture. Geographically, these only enterprises with headquarters, R&D centers and production plants located in economically more developed regions tell that they built the recycling system.

Table VI. 21 Statistic - Does manufacturer take responsibility of the disposal of his products?

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Yes	36	28	2	6	
No	31	21	2	7	
Response	Brand Nationality		Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Yes	31	5	18	5	12
No	30	1	19	4	8
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Yes	23	10	1	1	0
No	18	9	0	1	2
Response	R&D location				
	East-China	South-China	Central-China	West-China	North-China
Yes	19	6	1	0	0
No	18	10	0	2	1
Response	Production location				
	East-China	South-China	Central-China	West-China	North-China
Yes	20	13	5	6	1
No	19	15	7	7	6

In table VI.21, 67 of the 68 interviewed enterprises give response. We observe that positive responders and negative responders are almost balanced with 36 "Yes" against 31”No”; most of both kinds of responders are situated on the position A of production chain; 5 foreign brands are positive responders and 1 foreign brand gives “No”; the unique domestic market, unique oversea market and international market are proportionally focused by both positive responders and negative responders; geographically, these enterprises’ headquarters and R&D centers are located mostly in economically more developed regions, and their production plants are partly implemented in distressed regions.

From the above result, we can tell that for the disposal responsibility, the force of positively activated enterprises and passively activated enterprises are almost equilibrated. Their related geographical distributions are almost identic, with headquarters and R&D centers mostly located in developed regions and production plants located partly in distressed regions.

Table VI. 22 Statistic - Does manufacturer possess already the battery recycling system if the products function with battery?

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Yes	10	8	1	1	
No	28	20	2	5	
Response	**Brand Nationality**		**Main Target market**		
	Chinese	Foreign	Domestic	Oversea	All
Yes	8	2	5	1	3
No	27	1	17	2	9
Response	**Headquarters location**				
	East-China	South-China	Central-China	West-China	North-China
Yes	7	3	0	0	0
No	15	8	1	1	1
Response	**R&D location**				
	East-China	South-China	Central-China	West-China	North-China
Yes	3	4	0	0	0
No	16	9	1	2	0
Response	**Production location**				
	East-China	South-China	Central-China	West-China	North-China
Yes	4	5	0	1	0
No	15	13	7	6	5

Table VI. 23 Statistic - The way of wastes' disposal

Response	Number of manufacturers	Position on production chain			
		A	B	C	
Bth	4	3	0	1	
D	25	18	2	5	
P	7	6	0	1	
Response	Brand	Nationality	Main Target market		
	Chinese	Foreign	Domestic	Oversea	All
Bth	3	1	2	1	1
D	21	4	9	4	11
P	7	0	5	1	1
Response	Headquarters location				
	East-China	South-China	Central-China	West-China	North-China
Bth	1	1	0	1	0
D	20	5	0	0	0
P	3	3	0	0	1
Response	R&D location				
	East-China	South-China	Central-China	West-China	North-China
Bth	3	1	0	0	0
D	12	3	0	0	0
P	4	2	0	0	1
Response	Production location				
	East-China	South-China	Central-China	West-China	North-China
Bth	0	1	0	1	0
D	17	9	4	6	2
P	5	3	2	0	0

Note: P=by principal D=by delegation Bth=by both P and D

In table VI.22, only 38 of the 68 interviewed enterprises give response. We observe that positive responders is considerable less than negative responders with 10 "Yes" against 28"No"; most of both kinds of responders are situated on the position A of production chain; 2 foreign brands are positive responders and 1 foreign brand gives "No"; the unique domestic market are the most target market by both positive and negative responders; headquarters and R&D centers are extremely concentrated in economically more developed regions, especially no headquarter neither R&D center of positive responders is situated in the three relatively distressed regions; whereas, some of production plants of both the two kinds of responders appear in distressed regions，yet it's remarkable that only one production plant of positive responders appears in West-China.

36 of the 68 interviewed enterprises give their responses on the three ways of wastes' disposal. Most of them chose the delegation as the way for wastes' disposal with 25 "D", 4 "Bth" and 7 "P"；most of all are situated on the position A of the production chain, considerable part of enterprises that deal with the wastes by delegation is of position B and C; 4 foreign brands delegate wastes recycling business, 1 chooses the mixed way; enterprises that choose mixed way "Bth" and deal with the wastes by itself "P" focus principally on unique domestic market, as those that choose the way of delegation "D" focus more on international market; for all these enterprises, we observe extreme concentration of their headquarters, R&D centers and production plants in economically developed regions, except that enterprises that choose to delegate their wastes recycling business have great part of the production plants in distressed regions.

Section 3 Conclusions

- Consistency in general discussion

In this part, we have analyzed data based on questions around 68 ICT manufacturers throughout the survey taken by Switch-Asia program. From the general discussion in section1, it's consistent between the analyses of manufacturers' attitudes and actions about series of environmental measures, and the results are generally positive. The consistency reflects the fact that the geographical distribution of headquarters, R&D centers and production plants does not have impact on these results. Under this consistency, we find that most ICT enterprises have their headquarters and R&D centers situated in economically more developed regions and production plants situated more proportionally among all regions of different level of development.

From the perspective of product's life cycle, results in the general reflect the fact that for attitude, enterprises are more aware about waste recycling, comprehensive use of resources and energy saving of product's life cycle if their headquarters and production plants are situated in economically more developed regions; for action, enterprises prefer to invest on standard authentication & formation and green marketing, if, the production plants are situated in economically more developed regions.

In section2, we studied these interviewed enterprises' environmental actions according to different parts of life cycle. Questions are set for material purchase, the use phase of life cycle about energy saving, production process, marketing, eco-design and end of life.

The situation is positive for all the parts of life cycle except the end of life. For material purchase, the use phase about energy saving, production process, marketing and Eco-design, there exists strong consistency among these results: most enterprises are positive responders, and in these cases almost all foreign brands are positive responders; most manufacturers focus on the unique domestic market, but considerable part of them are also the ones who focus uniquely on the foreign market and international market, this is the case for both positive responders and negative responders; geographical distribution of their headquarters, R&D centers and production plants are almost under the same trend.

- Inconsistency among results from different parts of life cycle

Things change in the case for end of life management. Only for the issue of "*building measures for used products' recycling and disposal*", among the 49 available responses, there are more positive ones than negative ones, and the distribution of positions on production chain, the distribution of the focuses on different type of markets and related geographical information are almost of the same situation as in other parts of life cycle analyzed just before that.

As the question "does manufacturer take responsibility of the disposal of his products" walks on the concept more or less vague, the positive and negative responders are almost well equilibrated. Other statistical results for this question are similar to most of other analysis: for both positive and negative responders, great part of them is on the position A of production chain; considerable part of both the two responders focused uniquely on the domestic market; headquarters and R&D centers' locations are biased towards economically more developed regions, as production plants' locations are more proportionally distributed between developed and distressed regions.

The most subversive results emerge from the question "d*oes manufacturer build recycling system in China*" and the question "*does manufacturer possess already the battery recycling system if the products function with battery*": the number of negative responders exceeds the number of positive responders to a large extent. We note that these two questions are enough concrete, and enterprises respondent them with clear information. From these pessimist results, we observe that the end of life is the weakest part for environmental management throughout product's life cycle undertaken by ICT manufacturers. Furthermore, we also observe that geographical factor has impact on the results from the two questions: it appears an extreme concentration of headquarters, R&D centers and production plants in economically more developed regions for the positive responders, which is not the case for the negative responders. This phenomenon may reveal the message that for the ICT manufacturers that have their headquarters, R&D centers and production plants relatively more concentrated in developed regions are the ones who advance in the concrete end of life management, on which the enterprises relatively more located in distressed regions fall behind.

PART VII - CONCLUSIONS

Finally, we come to enclose results and conclusions in precedent parts with comprehensive conclusions. At the beginning of this paper, the first job we have done is to determine the concept of ICT for our research. This concept is a fusion of the evolved concept of ICT and of EEE. By pragmatic reason, we employ the term ICT products and EEE to designate the same thing throughout our study.

ICT industry's environmental problems are the objective of this research. Our goal is to find if the policy-making is efficient to resolve these problems by inciting manufacturers' correspondent actions, for example eco-design, to reduce the environmental impact through product's life cycle. LCA is the standard tool used for this kind of study. In our study, five principle parts of life cycle are mentioned: the production process, the transport, the use, the recycling and the disposal. Environmental impacts according to each part of life cycle are also determined. To have better view of the efficiency of environmental policy-making based on the life cycle of ICT product, we studied the ICT industry's environmental problems in China and in Chongqing, policy-making in China and reaction of ICT manufacturers in China. In the following, we review the conclusions of the three domains before we putting them together for comprehensive conclusions.

Section1 ICT industry's environmental problems in China and case study in Chongqing

Firstly, it's evident that ICT industry meets important unbalanced development among regions. Generally, East-China is the outstanding region for ICT production, and West-China is the most left behind region. The gap between the West and more developed regions is closing. This phenomenon indicates the eventual trend that the environmental impact issued from the production process starts to move from the costal regions to the west inland regions in the coming period, and this is proved by the case study of Chongqing.

In our study, we introduce the geographical factor into the analysis of ICT industry's environmental problems in China. For quantifying the environmental impacts for different regions, we analyzed the available data we find in China Statistical Yearbook combining with different LCA results sourcing to previous works, and this analysis is also applied to case study of Chongqing in using Chongqing Statistical Yearbook. The most evident result is that we find the inconsistent environmental balance for personal computer (PC) depending on if the share of environmental impact from production & transport is over or behind the share of environmental impact from use & end of life; contrarily, we obtain the consistent result for Mobile Phone (MP) and Television (TV).

For PC, 5 of the 6 results demonstrate that east region gains environmental benefice as the rest stay around equilibrium line; for TV, all results demonstrate that east region gains environmental benefices; for MP, all results reveal that east region has environmental deficit as the rest stay stably close to the equilibrium. Therefore, we find that geographical factor and type of ICT product have impact on the environmental problems for one region's ICT industry.

Chongqing case study focuses on two typical ICT products of this region. It's evident that from the production side, for the recent decade, Chongqing has lingered at the low level for most of the time, but met impressive growth since the last few years, especially for laptop production. From the diffusion side, we presented the evolution of the indicator of "*Ownership of Major Durable Consumer Goods Per 100 Urban Households at Year-end*". We find that for the seven main ICT and other electronic & electric durable consumer goods, this indicator of PC, MP and AC has experienced stable increase, and this indicator for the rest stays stable even decreases through the period.

This city could gain environmental benefice for laptop if we take into account the LCA result that the CO_2 emissions through the production & transport phase weight lighter than the CO_2 emissions through the use & end of life phase, and this city could have environmental deficit for laptop in 2008 and 2009 (period when consumption is more important than production), but starts to gain environmental benefice since 2010 and 2011 (period when production becomes more important than consumption).

Section2 Policy-making in China

- For laws

The production process is the phase the most considered in subject of environmental impact and environmental reaction for laws making, and end of life is the phase where we observe the increasing attention in subject of environmental impact. It may be expected that the end of life will be paid more attention in the future as the part of life cycle where policy makers intend to emphasize on related agents' environmental reaction to improve the environmental management.

- For specific regulations

The end of life takes the most important place in subject of environmental impact from both general perspective and dynamic perspective, and the negligible place in subject of environmental reaction from both general perspective and dynamic perspective.

- For relevant responsibilities

Laws are more active than specific regulations concerning all the correspondence between responsibilities and environmental actors. This could be explained that the specific regulations' drafting meets more difficult considering their role. Manufacturer is primarily focused as the liable for all these responsibilities in the contents of laws and regulations; the remarkable point is that manufacturer is taken as unique liable for the economic responsibility in these mentioned specific regulations. This matches well to the trend of policy-making principle toward the extended producer's responsibility (EPR).

Section3 Manufacturers' attitudes and actions

- Consistency in general discussion

The geographical distribution of headquarters, R&D centers and production plants does not have impact on manufacturers' attitudes and actions about series of environmental measures. Most ICT enterprises have their headquarters and R&D centers situated in economically more developed regions and production plants situated more proportionally among all regions.

For attitude, enterprises are more aware about waste recycling, comprehensive use of resources and energy saving of product's life cycle if their headquarters and production plants are situated in economically more developed regions; for action, enterprises prefer to invest on standard authentication & formation and green marketing if their production plants are situated in economically more developed regions.

The results are positive on all the parts of life cycle except the phase of end of life. Great part of these enterprises show their actions for material purchase, the use phase about energy saving, production process, marketing and eco-design， and almost all foreign brands are environmentally positive actioners; most manufacturers focus on the unique domestic market, but considerable part of them also focus uniquely on the foreign market and international market, this is the case for both positive responders and negative responders; geographical distribution of their headquarters, R&D centers and production plants are almost under the same trend.

- Inconsistency among results from different parts of life cycle

Most of the manufacturers (among 49 available responses) have set up measures for used products' recycling and disposal. The most impressive and serious result is that the manufacturers that have set up recycling system in China and the manufacturers that possess already the battery recycling system if the products function with battery weight much lighter than the manufacturers that do not set up these measures. The end of life is the weakest part of product's life cycle for environmental management undertaken by ICT manufacturers.

Furthermore, geographical factor has impact on the manufacturers' action of the two issues just mentioned above. There is an extreme concentration of headquarters, R&D centers and production plants in economically more developed regions for the active manufacturers, which is not the case for the passive ones. This phenomenon may reveal the message that for the ICT manufacturers that have their headquarters, R&D

centers and production plants relatively more concentrated in developed regions are the ones who advance in the end of life management practice, and the enterprises relatively more located in distressed regions fall behind on this.

Section4 Comprehensive conclusions

The findings from the three aspects above enclose the comprehensive conclusions in the following.

ICT's development is geographically unbalanced in China, form both production side and diffusion side, as east region is much more advanced than the rest regions especially the west region mostly left behind. According to the concept of spatial environmental balance, each region's environmental balance varies according to the category of products and depending on if the industry's balance tilting toward the production or the diffusion in the region. It should be mentioned that the consequence could be inconsistent for some products as PC for the inconsistent LCA results sourcing from different previous works.

On the other hand, most ICT manufacturers present active attitudes and practice positive actions on most environmental measures through ICT product's life cycle, and we don't see the geographical impact. But, for some important end of life management, the serious situation is observed, and at the same time, we find the geographical impact.

Based on these results, we propose that social planner should take into account the geographical factor and the category of products. For example, for TV, policy should be made to push forward the end of life management in distressed regions by manufacturers located in east region, but the lack of recycling system building should be taken into account at the same time; yet for Mobile Phone (MP), policy should be made to push forward the pollution control through the production process for the manufacturers located in east region, and this should be much more feasible based on results of manufacturers' attitudes and actions on environmental measures.

Returning to analysis of policy-making in China, we find that no geographical factor is taken into account, and all the laws and specific regulations are implemented from the central government to all provinces and autonomic municipalities without geographical differentiation. At this point, policy-making seems inefficient.

We note that end of life is the weakest part for specific regulations in perspective of regulating and promoting related agents' environmental reaction and from relevant laws and regulations' information, manufacturer is mostly focused for most relevant responsibilities, especially the economic responsibility and physical responsibility. This is the conflict with the result from analysis of manufacturers' action that is extremely negative on taking the real responsibility for end of life management. At this point, policy-making meets considerable difficult at regulations' level.

Meeting with geographical influence factor and manufactures' attitudes and reactions, policy-making in China about ICT industry's environmental issue shows the trend of pushing forward the EPR principle by charging manufacturers the economic responsibility as the physical responsibility, in expecting to push the eco-design by pushing them to manage the end of life. This is the core problem we considered in this paper: based on these findings, we propose to take geographical factor into account for promoting EPR based policy as we proposed earlier. The strategy could also be dynamic, as we consider the evident trend that the ICT industry's production plants start to move to the west region by bringing the environmental impact due to production process to the inland distressed region at the same time, which could very possibly change the environmental balance for the inland region, as most of headquarters and R&D centers still remained in developed regions without influencing manufacturers' plan of expansion.

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ACRONYMS

AC: Air Conditioner

AQSIQ: Administration of Quality, Supervision, Inspection and Quarantine

CO_2e: Carbon dioxide equivalent

B2B: Business-to-Business

BM: Brand Manufacturer

BRICs: Brazil, Russia, India, China

EEPLC: Environmentally Effected Part of Life Cycle

EA: Environmental Actor

EEE: Electrical and Electronic equipment

ERPLC: Environmentally Reacted Part of Life Cycle

EPR: Extended Producer's Responsibility

EU: European Union

FT: Fixed Telephone

GAQSIQ: General Administration of Quality Supervision, Inspection and Quarantine

GDP: Gross Domestic Product

GHG: Green House Gas

GWP100: Global arming potential over 100 years

ICT: Information and Communication Technology

IEC: International Electro-technical Commission

ISO: International Organization for Standardization

LCA: Life Cycle Assessment

LCIA: Life Cycle Impact Assessment

MEP: Ministry of Environmental Protection

MIIT: Ministry of Industry and Information Technology

MOFCOM: Ministry of Commerce People's Republic Of China

MOP: Ministry Of Finance

NAICS: North American Industry Classification System

NDRC: National Development and Reform Commission

OECD: Organization for Economic Co-operation and Development

OEM: Original Equipment Manufacturer

PC: Personal Computer,

PLC: Product Life Cycle

PMS： Production Material Supplier

R&D: Research and Development

REACH: Registration, Evaluation, Authorization and Restriction of Chemicals

RoHS: Restriction of Hazardous Substances

SEB: Spatial Environmental Balance

SETAC: Society of Environmental Toxicology and Chemistry

TV: Television

VITO: Flemish Institute for Technological Research

WEEE: Waste Electrical and Electronic Equipment

ANNEXES

Annex I. List of interviewed persons

Acronym name	Post	Organization	Date of interview
Miss. Yang	Directress	Information Center of MIIT	March 2011 to early 2013
Miss. Tong	Professor	School of Environment and Civil Engineering, Beijing University	March 2011 to early 2013
Miss. Tian	Expert	China Household Electric Appliance Research Institute (CHEARI)	March 2011 to early 2013
Miss. Li	Director	Laptop headquarters of Chongqing's Xiyong Micro-Electronic Zone	December 2012

Annex II. Information of interviewed enterprises

No.	Company	E-mail	Contact	Position	Website	Brand Nationality	Position on production chain (a)	Headquarters Location (b)	R&D Location (b)	Production plants Location (b)	Market boundaries (c)
1	ChangHong	hui.zhi@changhong.com	Zhi Hui	Secretary	www.changhong.com.cn	Chinese	1	4		4	1
2	HAIER GROUP	yinff@haier.com	Yin Fengfu	Director		Chinese	1		1		3
3	Shenzhen Si Semiconductor Co., Ltd.	huze@sisemi.com.cn	Hu Ze	Director Technical Office	www.sisemi.com.cn	Chinese	3	2		2	1
4	SHANGHAI HUA HONG NEC EIECTRONICS COMPANY, LIMITED	taoli@hhnec.com	Tao Li	Director		Chinese	2	1		1	2
5	Shenzhen saiyifa Microelectronics Co., Ltd.	yao.wang@st.com	Wang Yao	Safety Supervisor		Chinese	3	2			3

No.	Company	E-mail	Contact	Position	Website	Brand Nationality	Position on production chain (a)	Headquarters Location (b)	R&D Location (b)	Production plants Location (b)	Market boundaries (c)
6	Sony (China) Limited	rong.zeng@sony.com.cn	Zeng Rong		www.sony.com.cn	Japanese	1	1		1,4	
7	Semiconductor Manufacturing International Corporation(SH)	Amos_Jin@smics.com	Jin Qin	SSH Engineer	www.smics.com	Chinese	3	1		1,2	2
8	LG Electronics	shangbai@lge.com	Shang Bo	Environment&Safety Supervisor	www.lge.com	Korean	1			1,2,3,4,5	1
9	Philips(China) investment Ltd.Co Consumer lifestyle	yuqi.zhang@philips.com	Zhang Yunqi	Advisor of Sustainable Development	www.philips.com.cn	Pays-Bas	1	1	1	2	
10	TsingHua TongFang Co.,Ltd.	tianhui@thtfpc.com	Gao Yang		http://www.thtf.com.cn	Chinese	1	1		1,2,3,4,5	1
11	Lenovo (Beijing) Ltd.	liucfa@lenovo.com	Liu Chengfei	Manager	www.lenovo.com.cn	Chinese	1	1			3
12	Siemens Limited China	wu.di@siemens.com	Wu Di	(China) Manager of Environmental Affairs	www.siemens.com	Dutch	1	1	1,2		

No.	Company	E-mail	Contact	Position	Website	Brand Nationality	Position on production chain (a)	Headquarters Location (b)	R&D Location (b)	Production plants Location (b)	Market boundaries (c)
13	Hitachi (China) Ltd.	lbzhao@hitachi.cn	Zhao Libo	Vice Manager of Envionmental Management Center	www.hitachi.com.cn	Japanese	1	1		1,2	3
14	HISENSE KELON(GUANGDONG)AIR CONDITIONER CO.,LTD	xuzhan@hisense.com	Xu Zan	General Management Department Manager	www.kelon.com	Chinese	1	2		1,2,4	3
15	Ronshen Hisense refrigerator (Guangdong) Co. Ltd.	yeyonghong@sina.com	Ye Yonghong	Director of General Office of general manager		Chinese	1	2		1,2	3
16	Hisense Electric Co.,LTD	shaorenzhan@hisense.com	Shao Renzhan	Quality Management center director		Chinese	1	1	2	2	3
17	DESAY CORPORATION	pengyf@desay.com	Peng Yanfang	Statistic clerk	www.desay.com	Chinese	1	2	2	2	1
18	ZTE Co.Ltd	zhao.yan6@zte.com.cn	Zhao Yan	Environmental Manager	www.zte.com.cn	Chinese	1	2	2	2	3
19	Founder Technology Group Suzhou Manufactory Co. Ltd.	yugx@founder.com	Yu Guixi	Genergal Manager	www.foundertech.com	Chinese	1	1	1	1	1
20	Midea Group Co. Ltd.	liaojingdao@midea.com.cn	Liao Jindao			Chinese	1	2	2	1,2,3,4,5	3

No.	Company	E-mail	Contact	Position	Website	Brand Nationality	Position on production chain (a)	Headquarters Location (b)	R&D Location (b)	Production plants Location (b)	Market boundaries (c)
21	Beijing Huaqi Information Digital Technology Co., Ltd.	mahongyan@huaqi.com	Ma Hongdan	PR Executive	www.aigo.com	Chinese	1	1	1		1
22	TCL Corporation	chenghan@tcl.com	Chen Han	PR Manager of Beijing Representative Office	www.tcl.com	Chinese	1	1	2		
23	BYD COMPANY LIMITED	wang.qian6@byd.com	Wang Yao	Analysis Assistant	www.byd.com.cn	Chinese	1	2	2	1,2,3	3
24	Intel (China) Co., Ltd.	scott.zhao@intel.com	Zhao Xiaowu			Chinese	1	1	1	4,5	3
25	Etern Group Co.,Ltd.	wjl81@163.com	Lu Xiaolan	R&D Center	http://www.yongdinggroup.com/	Chinese	1	1	1	1	2
26	Aerospace Information Corporation	zhangxueyan@aisino.com	Zhang Xueyan	Synthetic Statistics	http://www.aisino.com	Chinese	1	1	1	1	1
27	Huawei Technologies Co., Ltd.	shadowtq@huawei.com	Tang Qi			Chinese	1	2	2	1	3
28	Insigma Technology Co.,Ltd.	lizhen@insigma.com.cn	Li Zhen	Vice Driector of President Office	www.insigma.com.cn	Chinese		1	1		2
29	Jinglong Industry and Commerce Group	jialiwei621@163.com	Ning Xuqin	Vice Driector of Office	www.jinglong.net	Chinese	1	5	1	1,3	2

No.	Company	E-mail	Contact	Position	Website	Brand Nationality	Position on production chain (a)	Headquarters Location (b)	R&D Location (b)	Production plants Location (b)	Market boundaries (c)
30	Shenzhen SED Electronics Group Co., Ltd.	wuyanhong212@sohu.com	Wu Yanhong			Chinese	1	2	2	2	1
31	Unisplendour Corporation Limited	lengxy@thunis.com	Leng Xinyi	Statistic Executive	www.thunis.com	Chinese	1	1	1	1	1
32	Inspur Electronic Information Industry Co.,Ltd	kuangzhp@inspur.com	Kuang Zhipeng		www.inspur.com	Chinese	1	1	1		1
33	SHANDONG GONGFANG LUYING ELECTRONIC CO.,LTD/YINAN DON`S ELECTRONIC COMPONENT CO.,LTD	fanbin@hisense.com	Su Qiang	Department Manager	www.sdtfly.com	Chinese		1	1	1	2
34	QINGDAO ORI-COLOR INDUSTRY AND COMMERCE CO.,LTD	miaoxingzhou@hisense.com	Li BO	Manager of Technique&&Quality Department	http://www.ori-color.com/	Chinese		1	1	1	1
35	Datang Telecom Technology Co;LTD	liulei@datang.com	liu Lei	Project Manager	www.datang.com	Chinese		1	1,2,4	1,2,4	3
36	Huizhou Huayang Group Co., Ltd.	jlei@foryougroup.com	Lei Jian		www.foryougroup.com	Chinese		2	2	2	1
37	Hengtong Group Co., Ltd.	jianghua@hengtonggroup.com.cn	Jiang Hua			Chinese	1	1	1	1,2,4,5	3

No.	Company	E-mail	Contact	Position	Website	Brand Nationality	Position on production chain (a)	Headquarters Location (b)	R&D Location (b)	Production plants Location (b)	Market boundaries (c)
38	Konka Group Limited by Share Ltd	limin@konka.com	Li Ming			Chinese	1	2	2	1,2,4,5	1
39	china hualu group co,ltd	hualu@hualu.com.cn	Chen Jie	Ordinary staff member	http://www.hualu.com.cn	Chinese	1		1,2	1,3	1
40	Tongding Group Co., Ltd.	zjh19701025.com@126.com	Zhang Jian	Assistant to Dean of Tongding Photoelectricity Research Institut	www.tdgd.com.cn	Chinese	1	1	1	1	1
41	IRICO Group Corporation	lying@ch.com.cn	Liang Ying	Director		Chinese	1	1	1	1,3	1
42	IRICO Group Corporation	scbyxq@ch.com.cn	Yang Xueqin	Business Manager	www.ch.com.cn	Chinese	1	1	1	1,3	1
43	ShenZhen Skyworth-RGB electronic CO.,Ltd	pingjing@skyworth.com	Ping Jing	Administrative Manager	http://www.skyworth.com	Chinese	1	2	1	2	3
44	Shenzhen Electronics Group Co.,Ltd	yif@seg.com.cn	Yi Feng	senior economist.	www.seg.com.cn	Chinese		2	1	2	2
45	FUTONG GROUP CO.,LTD	pjh@fso.com.cn	Pan Jinhua	Director of Investment Management Department	www.ftjt.net	Chinese	1	1	1	1	1
46	Zhongtian Technology Co.Ltd	gux@chinaztt.com	Gu Xin	Manager	www.chinaztt.com	Chinese	1	1	1	1	1

No.	Company	E-mail	Contact	Position	Website	Brand Nationality	Position on production chain (a)	Headquarters Location (b)	R&D Location (b)	Production plants Location (b)	Market boundaries (c)
47	NINGBO FORWARD RELAY CORP.LTD.	forward610257225@163.com	Wang Weiping	Vice Manager		Chinese	1	1	1	1	1
48	Beijing BOE Optoelectronics Technology Co.,Ltd.	songxinyang@boe.com.cn	Xu Lichen	Engineer	www.boe.com.cn	Chinese		1	1	1,3,4,5	3
49	Shandong Gettop Acoustic Co.,Ltd	xuying@gd-mic.com	Zhang Mingping	Executive Operation Head		Chinese		1		1	2
50	EPSON (CHINA)CO.,LTD	terry.tian@ecc.epson.com.cn	Tian Yuan			Japanese	1	1		1,2,3,4	3
51	Zhejiang Fuchunjiang Communication Group Co. Ltd.(FCJ)	huanjing@fcjjt.com	Zhao Bo			Chinese		1	1	1	1
52	Xi'an Chuanglian electronic component (Group) Co., Ltd.	qgtzb@xi-jing.com.cn	Zhu Atao	Secretary	www.clecgroup.com	Chinese		1	1	3	1
53	Jiangsu Shuangdeng Group Co.,Ltd	sd-zcb@shuangdeng.com.cn	Xiao Rong			Chinese	1	1	1	1	1
54	Nanjing Huadong Electronics Group Company(HDEG)	liyh@hdeg.com	Liu Juan			Chinese		1	1	1	1

No.	Company	E-mail	Contact	Position	Website	Brand Nationality	Position on production chain (a)	Headquarters Location (b)	R&D Location (b)	Production plants Location (b)	Market boundaries (c)
55	Guangzhou Radio Group Co., Ltd.	nic@grg.net.cn	S	Secretary		Chinese	1	2	2	2	1
56	CISDI ENGINEERING CO.,LTD	ZhengJun.Hu@cisdi.com.cn	Hu Zhengjun	Statistic Executive	www.cisdi.com.cn	Chinese		4	4		3
57	YANGTZE OPTICAL FIBRE AND CABLE COMPANY LTD.	luoling@yofc.com	Luo Ling		www.yofc.com.cn	Chinese	1	3	3	3	3
58	Panda Electronics Group Co., Ltd.	jing.lin@panda.cn	Lin Jing			Chinese	1	1	1	1	1
59	XJ Refco Group Ltd	byb@xjgc.com	Han Yupei			Chinese	1	1	1	1	1
60	China Great Wall Computer Shenzhen Co., Ltd.	lizhipeng@greatwall.com.cn	Su Zhipeng	Supervisor of Quality	www.greatwall.cn	Chinese	1	1	1	2	1
61	HISENSE KELON ELECTRICAL HOLDINGS CO.LTD.	huzhe@hisense.com	Hu Zhe		www.kelon.com	Chinese	1	2		1,2,4	3
62	FENGHUA ADVANCED TECHNOLOGY HOLDING CO.,LTD.	fhcto@163.com	Su Hongjuan	Vice Director od Department	www.china-fenghua.com	Chinese		2	1	2	2
63	Shanghai Business System Technology Co.,Ltd	boshi@boshiland.com.cn	Luo Yunhua	General Manager	www.boshiland.com	Chinese	1	1	1	1	1

No.	Company	E-mail	Contact	Position	Website	Brand Nationality	Position on production chain (a)	Headquarters Location (b)	R&D Location (b)	Production plants Location (b)	Market boundaries (c)
64	Beijing Qingtong Hongcheng Technology Development Co., Ltd.	bjqthc@sina.com	He Xiaohua	Manager	http://www.sicsky.com	Chinese	1	1	1	1	1
65	The fifteenth Research Institute of China Electronic Technology Group Corporation printed circuit board and assembly center	lufang3.25@163.com	Lv Fang	Director		Chinese		1	1	1	1
66	Printed Circuit Board Co., Ltd. Kunshan Jinpeng	jinpengpcb@126.com	Ling Yajuan	Manager of Business Department		Chinese		1	1	1	3
67	Shenzhen Malata Education Electronics Co. Ltd.	zex@upsino.net	Zhong XiangE			Chinese	1	2	2	2	1
68	SHEN ZHEN MALATA MOBILE COMMUNICATION CO.,LTD	genghong.chen@malatamobile.com	Chen Genghong	Assistant to Chairman of the Board	www.malatamobile.com	Chinese	1	2	2	2	1

(a): 1=brand; 2= Original Equipment Manufacturer (OEM); 3=production supplier

(b): 1=East-China (including Beijing); 2=South-China; 3=Central-China; 4=West-China;5=North-China

(C): 1=Unique domestic Market; 2=Unique foreign market; 3=International market

Annex III. Questionnaire of the survey of 68 enterprises designed by Switch-Asia programme

General questions

1. Please order the importance of different environmental measures:

a.to set up the overall environmental management system;

b.to reduce the hazardous substance contented in product;

c.to promote eco-design;

d.to debate the discharge of "three wastes" (waste gas, waste water and waste residues);

e.to develop green marketing;

f.to promote energy-saving;

g.to develop new energy exploration;

h.to develop waste recycling; **i.**to develop comprehensive use of resources.

2. Please tell the share of investment on each measure for environmental improvement in the total environmental investment:

p. investment on equipment for pollution control;

q. investment on eco-design;

r. investment on standard authentication and formation;

s. investment on green marketing;

t. investment on establishing products recycling system.

Enterprises' attitudes and activities about environmental information release

3. Does your company consider the eco-information transparency as one of company's social responsibilities?

4. Does your company support the right of the citizen to access to environmental

information?

5. Does your company support the legislation to guarantee the right of the citizen to access to environmental information?

6. Does your company agree with open and transparent system of environmental information?

7. Does your company consider that the environmental policies are enough open in China?

8. Does your company release the environmental information?

9. What is the way for your company's environmental information release?

Material purchase

10. Does manufacturer possess the management system for green supply chain in the purchase stage?

11. Does the present material management system satisfy RoHS of EU?

12. Does the present material management system satisfy the REACH of EU?

The use phase of life cycle - energy saving

13. Have the products been authenticated by Chinese Energy-Saving Standard?

14. Have the products been authenticated by any Energy-Saving Standard out of

China?

Production process

16. Does manufacturer take the pollution control measurements through the production process?

Marketing

17. Does manufacturer orient consumers' attention on product's environmental quality?

Eco-design

18. Does manufacturer integrate environmental impact factor into product's design?

19. Does manufacturer put energy-saving factor into product's design?

End of life

20. Does manufacturer build measures for used products' recycling and disposal?

21. Does manufacturer build recycling system in China?

22. Does manufacturer take responsibility of the disposal of his products?

23. Does manufacturer possess already the battery recycling system if the products function with battery?

24. Please tell the way of wastes' disposal?