

***Development and Pilot Application of  
a Measurement and Benchmarking Method for the  
Sustainable Consumption of Household Information and  
Communication Technology Appliances***

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## **Declaration**

I, Juan Li, declare that this dissertation is my own work and has not been submitted in any form for another degree or diploma at any university or other institute of tertiary education. Information derived from the published and unpublished work of others has been acknowledged in the text and a list of references is given.

Li, Juan

Mannheim

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## **Abstract**

The rapidly developed Information and Communication Technology (ICT) products have made great contributions in various application areas. However, the related problems in the consumption of household ICT appliances are crucial to economy, environment and society. As concluded from literature review of practice, assessment and legislation, there is obvious lack of information and understanding of the household consumption pattern of the ICT appliance in a more systematic “life-cycle thinking” approach – from purchase, usage to end-of-life, in environmental-social-economic three dimensional perspective. This deficiency could lead to ineffective policy programmes and implementation.

This exploratory study tentatively develops a measurement and benchmarking method, named as Sustainable Consumption Index (SCIndex) model, aiming at improving knowledge and holistic understanding of consumption patterns of household ICT appliances along the value chain in global or regional consumers’ households. This dissertation accomplishes the preliminary design of the SCIndex model and its pilot application with a global Internet survey on consumer behavior for detailed analysis, such as, cross-cultural comparison, three stages analysis (purchase, usage and end-of-life), and total SCIndex score benchmarking and analysis.

This study identified that overall consumption patterns of household ICT appliances in the developed countries are not necessarily more sustainable than in the developing countries, if all the stages of consumption are overviewed. The findings contribute to the gaps in knowledge of underlying behavioral factors that influence sustainable consumption of household ICT appliances entirely or in any stage; furthermore, they sketch out the national profiles and improvable aspects on the path of more sustainable consumption. The SCIndex model and pilot application stress the importance and provide empirical evidence to support concrete modelling with a multifaceted approach in measurement and benchmarking of household ICT appliances’ life-cycle consumption for “going beyond GDP”. The model is suggested to be optimized in

sampling, design and structure, data analysis methods and the implementation.

To efficiently promote sustainable consumption of the household ICT appliances, the pilot application provides further recommendations to the engaged stakeholders that include: i) sufficiency in purchase; ii) efficient usage; iii) responsible disposal; iv) smooth channels for reuse; v) further in-depth researches and projects.

## **Abstrakt**

Die sich rasch entwickelnde Informations- und Kommunikationstechnologie (ICT) hat in verschiedenen Anwendungsbereichen große Beiträge geleistet. Allerdings stellen die mit dem Konsum von ICT-Geräten im Haushalt verbundenen Probleme eine Herausforderung für Wirtschaft, Umwelt und Gesellschaft dar. Nach Aufarbeitung der Fachliteratur bezüglich der Praxis, der Beurteilung und der Gesetzgebung wird ein offensichtlicher Mangel an Information und Verständnis für die Konsumgewohnheiten der Haushalte bezüglich ICT-Anwendungen in einem systematischen Lebenszyklus-Konzept – von der Anschaffung, über die Nutzung bis zum Ende der Lebensdauer – in einer dreidimensionalen ökologischen, sozialen und wirtschaftlichen Perspektive deutlich. Dieser Mangel könnte zu unwirksamen Programmen und Umsetzungen führen.

Diese explorative Studie entwickelt eine vorläufige Messungs- und Benchmarking-methode, genannt Sustainable Consumption Index (SCIndex) Modell, sie dient zur Verbesserung der Kenntnisse und zum ganzheitlichen Verständnis von Konsumverhalten der ICT-Geräte im Haushalt entlang der Wertschöpfungskette in globalen oder regionalen Verbraucher-Haushalten. Diese Dissertation leistet eine Voruntersuchung für das SCIndex Modell und seine Pilotanwendung einschließlich einer globalen Internet-Umfrage zum Verbraucherverhalten für die detaillierte Analyse, nämlich einen interkulturellen Vergleich, drei-Stufen-Analyse (vom Kauf, über die Nutzung zum Ende der Lebensdauer), und die Gesamtpunktzahl des SCIndex Benchmarking und Analyse.

Diese Studie stellt fest, dass das gesamte Konsumverhalten bezüglich ICT-Geräten im Haushalt in den entwickelten Ländern nicht unbedingt nachhaltiger ist als in den Entwicklungsländern, wenn alle Phasen des Verbrauchs gezogen werden. Die Ergebnisse tragen dazu bei, Wissenslücken bezüglich zugrundeliegender Verhaltensfaktoren, die den nachhaltigen Konsum von ICT-Geräten im Haushalt in seiner Gesamtheit oder in jeder einzelnen Phase beeinflussen, zu schließen;

darüberhinaus skizzieren sie die nationalen Profile und verbesserungsfähige Aspekte auf dem Weg zu einem nachhaltigeren Konsumverhalten. Das SCIndex Modell und seine Pilotanwendung betonen die Bedeutung und liefern empirische Daten, die die konkrete Modellierung eines mehrdimensionalen Ansatzes zur Messung und zum Benchmarking des Lebenszyklus-Verbrauchs von ICT-Geräten im Haushaltsbereich über die Bruttoinlandsproduktrechnung hinaus unterstützen. Es wird vorgeschlagen, das Modell hinsichtlich Stichprobenverfahren, Design und Struktur, Methoden der Datenanalyse und der Durchführung zu optimieren.

Um den nachhaltigen Konsum von ICT-Geräten im Haushaltsbereich effizient zu fördern bietet die Pilotanwendung weitere Empfehlungen an die beteiligten Interessensgruppen, wie beispielsweise i) ausreichende Abnahmemengen; ii) effiziente Nutzung; iii) verantwortungsvolle Entsorgung; iv) reibungslose Wiederverwendung; v) weitere Forschung und Projekte.

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## Abbreviations

ANOVA	Analysis of Variance
BFL-IT Index	B üro-Fachhandel-Leasing Information Technology Index
CI	Confidence Interval
CRT	Cathode Ray Tubes
EC	European Communities
EEE	Electrical and Electronic Equipment
EPR	Extended Producer Responsibility
EU	European Union
EU27	European Union 27 Member States
EuP	Energy using Products
FPD	Flat Panel Display
GDP	Gross Domestic Product
GHG	Greenhouse Gas
ICT	Information and Communication Technology
ISO	International Organization for Standardization
IT	Information Technology
ITU	International Telecommunication Union
KMO	Kaiser-Meyer-Olkin measure of sampling adequacy
LCA	Life Cycle Assessment
LCD	Liquid Crystal Display
NGO	Non-Governmental Organization
OECD	Organization for Economic Co-operation and Development
PC	Personal Computer
REMODECE	Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe
RoHS	Reduction of Hazardous Substances
SCIndex	Sustainable Consumer Index

SMART	Specificity, Measurability, Achievability, Relevance, Time-bounding
SPSS	Statistical Package for Social Science
StEP	Solving the E-waste Problem
TBBPA	Tetrabromobisphenol A
TCO	Tjänstemännens Centralorganisation
TV	Television
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
US	United States of America
VDI	Verein Deutscher Ingenieure e.V. (Association of German Engineers)
WEEE	Waste Electrical and Electronic Equipment
yr	years

## Executive Summary

Consumption of household ICT appliances is crucial to the economic, environmental and social development, by practice, assessment and legislation. However, current most available data and information related to household ICT appliances are lack of consideration of all of the three dimensions of sustainability; furthermore, no global reference points for consumers and the engaged stakeholders to compare their own consumption patterns. Obviously, there is lack of information and understanding of the household consumption pattern of the ICT appliances in a more systematic and holistic “life-cycle thinking” approach – purchase, usage, to end-of-life, in environmental-social-economic three dimensional perspective; this deficiency could lead to ineffective policy programmes. In view of current gaps in knowledge and theoretical basis, this dissertation undertakes exploratory and descriptive social research to investigate household ICT appliance consumption. Thus, the **overarching aim** of this exploratory study is to: *Improve knowledge and holistic understanding of consumption patterns of household ICT appliances along the value chain in global or regional consumers’ households.*

The following **objectives** were identified to achieve this aim:

- ◆ Develop a social research methodology for household ICT appliance consumption, with applicable variables in a concrete model to gain the holistic information on end-consumers’ choices and behaviors in sample of global or regional households;
- ◆ Identify to what extent patterns of purchase, usage and end-of-life behavior contribute to the overall household ICT appliances’ sustainable consumption;
- ◆ Explore the underlying factors that largely influence household ICT appliance consumption, in purchase, usage to end-of-life as a whole or in any stage;
- ◆ Understand the national profiles and situation of the improved and improvable aspects of household ICT appliances’ consumption with global reference points;
- ◆ Provide recommendations with empirical basis to the engaged stakeholders to reduce the impacts from household ICT appliance consumption and to contribute to the global progress towards sustainability.

Based on literature review, targeting to the objectives, these **questions** were developed:

- ◆ how to qualitatively and quantitatively describe the current situation and progress of consumer behavior in the context of sustainable consumption of the household ICT appliances (more sustainable, or less, among the peers; improved or degraded, than the last years), in various facets – e.g., globally, cross-culturally, nationally; currently, annually in years sequence;
- ◆ what variables and concrete model could be applied to gain the holistic information on consumers' behaviors of purchase, usage and end-of-life activities;
- ◆ to what extent patterns of purchase, usage and end-of-life behavior contribute to overall ICT appliances' consumption in a sample of global or regional households;
- ◆ globally or nationally, what are the underlying factors that largely influence the purchase, usage, end-of-life as a whole or in any stage;
- ◆ what are the global or regional crucial and improvable aspects in household ICT appliances' consumption for the engaged stakeholders to efficiently collaborate.

Targeting to the aim and objectives, to answer the identified research questions and to close the gaps in existing knowledge, the **SCIndex model** of household ICT appliances' consumption is designed and carried out in **multilayer**. The first two steps have been covered in this dissertation, leaving the last step together with further in-depth researches and necessary on-field applications to be done:

- ◆ **Preliminary design** of the SCIndex model: structure, variables, questionnaire, database, scoring scheme, data collection and analysis methods;
- ◆ **Pilot application** of the model: exploratory and descriptive research, qualitative study with the best available time and budgets, targeting to the aim and objectives;
- ◆ **Global household SCIndex tracking survey** of consumers' choice and behavior of household ICT appliances: descriptive and explanatory, to quantitatively close the knowledge gaps with concrete model and data.

The **pilot application** that adopted the rough quota sampling globally obtained 1120 valid responses for detailed analysis; out of which, the 1069 respondents from 12 countries and districts are adopted for the cross-cultural comparison; the analysis is

channelled into purchase, usage and end-of-life three stages and total SCIndex. Detailed variables' relationship analysis is carried out for the case of China which has largest response quantity, as well, for the specific case of second-hand laptop's acceptance.

### **Summary of key findings**

- more than 40% of global household ICT appliances' consumers are motivated by advertisement and promotion to purchase; 1/4 of consumers could be urged by the fast emerging new products to catch up the trends;
- more than 50%, feel actual functionality of new products not as high as expected; 40% of consumers say always need to buy more are due to insufficient possessions;
- for the consumers, who replace mobile phone faster than 'twice a year', desktop or laptop computer 'every two years', the major reason is 'old one is outdated';
- 50% of consumers leave computer on until next time; never set it to standby mode; most consumers are not aware of the different electricity consumption of status – simply leaving it on; standby; switch-off and unplug;
- in the household ICT appliances' end-of-life, more than 50% of practices in the past five years are: never take it to a recycling or collection centre; never donate it to non-profit organization; sell it clear up, regardless of the price; never care about where the appliance will end up after collection; were never informed of disposal requirement of the appliances; and, have no time to think about used appliances;
- four latent factors of consumers' end-of-life behavior are obtained: casual disposal, responsible disposal, lifetime extension, and value retention;
- 'value-action gap' is obvious between consumers' awareness of environmental or energy saving label and purchase of labelled ICT appliances; moreover, between environmental consciousness of general awareness to sustainable production and consumption, and, actual choices and behaviors in purchase, usage and end-of-life;
- SCIndex total scores of twelve countries/districts are categorized into three groups: Brazil, France, Japan and Austria ranks in the first; Taiwan, United Kingdom (UK), Hong Kong, Belgium, United States (US) and Germany are in the middle level; China and Canada in the last. The SCIndex scores of developed countries are not



- definitely ranking higher;
- around 1/3 of consumers have ever used second-hand appliances; the major reason is to save money; hindrances to reuse are: quality of the products, aftermarket service, transparent price, actual functionality, honesty of the seller and warranty;
  - the highest potential consumers of second-hand laptop computer are: in graduate educational level; 25-35 years old; low-/middle-class consumers, living in the rented residence, 2-3 members household; top reasons to buy include: economical, portable, certified quality, good for short-term use and benefit to environment;
  - in China, critically improvable methods to make consumption of household ICT appliances more sustainable include: shift casual disposal to lifetime extension and responsible behavior; raise reuse and awareness; slow down high frequency of desktop computer replacement; cool down stimuli oriented purchase fever; avoid irresponsible electricity consumption, e.g., simply leave without switching off after using computer.

### **Methodology findings**

- **Sampling:** targeting to the various domains of interest – global or regional, cross-cultural or national, sufficient samples of quota size and profiles are crucial;
- **Design and structure** of the tentative SCIndex questionnaire should be improved through: combination and simplification of questions, elimination of option; and decoupling of the database and scoring scheme;
- **Data analysis methods** for the SCIndex model perform the functions of comparison, extraction, relationship analysis, and prediction;
- **SCIndex model** which is developed, optimized and implemented in multilayer; reveal strengths, weaknesses and improvable aspects, for sustainable consumption of household ICT appliances in the region or country context.

**Limitations** exist in the survey design, scoring scheme and sampling. The generalization of research results, the cross-cultural comparison and detailed analysis of some variables are constrained. The single pilot application could not prove whether the system could deliver consistent result repeatedly. Disadvantage of Internet survey and the unequal

scope of household ICT appliances' consumers and Internet users are also the factors.

The results of this dissertation have the following **contributions to knowledge**:

- provision of detailed “real world” consumption measurements of household ICT appliance; filling a current gap in the literature regarding the holistic consumption in life-cycle-thinking perspective – purchase, usage, end-of-life choices and behaviors
- it contributes to gaps in knowledge of underlying behavioral factors that influence sustainable consumption of household ICT appliances entirely or in any stage;
- “value-action gap” is rather obvious, in the household ICT appliances' consumption;
- the overall consumption patterns of household ICT appliances in the developed countries are not necessarily more sustainable than in the developing countries, if all the stages of consumption along the trip-bottom line are overviewed;
- providing empirical evidence to support modelling work and indicating that findings of sustainable consumption and social research on consumer behavior in general can be applied to the household ICT appliances;
- methodology used for this research – to develop the model of measurement and benchmarking indicator “going beyond GDP” to systematically quantify the consumers' behavior, through a multilevel implementation;
- stressing the importance of setting up concrete model to fill the gaps in knowledge, policy insufficiency and stakeholders' responsibility;
- development and implement of the SCIndex model contribute to face the challenges and paradoxes of sustainable consumption, e.g.: distributional concerns, limitations of market-based approaches, unrealistic time horizons for impact, over-emphasis on individual households' choice and on shifting household demand.

## **Recommendations**

The pilot application data analysis of SCIndex model would provide empirical arguments and first-hand references of consumers' choices, behaviors and general awareness in household ICT appliances consumption, for all the involved stakeholders to understand the whole pictures and the improvable aspects, so as to have more realistic and practical

action accordingly. Based on the data obtained from pilot application, to efficiently promote sustainable consumption of the household ICT appliances, the recommendations to the engaged stakeholders include sufficiency in purchase, efficient usage, responsible disposal, smooth channels for reuse, and further in-depth researches and projects.

## **1. Introduction**

This chapter begins with an overview of this dissertation (section 1.1). Nowadays, the fast booming ICT products (section 1.2) greatly contribute to economy, environment and society (detailed discussion will be found in section 1.3). However, the obvious problems relating to ICT products' consumption are identified all over the world, along the products' value chain – from production, through purchase, usage to the end-of-life treatment (section 1.4). Existing research in this area and gaps in knowledge are then briefly discussed (section 1.5). The principal aims and objectives of the research are presented (section 1.6) and the structure of the dissertation is outlined (section 1.7).

### **1.1 Thesis overview**

From mobile phones to the Internet, the Information and Communication Technologies (ICT) consistently deliver innovative products and services that are an integral part of everyday life, systematically increase productivity, and support economic growth, environmental protection and social cohesion. However, the related problems in the production, consumption and end-of-life of ICT products, especially, household ICT appliances, are seriously alarming to all the citizens in the planet with limited resource. Sustainable production and consumption has made a certain progress worldwide over decades, including the legislation and regulation systems establishing, performance standards and labels adopting, sufficiency instead of 'throwaway' lifestyle in consumption promoting, and efficient reuse encouraging, etc. Consumers play a crucial role in household consumption among the engaged stakeholders, which altogether shape consumers' lifestyle and reversely meet their tastes.

Reviewing the existing research and practices, there are gaps in knowledge regarding household ICT appliances' consumption in a holistic scope, lacking of concrete data on the global and regional end-consumers' behavior for the overall evaluation of the relevant legislation and implementation. Therefore, a Sustainable Consumer Index (SCIndex) model is developed to quantitatively measure the choices and behaviors of household consumers in purchase, usage and end-of-life of household ICT appliances;

furthermore, to benchmark the average performance of country, the current situations, risks, opportunities, and the embedded surroundings. The entire model is tested, evaluated and further optimized through a pilot application; the data analysis provides empirical findings for the further in-depth research. It is recommended to have efficient stakeholder engagement – from purchase to end-of-life along the value chain – to enhance the sustainable consumption of household ICT appliances in a long run.

## 1.2 Fast booming ICT products

The understanding of ICT products category varies among organizations, countries, and specific study scope. In the broad sense, ICTs facilitate the creation, storage, management and dissemination of information by electronic means, including radio, television, telephone, fax, computer and the Internet<sup>1</sup>. Organization for Economic Co-operation and Development (OECD) lists a certain ICT products to access for bridging digital divide, including television (TV), computer and mobile phones<sup>2</sup>. ICT is specialized as a tool serving practical and sustainable solutions to connect people and enable them to benefit from both modern media (such as computers, Internet, email and multimedia) and traditional media (such as radio and television)<sup>3</sup>. In the narrow sense, for the analysis feasibility, current study normally defines the ICT equipment within the scope of information technology (IT) and telecommunications equipment, such as computers and mobile phones<sup>4</sup>. In the dissertation, ICT products and their application refer to the broader understanding. The detailed research and pilot application focus on a narrow scope.

Based on the data reported by United Nations International Telecommunication Union (UN ITU), between 2000 and 2008, the global growth of mobile cellular subscribers has grown with 24% annually<sup>5</sup>. By the end of 2008, there were over 4 billion mobile cellular subscriptions worldwide, a penetration rate of 61%<sup>6</sup>. It is estimated that the

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<sup>1</sup> Gerster, R. & Zimmermann, S., 2005

<sup>2</sup> OECD, 2001a

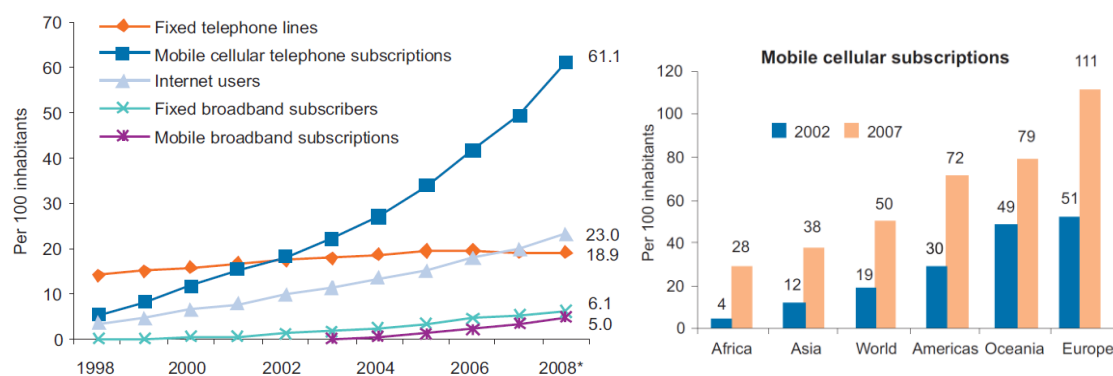
<sup>3</sup> IICD, 2009; Flash Eurobarometer, 2008

<sup>4</sup> Scheidt, L.-G. & Dempsey, M., 2007

<sup>5</sup> UN ITU, 2008

<sup>6</sup> UN ITU, 2009

world had 1.3 billion fixed telephone lines, which is 19% inhabitants; almost a 25% of the world's 6.7 billion people were using the Internet up to the end of 2008 (Figure 1 left)<sup>7</sup>. The Internet penetration in the developing countries is still relatively low: in Africa, less than 5% of the population uses the Internet; in Asia, less than 15 % of people use the Internet, compared to 43% in Europe and 44% in Americas<sup>8</sup>. However, the rapid development of mobile phone crosses both developed and developing countries, especially Asia<sup>9</sup> and Africa<sup>10</sup> (Figure 1 right).



**Figure 1** Global ICT development and mobile cellular subscriptions<sup>11</sup>

Globally, the number of computer is expected to increase from 592 million in 2002 to more than 4 billion in 2020, with two major technology developments expected<sup>12</sup>:

- ◆ First, the desktop computers that dominate today's market (84%) will be largely replaced by laptops, that is, 74% of all computers in use will be laptops in 2020;
- ◆ Second, all Cathode Ray Tube (CRT) screens will be replaced by low energy alternatives, such as liquid crystal display (LCD) screens.

Europe ranks the first in broadband Internet; meanwhile, regular Internet use becomes more inclusive of the disadvantaged groups (the inactive, the less educated and those aged 55-64)<sup>13</sup>. In Europe, people aged 16 to 24 are the most active Internet users: 73% of them regularly use advanced services to create and share online content, twice of the

<sup>7</sup> UN ITU, 2008

<sup>8</sup> UN ITU, 2009

<sup>9</sup> UN ITU Asia Report, 2008

<sup>10</sup> UN ITU Africa Report, 2008

<sup>11</sup> UN ITU, 2009

<sup>12</sup> Climate Group, 2008

<sup>13</sup> IP/09/1221, 2009, press release "Digital economy can lift Europe out of crisis"; COM (2009) 390 final, 2009, "Europe's Digital Competitiveness Report Main achievements of the i2010 strategy 2005-2009"

EU population average (35%); 66% of all Europeans under 24 years old use the Internet every day, compared to the EU average of 43%<sup>14</sup>. 60% of Europeans are today able to use government services online, and 87% of European medical doctors already use a computer, 48% with a broadband connection<sup>15</sup>. Up to 2012, world total amount of Internet users reported by Internet World Stats is around 2.4 billion<sup>16</sup>, including:

- In Asia, top two countries are China and Japan, with 538.0 million and 101.0 million Internet users, respectively. Internet users in Asia account for 44.8% of the world total amount – 1.08 billion;
- In Europe, Germany, UK, France have 67.6 million, 52.7 million and 52.2 million, respectively, which have the largest user population;
- US with 245.2 million Internet users ranks the first in North America; while, Brazil with 88.5 million is on the top of Latin American;
- North America (78.6%) and Europe (63.2%) have the much higher Internet penetration rates than the world average (34.3%)<sup>17</sup>.

By 2008, it is estimated that the world TV stock is already more than 2 billion, which is contributed mostly by the developed countries with ownership of around two per household; while, developing countries like China have 1.33 TVs per household in urban areas<sup>18</sup>. Worldwide, in total of 45.5 million TVs were sold in one fiscal year, a growth of 3% from 2005-2006, driven by fast growth in China (17%) and North America (8%) market<sup>19</sup>. LCD TVs are taking up a growing share of the market<sup>20</sup>. The production, import, export and domestic sales data of the ICT products in China (Appendix 1) indicate an obvious increment in supply and demand.

### **1.3 Contributions of ICT products**

ICT products are recognized to potentially act as catalysts to achieve the United

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<sup>14</sup> IP/09/1221, 2009, press release *"Digital economy can lift Europe out of crisis"*

<sup>15</sup> EC ISM, 2009

<sup>16</sup> IWS, 2012

<sup>17</sup> IWS, 2012

<sup>18</sup> E3 Report, 2008

<sup>19</sup> Display Search, 2006

<sup>20</sup> UNEP, 2006b

Nations' Millennium Development Goals<sup>21</sup>. They increase productivity and supported economic growth worldwide; help to enhance creativity and innovation to solve problems; build communities; and give more people access to goods and services, and more efficiently use resources<sup>22</sup>. Globally, ICT sector itself and the ICT investment largely contributed the GDP growth, especially in most OECD countries<sup>23</sup>. In Europe<sup>24</sup>, America<sup>25</sup> and Korea<sup>26</sup>, ICT promotes the productivity growth and economy prosperity, as well, benefits to the modern and traditional sectors. A series of EU strategies and guidelines on ICT products and services are creating more opportunities to benefit consumers, businesses and administrations; furthermore, driving to an inclusive information society and a greener economy<sup>27</sup>.

Analyst Gartner illustrates the effects of ICT on environmental sustainability in three orders (Appendix 2a has a clear figure)<sup>28</sup>:

- 1<sup>st</sup> order: negative effect through the direct result of its existence, use of ICT and the manufacturing processes, e.g., Greenhouse Gas (GHG) emission, e-waste, hazardous substances, scarce and non-renewable resources;
- 2<sup>nd</sup> order: positive effect from application, e.g., travel substitution, transport optimization, e-business and e-government, environmental control systems;
- 3<sup>rd</sup> order: positive effect which leads to long term socio-economic structural changes, substitution effects in various aspects due to large numbers of people using ICT over medium to long term, e.g., energy intensity, GHG intensity, transport intensity and material intensity.

<sup>21</sup> UN Millennium Declaration, 2000, "Resolution adopted by the General Assembly"; Gerster, R. & Zimmermann, S., 2005; UN ITU, 2008

<sup>22</sup> Madden, P. & Weißbrod, I., 2008

<sup>23</sup> OECD, 2005; Jorgenson, D.W., Ho, M. and Stiroh, K.J., 2005; Climate Group, 2008; Burda, M.C., 2009

<sup>24</sup> IP/05/643, 2005, press release "Commission launches five-year strategy to boost the digital economy"; COM (2005) 229, 2005, "i2010 – A European Information Society for growth and employment"; COM (2009) 324 final, 2009, "White Paper "Modernizing ICT standardization in the EU – The Way Forward"; EC ISM, 2009

<sup>25</sup> Stiroh, K.J., 2002

<sup>26</sup> Kim, D., 2009

<sup>27</sup> IP/05/643, 2005, press release "Commission launches five-year strategy to boost the digital economy"; COM (2007) 803 final, 2007, "Integrated Guidelines for Growth and Jobs (2008-2010) – including a Commission Recommendation and a proposal for Council Decision"; IP/09/1221, 2009, press release "Digital economy can lift Europe out of crisis"; EC ISM, 2009; COM (2009) 390 final, "Europe's Digital Competitiveness Report Main achievements of the i2010 strategy 2005-2009"

<sup>28</sup> Gartner Consulting, 2007



In 2007, ICT sector was responsible for 2% of global carbon emissions<sup>29</sup>; here ICT refers to personal computers (PCs), telecoms networks and devices, printers and data centres<sup>30</sup>, including the large-volume devices, namely PCs and mobile phones; as well, commercial and governmental IT, and telecommunications infrastructure (Appendix 2b sketches the composition of carbon emission by different ICTs)<sup>31</sup>. Though the 2% is still unsustainable, yet the good news is ICT can significantly contribute to control and reduce the 98% of CO<sub>2</sub> emissions caused by other sectors<sup>32</sup>. ICT applications have contribution to the energy conservation<sup>33</sup> and climate protection<sup>34</sup>. For example, ICTs are used in monitoring climate change and data collection using ICT-equipped sensors (telemetry) in the typical and remote locations, such as the polar ice caps, glaciers, ocean bed, etc; besides, ICTs provide meteorological services in computer modelling of the earth's atmosphere<sup>35</sup>. Take an example of ICT-based technologies and equipment, they can enable 'greener' behavior to massively cut carbon footprint if widely deployed in energy-intensive areas across the value chain, e.g., generation and logistics, buildings, lighting, smart motor systems, grids and dematerialization<sup>36</sup>. By the application of ICT, it is estimated a total saving of 15% fewer emissions in 2020 will be obtained, equal to €600 billion of energy cost savings<sup>37</sup>. In Europe, mobile communications alone could save 2.4% of total emissions by 2020<sup>38</sup>. ICTs improve energy use monitoring and management in factories, offices and public places; above all, they increase consumers' awareness of energy using; e.g., European consumers with smart metering at home reduced the energy consumption by 10% in 2009<sup>39</sup>.

ICT is now fundamental across every sector, from manufacturing and energy to

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<sup>29</sup> Mingay, S., 2007

<sup>30</sup> Climate Group, 2008

<sup>31</sup> Gartner Consulting, 2007

<sup>32</sup> Gartner Consulting, 2007; IP/09/393, 2009, press release "*Commission pushes ICT use for a greener Europe*"; GeSI, 2009

<sup>33</sup> ETNOA and WWF, 2006; COM (2008) 30 final, 2008, "*20 20 by 2020 – Europe's climate change opportunity*"

<sup>34</sup> Kyoto Protocol, 1998; UN ITU, 2007a; UN IPCC, 2007; IP/07/29, 2007, press release "*Commission proposes an integrated energy and climate change package to cut emissions for the 21st Century*"; IP/09/393, 2009, press release "*Commission pushes ICT use for a greener Europe*"

<sup>35</sup> UN ITU 2007a

<sup>36</sup> COM (2008) 241, 2008, "*Communication Addressing the challenge of energy efficiency through Information and Communication Technologies*"; European Commission, 2009; GeSI, 2009

<sup>37</sup> Climate Group, 2008

<sup>38</sup> Accenture, 2009

<sup>39</sup> SEC(2009) 1103

transport, retailing and health services; enables a range of socially desirable and valuable online public services, such as e-education, e-health<sup>40</sup> and e-government<sup>41</sup>. E-learning with ICTs enriches teaching, stimulate learning, and create a knowledge society for lifelong learning largely improves education quality<sup>42</sup>. ICTs can be applied to a range of daily practices and ultimately reduce the number of material objects, e.g., online billing, tele-conference, less paper in office, reduced CDs, enable new ways of learning, travelling, working and living; therefore, stimulating the transition to a high-value, high efficiency and low-carbon economy<sup>43</sup>. One study reported, compared with conventional campus-based courses, distance learning consumed 90% less energy per student<sup>44</sup>, which is not necessarily to replace the conventional one, but serves as an alternative to compensate for the limitations of on-site study.

Previous studies warned about potential negative effects of ICTs on social capital<sup>45</sup>. There are researches saying that social cohesion is loosening when examining some technologies (the TV and perhaps some functions of the Internet), and tightening when looking at other technologies such as the mobile phone<sup>46</sup>. Work done in Europe and East Asia indicates that there is a covariance between mobile phone use and informal “strong tie” social interaction<sup>47</sup>. Work in France suggests, for example, that mobile communication leads to tightly integrated small groups<sup>48</sup>. The researches in the United States of America (US), Malaysia, Germany and Norway support the idea that this is an important function particularly in the context of the innermost circle of friends and family<sup>49</sup>. Further analysis showed that Internet might support existing face-to-face

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<sup>40</sup> COM (2008) 689, 2008, “*Communication on telemedicine for the benefit of patients, healthcare systems and society*”; Recommendation 2008/594/EC, “*Recommendation on cross-border interoperability of electronic health record (EHR) systems*”; Health-EU portal

<sup>41</sup> COM (2006) 45, 2006, “*Communication on interoperability for pan-European eGovernment services*”; COM (2006) 173, 2006, “*Communication on i2010 eGovernment Action Plan: Accelerating eGovernment in Europe for the Benefit of All*”; COM (2009) 390 final; UNDESA, 2009

<sup>42</sup> Haddad, W. & Jurich, S., 2002; Gerster, R. & Zimmermann, S., 2005; Gutterman, B., Rahman, S., Supelano, J., Thies, L. & Yang, M., 2009; Economist Intelligence Unit, 2008

<sup>43</sup> Young, S., 2007; Climate Group, 2008; EC ISMDG, 2008; Forge, S., Blackmann, C., Bohlin, E. & Cave, M., 2009; COM (2009) 116, 2009, “*Communication 'A strategy for ICT R&D and innovation in Europe: raising the game'*”

<sup>44</sup> James, P. & Hopkinson, L., 2009

<sup>45</sup> Wilsden, 2001; Anderson, B., Brynlin, M., Gershuny, J. & Raban, Y., 2006; Giddens, A., 2009

<sup>46</sup> Ling, R., 2007

<sup>47</sup> Ling, R., Yttri, B., Anderson, B. & DeDuchia, D., 2003; Kim, H., 2006; Miyata, K., 2006

<sup>48</sup> Licoppe, C., 2004

<sup>49</sup> Choi, J., 2004; Abdullah, M. Y. H., 2004; Roessler, P. & Hoeflich, J., 2002; Ling, R. & Yttri, B., 2002

relationships by acting as an additional communication device, creating a new type of social capital linked to community involvement, which, therefore increasing stocks of social capital; the 2008 survey to over 27,000 citizens in EU27 suggests that<sup>50</sup>:

- those rich in social resources might have stronger motivation to use ICT more frequently; Internet users are also more active in social leisure activities;
- The majority of Internet users have a positive perception about the impact of the Internet on everyday life and resource-enhancing capabilities (learning, culture, health-related information and work);
- More than half of users feel that the Internet has improved their relationship with family and friends. Internet use is positively associated with social capital. They also exhibit higher levels of trust.

Despite of the fast technological development, the world is divided into a part having the infrastructure to use the advantages of ICT and, a part not connected to the Internet, in particular in least developed countries, like Africa. One Laptop per Child Project in African countries offers a partial solution to the global digital divide<sup>51</sup>. ICT empowers the ideal model of ‘Green Knowledge Society’, which is inclusive, innovative, secure and sustainable<sup>52</sup>. In summary, it is evident that ICT accelerates economic growth; socially, it enables people to participate and may largely benefit in life, work and study; besides, it provides a solution to enhance eco-efficiency and eliminate enabling effect, such as environmental harms caused by other sectors.

#### **1.4 Problems relating to ICT products’ consumption**

Consumption could be defined as “an inherent part of human activity which uses up material, energy and other valued things”<sup>53</sup>. Beyond a classic economic definition, consumption also refers to a sequence of choice and actions by household consisting of the “selection, purchase, use, maintenance, repair and disposal of any product or

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<sup>50</sup> Flash Eurobarometer, 2008; SEC(2009) 1103

<sup>51</sup> OECD, 2001a; OLPC, 2009; BBC News, 2009; OLPC News, 2009; Farrel, G. & Isaacs, S., 2007

<sup>52</sup> Forge, S., Blackmann, C., Bohlin, E. & Cave, M., 2009

<sup>53</sup> Daly, H., 1996

service”<sup>54</sup>. The consuming behavior is stressed to be featured with ‘material provisioning that permanently degrades material and energy to serve some purpose to the individual or to the group’<sup>55</sup>. The functional role of consumption is that it satisfies needs for food, housing, transport, recreation, etc.; however, in the modern society consumption is often linked with pursuit of personal and cultural meaning, playing an important role in identity formation, in defining status and distinction, social cohesion and belonging, dreaming and hedonic desires<sup>56</sup>.

The United Nations Commission on Sustainable Development defined sustainable consumption as ‘the use of goods and services that respond to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardize the needs of future generations’<sup>57</sup>. Regarding sustainable consumption, the current focus of the most businesses always associates with increase in consumption of sustainable products (what is consumed), completely omitting sustainable patterns of consumption (how it is consumed)<sup>58</sup>. In some cases purchase decision is more important to act in line with sustainability principles; while in others the actual product use or pattern of use provide more opportunities<sup>59</sup>. For example, ITU 2007 Report gave an example that 20 years ago, a single TV might have provided entertainment for a household; now a typical family in a developed country might own multiple TVs, a digital cinema, mobile phones, video-recorder, a DVD player, etc; the rapidly increasing of user devices, which need power and many are routinely left on standby overnight<sup>60</sup>. People have more stuff but less time for what really make them happy: family, friends and leisure time; instead, watching TV and shopping<sup>61</sup>.

On one hand, ICT products are playing an important role in the human being activities – living, working, studying, manufacturing, etc. – with the significant contribution to

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<sup>54</sup> Campbell, C., 1998

<sup>55</sup> Princen, T., 1999

<sup>56</sup> Jackson, T., 2004

<sup>57</sup> UNCSD, 1994

<sup>58</sup> Michaelis, L., 2003

<sup>59</sup> Korsunova, A., 2005

<sup>60</sup> UN ITU, 2007a

<sup>61</sup> Colwell, D., 2007; McKibben, B., 2007; Leonard, A., 2008

economy, environment and society, in various sectors as discussed in section 1.3. On the other hand, if developed and applied badly, ICT could deteriorate the existing problems – devouring energy, accelerating climate change, worsening inequality for those who do not have access, increasing pollution and resource use by encouraging frenetic consumerism<sup>62</sup>. The major environmental impacts of ICTs are the energy and materials consumption in the products' lifecycle, together with potential damage to the environment and people (health impact to workers and users)<sup>63</sup>. The focus of ICTs discussed and analyzed in this thesis specifically refers to the household consumer products, not the ones in factories, offices and public sectors as mentioned in section 1.3 in general. Electronic devices are a complex mixture of several hundred materials, for example, a mobile phone contains 500 to 1,000 components, many of which contain toxic heavy metals and hazardous chemicals, for example, 1,450 tonnes of a brominated flame retardant called TBBPA (Tetrabromobisphenol A), which links to neurotoxicity, was used to manufacture 991 million mobile phones sold in 2006<sup>64</sup>. The “Story of Stuff” Project vividly illustrates the alarming problems of material economy in a linear system – extraction, production, consumption and disposal, rather than a cycle-economy or life-cycle-thinking approach, due to the long term “throw-away” mindset which is formed by the joint action of all the relevant stakeholders, e.g. governments, business, retailers, media and consumers<sup>65</sup>. In the literature review of Chapter Two to Four, detailed discussion about the challenges and opportunities of the sustainable consumption of the household ICT appliances are given, along the value chain from the production, purchase, through usage to the end-of-life treatment.

### **1.5 Existing research and gaps**

Based on the literature review in the Chapter Two to Four, it is identified that consumption of household ICT appliances is crucial to the economy, environment and society. However, the results of these reviews suggest that currently there are a number of significant gaps in knowledge. Knowledge concerning “real world” household ICT

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<sup>62</sup> Madden, P. & Weibrod, I., 2008

<sup>63</sup> Forge, S., Blackmann, C., Bohlin, E. & Cave, M., 2009

<sup>64</sup> Greenpeace International, 2008a

<sup>65</sup> Leonard, A., 2008

appliances' sustainable consumption is currently limited and fragmentary; and this deficiency could lead to ineffective policy programmes. In brief summary,

- There is only limited data, model and research findings on the regional and global consumption of household ICT appliances – purchase, usage and end-of-life;
- Besides market and manufacturer data sources, information to policy makers is very limited for clear and comprehensive understanding of the factors influencing changes in consumption patterns by examining end-users;
- There is no inclusive indicator to measure and benchmark the national profile of development in sustainable consumption, going beyond GDP; as well, not only efficiency, but also sufficiency in consumption;
- The ICT indicators are mainly supply side access indicators; lack of measuring the access, usage and impact of ICTs across countries, e.g., household surveys;
- There is little data on behavior of appliance users' electricity consumption; and lack of available information for a systematic and quantitative assessment of the end-of-life legislations' impacts; for municipal collection quality, for consumer behavior to deal with used ICT appliances, e.g., motivated timely take-back;
- It is challenging to understand the dynamic complexity and holistic picture of the sustainable consumption of ICT appliances, which is highly context dependent.

These gaps urgently call for developing the “ICT consumption specific index and model” to measure the global and regional end-consumers' behavior of household ICT appliances consumption. These data will provide the reference to evaluate the national and regional situation, progress and gaps, providing the insights to facilitate or encourage sustainable consumer behavior, by further research, government legislation, product development, or sustainability initiatives. Correspondingly, as the consumers' behavior and choices are highly context-dependent and interacted with the other actors, the qualitative and quantitative tracking of their consumption pattern could also reflect the whereabouts of the engaged stakeholders. Regarding the above identified gaps in knowledge, in this dissertation, the definition of ‘consumption’ is selected as “referring to a sequence of choice and actions by household consisting of the selection, purchase,

use, maintenance, repair and disposal of any product or service”<sup>66</sup>, revealing the “life-cycle thinking” concept.

## **1.6 Aim, objectives and methodology**

In view of current gaps in knowledge and theoretical basis, this dissertation undertakes exploratory and descriptive social research to investigate household ICT appliance consumption. Thus, the overarching aim of this exploratory study is to:

*Improve knowledge and holistic understanding of consumption patterns of household ICT appliances along the value chain in global or regional consumers' households.*

The following objectives were identified to achieve this aim:

- ◆ Develop social research methodology for household ICT appliance consumption, with applicable variables in a concrete model to gain the holistic information on consumers' choices and behaviors in sample of global or regional households;
- ◆ Identify to what extent patterns of purchase, usage and end-of-life behavior contribute to the overall household ICT appliances' sustainable consumption;
- ◆ Explore the underlying factors that largely influence household ICT appliance consumption, in purchase, usage to end-of-life as a whole or in any stage;
- ◆ Understand the national profiles and situation of the improved and improvable aspects of household ICT appliances' consumption with global reference points;
- ◆ Provide recommendations with empirical basis to the engaged stakeholders to reduce the impacts from household ICT appliance consumption and to contribute to the global progress towards sustainability.

Targeting at the above objectives and based on the literature review, the methodology of the research is: 1) to develop the Sustainable Consumer Index (SCIndex) model to measure and benchmark the global and regional consumption of household ICT appliances, focusing on the end-consumers' choices and behaviors; 2) to test and evaluate the model with a pilot application and to further optimize the model:

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<sup>66</sup> Campbell, C., 1998

- A tentative model is developed based on literature review, experts consulting and research experience, to close the gaps of knowledge on understanding the dynamic complexity of household ICTs' consumption from the consumer side;
- An exploratory and descriptive pilot application is implemented to test, evaluate and optimize the entire model, targeting the research objectives;
- The pilot application data analysis procedure and results are applied to verify and further improve the models' variable section, structure, design, scoring scheme, sampling, data analysis methods of the SCIndex model;
- Data contribute to knowledge of consumers' choices and behaviors in selection, purchase, usage, repair, reuse and final disposal of these appliances; highlight the improvable aspects and benchmark national profiles with global reference points;
- Underlying factors that determine the household ICT appliances' consumption are identified with the data of comprehensive variables in the specific cases;
- Recommendations to the engaged stakeholders are given, based on the strengths and weaknesses, for developing the corresponding legislations, technologies, management system, business model, markets and communication channels, in the local, national and regional level;

Similar as Greendex over four years 2008-2010 and 2012 (as mentioned in this thesis section 4.5), if the consumer's choice and behavior of ICT appliances could be tracked over time and with subsequent waves of the survey, it could therefore quantitatively sketch out the progress in sustainable consumption in specific countries at the global level.

### **1.7 Thesis structure**

This thesis has eight chapters following this introduction, as outlined below. Literature reviews in Chapter Two, Three and Four provide theoretical and practical foundation, and identify the gaps in knowledge of household ICT appliance consumption. Chapter Five and Six are the methodology, analysis and discussion of the empirical research. Chapter Seven summarizes the overall results of the pilot application. In the very end, Chapter Eight gives conclusions and recommendations.



***Chapter 2 Literature Review 1: problems with household ICT appliances' consumption***

It presents a review of problems in the production and consumption of household ICT appliances; especially emphasize on the three stages of 'consumption' in a broader definition revealing a 'life-cycle thinking' concept – purchase, usage and end-of-life;

***Chapter 3 Literature Review 2: sustainable consumption of EEEs and ICTs***

It provides a review of literature from the development of sustainable consumption; the regional and national legislations, management systems and practice related to EEE and ICT's life-cycle; the importance and practices of efficiency and sufficiency;

***Chapter 4 Literature Review 3: social research on consumer behaviors***

It provides a review of the social research on consumer behaviors, discussing in detail of the consumption related factors, paradoxes and challenges, the necessity of going beyond GDP, as well, the social research background;

***Chapter 5 Development of the SCIndex model***

It focuses on the methodology of the dissertation research, the development and pilot application of the SCIndex model for the consumption of household ICT appliances;

***Chapter 6 Validation and optimization of the SCIndex with pilot application***

It presents results of the pilot application, including detailed data analysis of variables and factors, and processing of the specific cases; moreover, analyzing the reliability, and optimizing the model based on the pilot application and the data analysis;

***Chapter 7 Summary of the SCIndex pilot application overall results***

It briefly summarizes the results of SCIndex pilot application data analysis, statistical reliability and limitation analysis, as well, overall optimization of the model;

***Chapter 8 Conclusions and recommendations***

It presents a brief summary of key findings and contribution to knowledge; limitations are highlighted along with potential areas for future research and recommendations.

## **2 Literature Review 1: problems with household ICT appliances' consumption**

### **2.1 Introduction**

Along the value chain of the Electrical and Electronic Equipments (EEEs), especially, ICTs, from extraction, production through distribution and consumption to final disposal, there are severe impacts on the environment and society noticed all over the world. Although there are relevant legislations and management systems in regional and national level which have already existed for decades and which are gradually improving, furthermore, producers have started to take their responsibilities in society and environment besides merely pursuing economy maximization, yet the true cost of products (including overall impact on resource and environment) is still externalized. That means, on the natural resource and environmental capacity limited planet, under the industries' for decades 'design for dump' mentality, the 'planned obsolescence' of the ICT appliances within increasingly shorter utility age continues worsening the problems<sup>67</sup>. The following sections go into detailed discussion about these issues related with different stages of the entire life cycle of household ICT appliances: production (section 2.2), purchase (section 2.3), usage (section 2.4), end-of-life (section 2.5), and reuse practice in reality (section 2.6).

### **2.2 Production of household ICT appliances**

The most significant environmental impacts associated with ICT production are mainly from the material extraction, energy consumption and waste generated. Study of a European PC with 17 inch LCD monitor in 2005 revealed that in total 20kg of materials were used in the production of this computer; 51% of these were ferrous metals and 17% plastics by weight<sup>68</sup>. Materials extraction has 4 times CO<sub>2</sub> equivalent emission of manufacturing, associated with production of an office desktop computer (excluding monitor)<sup>69</sup>. The production of a typical office computer and LCD monitor,

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<sup>67</sup> Leonard, A., 2009

<sup>68</sup> IVF, 2007; James, P. & Hopkinson, L., 2009a

<sup>69</sup> James, P. & Hopkinson, L., 2008

including materials extraction and manufacturing, involved<sup>70</sup>:

- Disposing of 37 kg of non-hazardous waste and 0.7 kg of hazardous waste (61 kg of non-hazardous waste and 5 kg of hazardous waste over its lifetime);
- Consuming 3,244 MJ energy (compared to 23,396 MJ over its lifetime);
- Using 920 litre water for processing (compared to 2,146 litre over its lifetime);
- Generating 193 kg Greenhouse Gas (compared to 1,097 kg over its lifetime);
- Releasing considerable quantities of heavy metals, acid rain precursors and other air and water pollutants.

Though the computer or mobile phone itself is not toxic, the manufacturing process of the product and components can be hazardous or exert burden to the environment and resource, as well, have health impact to the workers. For mobile phones, whose average service life in Europe is estimated to be no more than two years even around one year, the energy consumption in the manufacturing becomes more important than in the use phase<sup>71</sup>. Aside the mobile phone or computer, taking the widely applied component – semiconductor – as an example, which is particularly useful as a base material in manufacturing of computer chips, automotive, industrial, communications, and other consumer purposes. Strong ongoing consumer demand for wireless products like mobile phones and media tablets has prompted steady annual growth of semiconductor industry<sup>72</sup>. Environmental and health issues in the manufacturing of semiconductors primarily include the following:

- Hazardous material use and waste: a host of toxic materials are used in the fabrication process, including arsenic, antimony, phosphorous, hydrogen peroxide, nitric acid, sulphuric acid and hydrofluoric acid<sup>73</sup>; almost all processes in semiconductors manufacturing generate hazardous or potentially hazardous wastes, such as spent deionized water, spent solvents and developers, spent cleaning solutions, sludge from wastewater treatment, spent epoxy material,

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<sup>70</sup> IVF, 2007; James, P. & Hopkinson, L., 2009a

<sup>71</sup> Røpke, I., Gram-Hanssen, K. & Jensen, J.O., 2007; Jönbrink, A.K. & Zackrisson, M., 2007

<sup>72</sup> Jelinek, L., 2012

<sup>73</sup> GWI, 2009

spent cyanide solutions, and soldering fluxes and metals residue<sup>74</sup>;

- Air emissions: greenhouse gases, toxic, reactive, and corrosive substances (for example, acid fumes, cleaning gases, and volatile organic compounds), resulting from diffusion, cleaning, and wet-etching processes; approximately 30 hazardous air pollutants have been identified by the US Environmental Protection Agency in semiconductors manufacturing<sup>75</sup>.
- Wastewater: Water is vital to producing microchips, which are critical to today's communication lifestyle; ultrapure water plays an essential role for the global \$250 billion semiconductor industry<sup>76</sup>. Manufacturing semiconductors results in various levels of wastewater generated, including organic and inorganic compounds, such as metals, acids and alkalis, cyanides and suspended solids<sup>77</sup>.
- Energy use: semiconductor manufacturing involves significant energy use in many thermal processes and highly mechanized wafers handling<sup>78</sup>.
- Occupational health and safety hazards: exposure to material released by substrates during handling or mechanical manipulation; exposure to hazardous process chemicals, including metallic powders; physical hazards and exposure to energy hazards (including, kinetic, electrical, pneumatic and hydraulic); exposure to ionizing and non-ionizing radiation and lasers<sup>79</sup>.

### 2.3 Purchase of household ICT appliances

'Planned obsolescence' is a key feature of ICT consumer marketing; short product life leading to rapid replacement; it is also rampant for computers, particularly using the leverage of operating system updates to sell more; however, the extreme is mobile phones, which may have a life of around twelve months in some cases<sup>80</sup>. The basis of consumption propensity is not the disposable products, but the very concept of disposability itself: buying, trashing, and buying again. Actually, the technology and

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<sup>74</sup> IFC, 2007

<sup>75</sup> IFC, 2007

<sup>76</sup> GWI, 2009

<sup>77</sup> IFC, 2007

<sup>78</sup> IFC, 2007

<sup>79</sup> IFC, 2007

<sup>80</sup> COM (2009) 111 final, 2009, "Communication on mobilizing information and communication technologies to facilitate the transition to an energy-efficient, low-carbon economy"

function updates with a new shape are only a tiny little piece in corner. Advertisements and media hide the extraction, production and disposal outside consumers' vision field, left the only part – shopping<sup>81</sup>. Though the OECD recently reported the good practice of advertisement in promoting sustainable consumption of “sustainable product”<sup>82</sup>, yet it still boosts consumption, rather than touching the problem and potential crisis at root. Consumers use electronics to shape their identities, for example, young people use mobile phone create communities outside of their family; and certain brands imply "coolness" while others are dated and conformist<sup>83</sup>. Even though energy labelling is a well known and accepted scheme that is active for some years, work still needs to be done in consumer's awareness and enforcement, e.g., informing the consumers about the importance and the benefits of buying energy efficient appliances, and about the importance of choosing Energy Star products<sup>84</sup>.

Purchase is an essential part which links the production and consumption. Nowadays, a common trend is to oversize the household appliances (especially TVs), either due to wish to maintain a certain lifestyle image or the almost similar price of different sizes (e.g., flat TVs)<sup>85</sup>. To buy “greener” and more efficient ICT products seem to be a better choice; however, the related problems of household ICT appliances' production and consumption in resource, energy, environment and health aspects will not be eventually solved. Therefore, it is crucial to have efficiency go together with sufficiency so as to bring the fundamental change. In the following part, moreover, in Chapter Three and Four, more literature review and discussion on purchase choices and behaviors will be found.

#### **2.4 Usage and energy consumption of household ICT appliances**

Growth of electricity consumption by small electrical and electronic devices has been the most rapid of all appliance categories over the past five years; while, ICTs and consumer electronics altogether account for approximately 15% of global residential

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<sup>81</sup> Leonard, A., 2008

<sup>82</sup> OECD, 2008

<sup>83</sup> Ling, R., 2001

<sup>84</sup> De Almeida, A., Fonseca, P., Feilberg, N. Grinden, B., Kreitz, T. and Dupret, M., 2009

<sup>85</sup> Coleman, M., 2011

electricity consumption<sup>86</sup>. Consumer ICT appliances present the largest ICT energy load, especially mobile phones, personal computers and TV sets. 49% of the global ICT carbon footprint in 2007 was contributed by PCs, peripherals and printers; the figure is forecasted to rise to 57% by 2020<sup>87</sup>. Switching to the best technologies would save at least 40% of residential electricity consumption in most appliance categories<sup>88</sup>. A recent global analysis by Gartner estimates that, ICT use in 2007 accounted for 2% of all human-made carbon emissions<sup>89</sup>. 75% of ICT overall carbon emission is generated from its use stage; while, about one quarter is from materials and manufacture<sup>90</sup>. ICT products and services consume 7.8% of EU electricity and may grow to 10.5% by 2020<sup>91</sup>. It is reported that a seven-fold gain is expected in Europe over the period 1990-2030, for the residential sector for consumption by ICT and consumer electronic equipment<sup>92</sup>.

Sociologist concluded that young people's daily routines and habits are the significant consequences from watching TV, as individuals aged 4 and over in the UK watch an average of 25 hours a week, at most 3-6 hours per day<sup>93</sup>. However, in recent years, TV watching habits are changing, particularly amongst young people, due to more Internet use and interactive video sharing websites such as YouTube, as well, the new social networking websites such as Facebook<sup>94</sup>. California State University source book for teaching science published that in 2007 the average American watches more than 4 hours of TV each day<sup>95</sup>. Motorola's 2010 Media Engagement Global Barometer study from 7,500 consumers in 13 international markets reported that the amount of time spent in watching TV is on average 17 hours each week around the world<sup>96</sup>.

Desktop computers and TVs were the most significant electricity consuming

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<sup>86</sup> OECD/IEA, 2009

<sup>87</sup> Climate Group, 2008

<sup>88</sup> OECD/IEA, 2009

<sup>89</sup> Gartner Consulting, 2007

<sup>90</sup> Climate Group, 2008

<sup>91</sup> COM (2009) 111 final, "*Communication on mobilizing information and communication technologies to facilitate the transition to an energy-efficient, low-carbon economy*"

<sup>92</sup> OECD/IEA, 2009

<sup>93</sup> Ofcom, 2007

<sup>94</sup> Giddens, A., 2009

<sup>95</sup> Herr, N., 2007

<sup>96</sup> Motorola survey, 2010

appliances and the majority of their electricity consumption was from the active power mode<sup>97</sup>. With more affordable access to broadband Internet and growth in online-services, the overall computer energy consumption is rising dramatically<sup>98</sup>. In addition, each individual user now owns many more devices as discussed in section 1.4. The replacement of old energy-consuming CRT screens with modern LCD flat screens might lead to energy efficiency; however, the increased screen size and more products will eventually counterbalance the efficiency improvements<sup>99</sup>, resulting in increased energy consumption and environmental impacts<sup>100</sup>. The Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe (REMODECE) project, which carried out a large monitoring campaign in twelve countries, reported that though there is a shift towards LCD and Plasma TVs, which are more efficient than conventional CRT TVs, the energy consumption of the flat TVs (LCD TVs use in average about 190 kWh; Plasma TVs, 400 kWh) is even larger, compared to the conventional TVs (125 kWh on average), due to the larger screens<sup>101</sup>. In all, the main factors increasing ICT energy consumption are: 1) an increasing number of devices; 2) rising LCD screen sizes; 3) more time spend on activities using ICTs; 4) expansion of colour printing<sup>102</sup>. The most significant growth of ICTs' carbon footprint is attributable to increasing demand in developing countries, like China and India; if catch up with developed countries' levels, they will account for more than 60% of ICT's carbon emissions<sup>103</sup>.

Energy consumption of computer and monitor is highly dependent upon types and time in the various operational modes (e.g., idle, sleep, standby or off)<sup>104</sup>. In general, desktop computers in 'active mode' consumes energy three times more than 'standby/sleep mode'; while, 'active-off mode' consume only 1/9 energy of 'standby/sleep mode'<sup>105</sup>. It is applicable for both desktop computers with CRT and LCD monitors; as these ICT devices acquire more processing power, their

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<sup>97</sup> Coleman, M., 2011

<sup>98</sup> James, P. & Hopkinson, L., 2009

<sup>99</sup> Røpke, I., Gram-Hanssen, K. & Jensen, J.O., 2008

<sup>100</sup> Polimeni, J., Mayumi, K., Giampietro, M., & Alcott, B., 2007; James, P., 2008

<sup>101</sup> De Almeida, A., Fonseca, P., Bandeirinha, R., Fernandes, T., Araújo, R. and Nunes, U., 2008

<sup>102</sup> Market Transformation Programme, 2007; Røpke, I., Gram-Hanssen, K. & Jensen, J.O., 2008

<sup>103</sup> Climate Group, 2008

<sup>104</sup> E3 Team, 2007

<sup>105</sup> Eugster, M., Hischier, R. & Duan, H., 2007

requirements for power and for cooling, also rise<sup>106</sup>. Carbon Trust data estimate that leaving a computer on overnight for a year creates enough CO<sub>2</sub> to fill a double-decker bus; and a photocopier left on standby overnight wastes enough energy to make 30 cups of tea<sup>107</sup>. More recent standby power studies have presented that for most OECD countries, standby power accounts for around 10% of total domestic electricity consumption<sup>108</sup>. According to International Energy Agency, by 2030, 15% of total appliance electricity consumption in Europe is due to stand-by functionality<sup>109</sup>. User behavior had a significant impact on the electricity consumption from ICT appliances, for example, on average, around 40% of 1300 households in the Europe REMODECE project do not turn off televisions, preferring to use the standby function; in some cases, users leave computers on when not in use, to avoid rebooting the computer or due to some tasks running; however, by changing to the Best Available Technology and Best Practice Behavior, households can reduce about 48% of their total electricity consumption<sup>110</sup>.

## **2.5 End-of-life of electronic appliances**

The annually increasing “market penetration” and global “high obsolescence rate” make e-waste stream rise at an exponential pace; globally, e-waste is now the fastest growing component<sup>111</sup>. The total amount of discarded electronic products around the world has sky-rocketed over the past few years, with 20-50 million tonnes generated every year<sup>112</sup>. Based on the global sales data, PCs, mobile phones and TVs in total will generate 9.8 million tonnes in 2016<sup>113</sup>. The average lifespan of computers in developed countries has dropped from six years in 1997 to just two years in 2005; mobile phones have a lifecycle of even only one year in developed countries<sup>114</sup>.

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<sup>106</sup> UN ITU, 2007a

<sup>107</sup> Carbon Trust, 2008

<sup>108</sup> De Almeida, A., Fonseca, P., Bandeirinha, R., Fernandes, T., Araújo, R. and Nunes, U., 2008; Coleman, M., 2011

<sup>109</sup> OECD/IEA, 2003

<sup>110</sup> De Almeida, A., Fonseca, P., Bandeirinha, R., Fernandes, T., Araújo, R. and Nunes, U., 2008

<sup>111</sup> SECO, 2003

<sup>112</sup> UNEP, 2005

<sup>113</sup> Greenpeace International, 2008b

<sup>114</sup> Greenpeace International, 2005a



In a country like China, the existing implemented e-waste regulations are fragmented and lack of procedural laws to ensure the implementation; so far the available ones are: “Law of Prevention and Control of Environmental Pollution by Solid Waste” (2005)<sup>115</sup>, “Measures for Administration of the Pollution Control of Electronic Information Products” (2007)<sup>116</sup>, “Circular Economy Promotion Law” (2008)<sup>117</sup>, and “Regulation for the Management of Recycling and Disposal of Waste Electrical and Electronic Products” (2009)<sup>118</sup>. Challenges for China e-waste management include difficulties of recycling pilot projects and stakeholders' responsibility. For example, in the e-waste collection, due to convenience and lacking of other efficient take-back channel, to directly sell e-waste with a rather low price to the roadside informal collectors has well embedded in Chinese e-waste disposal practice<sup>119</sup>. However, household electronic appliances are rapidly rushing into end-consumers in China, accelerated by a series of economic incentives, e.g., “village appliance” schemes with subsidies to increase sales of TVs, refrigerators, washing machines and mobile phones in rural areas<sup>120</sup>; and “home appliances trade-in policy” that provides 10% subsidy if consumers bring back the old appliances to buy a new one<sup>121</sup>. As a result, some 5 million appliances will be replaced; that is, 2.3 million tonnes of resources for reuse<sup>122</sup>.

From both domestic and overseas sources, China had to deal with 70% of worldwide e-waste annually by 2002<sup>123</sup>. Öko-Institut estimates in 2007 that, there are 700,000 people working in the e-waste recycling economy in China, the biggest in the world<sup>124</sup>. Electronic devices, such as, high-tech parts of computers, are a complex mixture of several hundred materials and difficult to recycle, many of which contain heavy metals and hazardous chemicals<sup>125</sup>. Recycling processes require energy to extract; overall, the

<sup>115</sup> Order of China No.31, 2005, “*Law of the Peoples Republic of China on Prevention and Control of Environmental Pollution by Solid Waste*”

<sup>116</sup> Order of the China Ministry of Information Industry No. 39, 2007, “*Measures for Administration of the Pollution Control of Electronic Information Products*”

<sup>117</sup> CEPL, 2008

<sup>118</sup> State Council Decree of the People's Republic of China No. 551, 2009, “*Regulations on Recovery Processing of Waste Electrical and Electronic Equipments*”

<sup>119</sup> Wang, B., 2005

<sup>120</sup> Rural Subsidy Scheme, 2008

<sup>121</sup> China Trade-in, 2009

<sup>122</sup> Huo, W., 2009

<sup>123</sup> BAN Report, 2002

<sup>124</sup> Manhart, A., 2007

<sup>125</sup> Greenpeace International, 2005b

energy aspect of waste handling is negligible, whereas the problem with toxins and working environment are huge<sup>126</sup>. The alarming fact is that, right now, the major outlets of the e-waste disposal are the primitive and heavy-polluted scrap yards in developing countries, where workers are recycling the 21<sup>st</sup> century's e-waste with 19<sup>th</sup> century's technology, which squandering material resources posing significant risks in occupational health, safety and environment<sup>127</sup>. A recent study by Greenpeace estimates the gold recovered from printed wiring boards in India at a maximum of 20%; compares to 95% in a state-of-the-art facility in the EU together with 16 other precious metals with lower total emissions<sup>128</sup>.

A few of the major PC producers (Hewlett Packard, Dell, Apple, Lenovo, Sony and Toshiba) provide an estimate of their recycling rate of computer from 8.8% to 53%; while, lower figures are reported for the recycling of mobile phones (recycled through take back point, Nokia provides a figure of 2% of recycled mobiles, Motorola 3.32%), probably due to difficulties in collection<sup>129</sup>. It is estimated that only 25% of the e-waste generated within EU is currently collected and treated<sup>130</sup>. Greenpeace reported the 'hidden flow' of branded PCs and mobile phones currently amounts to an average of 91% of past sales; while, in the US, this figure is around 80%<sup>131</sup>. As a result, impacts have already been reported, particularly in Asia; recently emerging in Africa<sup>132</sup>. There, high levels of hazardous chemicals were found in water, soil and sediment around e-waste scrap yards<sup>133</sup>.

## 2.6 Challenges of reuse

“Reuse” has several definitions in international legislations, norms and practice, which are highly context-dependent, for example, in the End-of-Life Vehicles Directive<sup>134</sup>,

<sup>126</sup> Jönbrink, A.K. & Zackrisson, M., 2007

<sup>127</sup> Ke, J., 2005; Manhart, A., 2007

<sup>128</sup> Greenpeace International, 2008a

<sup>129</sup> Greenpeace International, 2008a

<sup>130</sup> Huisman, J., Magalini, F., Kuehr, R., Maurer, C., Ogilvie, S., Poll, J., Delgado, C., Artim, E., Szlezak, J., Stevels, A., 2008

<sup>131</sup> Greenpeace International, 2008a

<sup>132</sup> Marshall, 2008

<sup>133</sup> Greenpeace International, 2008a&b

<sup>134</sup> Directive 2000/53/EC, 2000, “*Directive on End-of-Life Vehicles*”

Packaging Waste Directive<sup>135</sup>, Waste Electrical and Electronic Equipment (WEEE) Directive<sup>136</sup>, OECD/Eurostat Joint Questionnaire on Waste<sup>137</sup>, and German VDI 2343 Guideline Part VII Reuse<sup>138</sup>. Encouraging reuse is regarded as a way to prevent the generation of e-waste, in view of the WEEE Directive<sup>139</sup>. Obviously, mixed definitions of the key terms became barriers for solutions, creating confusion among academia, government, business and consumers, eventually hindering an efficient reuse market. The United Nations University Solving the E-waste Problem (StEP) Initiative tries to raise common definition of reuse for the engaged stakeholders to foster reuse practice to prevent EEE from being put into storage or waste stream<sup>140</sup>. The reuse cascade, activity-oriented view, and preparation alternatives are attached in Appendix 3. The Directive 2008/98/EC on Waste (Waste Framework Directive) defines reuse as “any operation by which products or components that are not waste are used again for the same purpose for which they were conceived”<sup>141</sup>.

The Ban Amendment of the UN Basel Convention<sup>142</sup> and the European Community Waste Shipment Regulation<sup>143</sup> has prohibited the transboundary shipment of e-waste; Countries, like the US and Japan, opposed the Ban Amendment and blocked any progress<sup>144</sup>. Japanese analysts conclude that there is no domestic scheme, rule even market for reuse of second-hand mobile phone and computer in Japan, instead, to be exported<sup>145</sup>. A 2008 quantitative analysis of e-waste material flow in Asia revealed the many “invisible flows” of second hand EEE<sup>146</sup>. It is imperative to have e-waste recycling legislation to improve recycling conditions and to formalize this sector<sup>147</sup>. The WEEE Directive Review suggested that the legal loopholes for the export of used

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<sup>135</sup> Packing Waste Directive, 1994

<sup>136</sup> Directive 2002/96/EC, 2002, “*Directive on Waste Electrical and Electronic Equipment (WEEE)*”

<sup>137</sup> OECD/Eurostat, 2005

<sup>138</sup> Brüning, R., Rosemann, B. & Enderle, B., 2008

<sup>139</sup> Directive 2002/96/EC, 2002, “*Directive on Waste Electrical and Electronic Equipment (WEEE)*”

<sup>140</sup> StEP White Paper, 2009, “*One Global Understanding of Re-Use – Common Definitions*”

<sup>141</sup> Waste Framework Directive 2006/12/EC, 2008, “*Directive of European Parliament and the Council on waste*”

<sup>142</sup> Basel Convention, 1989; Basel Convention Ban Amendment, 1994

<sup>143</sup> Regulation 1013/2006/EC, 2006, “*Regulation on shipments of waste*”

<sup>144</sup> BAN, 2008

<sup>145</sup> Cardenas, M.F., 2007; Yoshida, F. & Yoshida, H., 2008; Yoshida, A. & Terazono, A., 2008

<sup>146</sup> Terazono, A. & Yoshida, A., 2008

<sup>147</sup> Greenpeace International, 2008b

equipment and the problem are due to lack of criteria for reusability<sup>148</sup>.

The 2007 German research identified that end-of-life EEE arising from households is normally collected in large containers which causes products to become mixed and damaged; furthermore, due to the age of returned products in practice, there are negligible volumes of reusable equipment returned to municipal collection centres<sup>149</sup>. Therefore, in practice, reuse is rather challenging, highly depending on the context of technology, legislation, market, involved stakeholders, social and cultural background, etc<sup>150</sup>. Before the end-user discards the products, reuse occurs through market forces, undertaken by professional refurbishers and social enterprises, also takes place when the products are passed on to family and friends or sold online.

Consumers are the essential part in secondary market, who in the upstream of reuse activity are responsible for the flow of used computers into the market; while, in the downstream, representing the potential buyers of used products<sup>151</sup>. Practical analysis of the total volume at five collection sites in Germany reported that ICT products are often stored for between three to five years before they are disposed of; only 1.27% of products arising through the WEEE collection system are economically reusable, attributed to the high percentage of CRT based products and ink based printers within the waste stream, and also partly dismantled computers<sup>152</sup>. To timely salvage the used but still functional ICTs from value-destructive storage is crucial for different stakeholders to play their specific roles. For example, consumers require awareness and incentives to return the functional products; producers and retailers should provide financial incentives and logistics convenience with transparent market value<sup>153</sup>.

EU proposed collection target of 65% of average weight for producers responsible for products placed on the market in the previous two years for reuse and recycling<sup>154</sup>. A

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<sup>148</sup> Huisman, J., Magalini, F., Kuehr, R., Maurer, C., Ogilvie, S., Poll, J., Delgado, C., Artim, E., Szlezak, J., Stevels, A., 2008

<sup>149</sup> Scheidt, L.-G. & Dempsey, M. 2007

<sup>150</sup> Van Nes, N., Cramer, J., Stevels, A., 1999; UNIDO/Microsoft, 2007; Brühl-Kerner, H., 2008b

<sup>151</sup> Michaud, C. & Lierena, D., 2006; Hickey, S. & Fitzpatrick, C., 2008

<sup>152</sup> Scheidt, L.-G. & Dempsey, M. 2007; Scheidt, L.-G., 2007

<sup>153</sup> Li, J., Scheidt, L.-G. & Fischer, F., 2008

<sup>154</sup> Directive 2008/34/EC (amending Directive 2002/96/EC on waste electrical and electronic equipment (WEEE))

number of organizations, especially producer trade associations, have cast doubt on the feasibility of the reuse targets. Time-sensitive consumer electronics products like computers have been reported to lose value at rates in excess of 1%/week; while, the rate increases approaching their end-of-life<sup>155</sup>. The reuse and refurbishment markets depend on the age, brand and model of the equipment. German desk study of ICT appliances' resale potential, suggests that for notebooks manufactured between 1993 and 2005, there is a consistent reduction in the EBAY remarketing value of products over time; however, between seven years and nine years the notebook computer drops from €225 to €125, which is a 44.4% drop in two years<sup>156</sup>. Consumer acceptance and product return behavior survey in Germany second-hand store revealed that there are 38% consumers initiating reuse of their obsolete computers; however, about 1/3 used computer with largely reduction of the reuse potential due to storage<sup>157</sup>. Study in UK also reported rather low value for reuse of particular e-waste, such as mobile phones and MP3 players<sup>158</sup>.

## **2.7 Summary**

In this chapter, the problems with household ICT appliances production and consumption are reviewed. For these material and energy intensive products, the negative impacts and risks are exerted on health, society and environment, along the value chain. To buy more efficient products is a better choice; however, the trend of having more items, with rapid replacement and shorter lifetime, it still have not yet touched the roots of the problem in the energy, resource and ecological capacity limited planet. The status that consumers set, after using the ICT appliances, may largely influence the energy consumption in the usage stage as well. Though there is already a certain progress, yet, practices and current situation in the end-of-life of household ICT appliances, e.g., repair, reuse, take-back and recycling, bring great challenges and problems, both globally and nationally. It is urgently calling for sustainable consumption of ICTs. In the following chapter, literature review focusing

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<sup>155</sup> Escherich, M., 2005

<sup>156</sup> Scheidt, L.-G. & Dempsey, M. 2007; Scheidt, L.-G., 2007

<sup>157</sup> Herrmann, C. & Luger, T., 2008

<sup>158</sup> Darby, L. & Obara, L., 2004

on this aspect will be presented.

## **3. Literature Review 2: sustainable consumption of EEEs and ICTs**

### **3.1 Introduction**

This chapter, first of all, gives a brief overview on the global economic growth and consumption (section 3.2), from the macroscopic view, which impels the paces moving towards sustainable production and consumption (section 3.3). The definitions of sustainable consumption are summarized (in section 3.4); life-cycle-thinking largely contributes to sustainable production and consumption (3.5). International and regional related legislation and management system are summarized, especially, cycle economy in German and Japan (section 3.6). Environmental and energy labels are common used instruments to influence consumption purchase choice (section 3.7). Besides resource and energy efficiency (section 3.8), sufficiency of consumption which deeply touches the root of the problem, should be paid more attention (section 3.8); reuse of household ICT appliances as a practical example is discussed in the end (section 3.10).

### **3.2 Global economic growth and consumption**

Rapid population growth coupled with current high levels of consumption patterns place increasing and unsustainable stress on the Earth support systems, 60% of which have been degraded in the past 50 years<sup>159</sup>. It leads to energy and material resource scarcity, climate change, toxic waste accumulation and biodiversity loss. Consumption as a social process and consumerism as a social reality substantially contribute to the environmental problems and pose serious constraints to sustainable development of the planet<sup>160</sup>. Global consumption levels and patterns are driven by rapid global population growth; increasing of middle and lower-income consumers; culture of “consumerism” among higher income groups; and political direction of government.

Half a century after stated that “American economy’s ultimate purpose is to produce more consumer goods”, the suggestion following the grief-stricken days in 2001 is still

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<sup>159</sup> Timmer, V., Prinet, E. & Timmer, D., 2009

<sup>160</sup> Stern, P.C., Dietz, T., Ruttan, V.W., Socolow, R.H., Sweeney, J.L., 1997; Princen, T., Maniates, M. & Conca, K., 2002; Lodziak, C., 2002

to “go shopping – to show the unshakable resolve and values<sup>161</sup>. Almost 99% of the stuff running through this material economy system that harvest, mine, process and transport is trashed within six months in the US<sup>162</sup>. From 1900 until 1989, the US population tripled while the use of raw materials multiplied 17 times; moreover, the US population of 300 million is only 5% of the world population, but is responsible for 50% of the world's solid waste<sup>163</sup>. Up to 2006, about 250,000 tons of discarded but still usable mobile phones in stockpiles in America, awaiting disposal<sup>164</sup>. 2006 national survey find out that, each US household has on average, at least four small and 2.4 large e-waste items in storage; which means, a total exceeding 747 million items stored by US households, that is much more than Environmental Protection Agency's estimate of 180.3 million items in storage<sup>165</sup>.

The western lifestyle is increasingly what the rest of the world aspires to; hence, the shift “from production to pleasure” prolongs<sup>166</sup>. Global GHG emissions grew faster in the 2000s than in the 1990s; in 2010, they were 45 % higher than in 1990<sup>167</sup>. Though the ranks of developed countries' per capital CO<sub>2</sub> emission are in general above that of developing countries, yet since 2008 up to now, China has become the world largest GHG emitter<sup>168</sup>, and as reported by the Emission Database of Global Atmospheric Research, the value keeps increasing year by year<sup>169</sup>. On current growth rate, China will be the world second largest market of household consumption by 2014<sup>170</sup>. Facing the economic crisis, one preferable policy to maintain economic growth is to stimulate consumption, both in the Western countries<sup>171</sup> and China<sup>172</sup>. On one hand this promotes the technology and society development; on the other hand, it may not be a comprehensively beneficial solution in a long term. Two to four planets would be required, if everyone adopts the consumption patterns and lifestyles of the average

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<sup>161</sup> Leonard, A., 2008

<sup>162</sup> Hawken, P., Lovins, A. & Lovins, H., 1999

<sup>163</sup> Tilford, D., 2000

<sup>164</sup> Slade, G., 2006

<sup>165</sup> Saphores, J.D., Nixon, H.K., Ogunseitan, O.A. & Shapiro, A.A., 2008

<sup>166</sup> Schipper, L.J., 1997

<sup>167</sup> Randers, J., 2012

<sup>168</sup> WWI, 2008

<sup>169</sup> EDGAR, 2012

<sup>170</sup> Panitchpakdi, S., 2006

<sup>171</sup> SPEECH/09/336, 2009

<sup>172</sup> Chinaview, 2008; Bloomberg News, 2009



citizen in the Western Europe; while, more than four, if like the US<sup>173</sup>. The recent report of the Club of Rome, based on the extensive database, forecasted that over the next forty years up to 2052, there will be advances in resource efficiency and climate-friendly solutions, however, humanity's resource use and environmental impact will not be sustained in the long run<sup>174</sup>.

### 3.3 Paces towards sustainable production and consumption

Sustainable development was raised in 1987 in the report of the World Commission on Environment and Development "Our Common Future" and defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"<sup>175</sup>. People in the past decades pursue economic prosperity at the cost of depleting natural resources and degrading environment to meet the short-term objectives, which might largely endanger the ability of future generations to meet their needs. However, human being's responses to environmental pollution problems are in progress: from simply ignoring them in the 1950s, through inefficient dilution and dispersion in the 1960s, to the costly end-of-pipe technology in the 1970s<sup>176</sup>. Coming to the pollution prevention practices such as cleaner production, it reduces pollution at source and more cost-effective, often resulting in reduced energy and material usage and lower treatment costs<sup>177</sup>. The effort of transition, which is from remedy to profitability, through environmental protection towards integrated resource efficiency, consists of eco-efficiency, eco-sustainability, eco-design, product life cycle, green productivity, and industrial ecology<sup>178</sup>.

In 2002, the World Summit on Sustainable Development in Johannesburg encouraged the shift towards sustainable consumption and production, specifically endorses the reduction, reuse and recycle, promoting to establish a sound material-cycle society within the concept of a life-cycle economy, where consumption of natural resources is

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<sup>173</sup> WWF, 2008

<sup>174</sup> Randers, J., 2012

<sup>175</sup> Brundtland Commission, 1987, "Our common future"

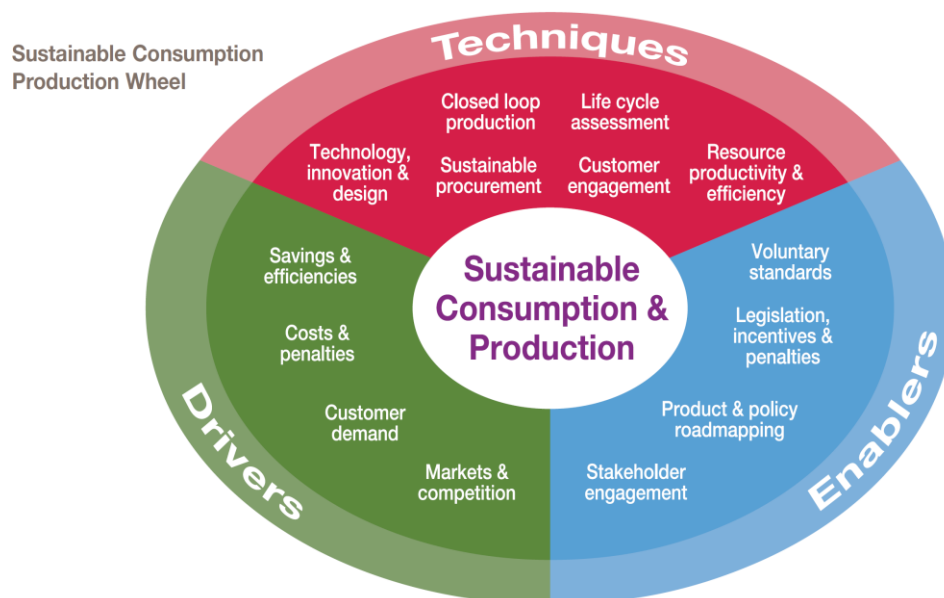
<sup>176</sup> APO, 2002

<sup>177</sup> USC, 1994

<sup>178</sup> WBCSD, 1992; Keoleian, G. A. & Menerey, D., 1994; Graedel, T. E. & Allenby, B. R., 2003; Kibert, C. J., 2003

minimized, environmental load is reduced and sustainable life quality is fulfilled<sup>179</sup>. One year later, it followed by a negotiation on an enforced policy formulation on sustainable development<sup>180</sup>. On the regional level, for example, in EU, the sustainable development strategy adopted by European Council in 2006 includes, firstly, using dynamic performance requirements, sustainability labels, eco-design instruments and standardization for the production of better products; secondly, fostering smarter consumption by means of retailer agreements, market instruments, value added tax rates, the EU Eco-Label, advertising, and green procurement<sup>181</sup>. In 2008, the European Commission Action Plan emphasized the role of life-cycle methodologies for sustainable production and consumption<sup>182</sup>.

Moving towards the goal of Sustainable Consumption and Production will not be easily achieved. It requires active engagement of different stakeholders, technology innovation and development, economic instruments, as well as, legislation and standard. All together, the elements, comprehensively playing the role as drivers, enablers and techniques, promote the progress to sustainable development (Figure 2).



<sup>179</sup> Johannesburg Summit, 2002, "World Summit on Sustainable Development – Plan of Implementation"; JME, 2005; 3R Initiative, 2006; UNEP, 2006a

<sup>180</sup> Marrakech process

<sup>181</sup> WBCSD, 2008

<sup>182</sup> COM (2008) 397 final, 2008, "Communication on sustainable consumption and production and sustainable industrial policy action plan"

**Figure 2** Sustainable Consumption and Production Wheel<sup>183</sup>

Extended Producer Responsibility (EPR) is a preventative environmental protection strategy which effectively internalizes social and environmental costs of products, throughout their life cycles collaborating with all the players in the product chain, from the upstream (design of products) to the downstream (end-of-life management) of feedback loop<sup>184</sup>. In take-back and other end-of-life operation, the degree of cooperation among producers makes a notable distinction in fulfilling responsibility, regarding both incentives and administrative challenges<sup>185</sup>. Individual Producer Responsibility (IPR) makes each producer taking responsibility of the entire lifecycle of his own products, example of IPR implementation in Japan, Germany and US demonstrating the feasibility and viability<sup>186</sup>. EPR practice around the world has successfully embedded various elements of IPR: e.g., separate collection points for ICT equipment in Sweden and Norway<sup>187</sup>; in the European WEEE implementation, IPR is applied to level the economic playing field between various EPR schemes<sup>188</sup>.

**3.4 Definition of sustainable consumption**

“Sustainable household consumption” means a consumption of goods and services that meets human needs and provides increased quality of life while at the same time minimizing the negative impacts of consumption on health and environment, to the benefit of a fair and global development<sup>189</sup>. United Nations Environment Programme (UNEP) defines that “sustainable consumption” is related to the process of purchasing, consuming and disposing of products<sup>190</sup>. It is a site and problem-specific norm; as well, a dynamic concept that indicates the direction and sometimes magnitude of change, and that can evolve over time<sup>191</sup>. European Commission appeals ‘smarter and cleaner’

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<sup>183</sup> Sabapathy, J., 2007

<sup>184</sup> EPA, 1998; Lindqvist, T., 2000; OECD, 2001b; Tchobanoglous, G. & Kreith, F., 2002; Peck, P., 2003; Rossem, C.v., Tojo, N. & Lindqvist, T., 2006a

<sup>185</sup> Directive 2002/96/EC, 2002, “*Directive on Waste Electrical and Electronic Equipment (WEEE)*”; Veerman, K., 2004

<sup>186</sup> Sander, K., Schilling, S., Tojo, N., van Rossem, C., Verson, J. & George, C., 2007; ECOLAS/RPA, 2007; Hieronymi, K. & Dempsey, M., 2008; Rotter, V.S., Chancerel, P. & Schill, W-P., 2008

<sup>187</sup> Rossem, C.v., Tojo, N. & Lindqvist, T., 2006a

<sup>188</sup> Rossem, C.v., Tojo, N. & Lindqvist, T., 2006b

<sup>189</sup> Timmer, V., Prinnet, E. & Timmer, D., 2009

<sup>190</sup> UNEP, 2008

<sup>191</sup> OECD, 2002

for consuming sustainably, which concerns people's lifestyle, buying behavior and how to use and dispose of products and services<sup>192</sup>.

### 3.5 Life-cycle-thinking and “cradle-to-grave”

In 2001, the European Council adopted the Sustainable Development Strategy, one of which core objectives is to decouple environmental degradation and resource consumption from economic and social development, further integrating the life-cycle thinking in European environmental policy<sup>193</sup>. In 2003, the European Commission adopted the Integrated Product Policy Communication to improve the environmental performance of products throughout their life cycles, i.e. from raw material extraction, through processing and production, to use, re-use, recovery, end of life treatment, and disposal of remaining waste (“cradle-to-grave” approach)<sup>194</sup>. The concept is carried out through the Thematic Strategy on Sustainable Use of Natural Resources<sup>195</sup>, the Prevention and Recycling of Waste<sup>196</sup>, revisions of Waste Framework Directive<sup>197</sup>, Energy-using-Products (EuP) Directive<sup>198</sup> and the Eco-label Regulation<sup>199</sup>. By the end of 2007, this is further strengthened and many policies are integrated through the Sustainable Consumption and Production Action Plan<sup>200</sup>.

Life-cycle-thinking is the process of taking into account in decision making all resources consumed and all environmental and health pressures that are associated with the life cycle of a product, considering the extraction of resources, production, use, re-use, transport, recycling, and waste disposal<sup>201</sup>. Being the method for quantitative environmental life-cycle-thinking, Life Cycle Assessment (LCA) is internationally

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<sup>192</sup> EC, 2009

<sup>193</sup> COM (2001) 264 final, 2001, “A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development”

<sup>194</sup> COM (2003) 302 final, 2003, “Integrated Product Policy Communication – Building on Environmental Life-Cycle Thinking”

<sup>195</sup> COM (2005) 670 final, 2005, “Communication on the Sustainable Use of Natural Resources”

<sup>196</sup> COM (2005) 666 final, 2005, “Communication on the Prevention and Recycling of Waste”

<sup>197</sup> Waste Framework Directive 2006/12/EC, 2008, “Directive of European Parliament and the Council on waste”

<sup>198</sup> Directive 2005/32/EC, 2005, “Directive on establishing a framework for the setting of eco-design requirement for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC”

<sup>199</sup> Regulation (EC) No 1980/2000, 2000, “Regulation on revised community eco-label award scheme”

<sup>200</sup> COM (2008) 397 final, 2008, “Communication on sustainable consumption and production and sustainable industrial policy action plan”

<sup>201</sup> JRC, 2007; UNEP, 2009a

standardized as ISO 14040<sup>202</sup>. Beyond traditional Environmental LCA, Social LCA was introduced by UNEP in 2009 to integrate social aspects along the life cycle<sup>203</sup>.

### 3.6 Legislations and management systems related to EEE's life-cycle

In Europe, the legislative framework relating to the life-cycle of EEE consists of a certain concrete directives, such as, WEEE Directive<sup>204</sup>, the Reduction of Hazardous Substances (RoHS) Directive<sup>205</sup>, as well as, the EuP Directive<sup>206</sup>. The WEEE Directive prioritizes the prevention of e-waste, following the reuse, recycling and other forms of recovery to reduce the disposal; seeks to improve the environmental performance of all operators involved in the life cycle of EEEs<sup>207</sup>. For example, before the WEEE Directive, the German public waste management authorities were responsible for the collection and treatment of e-waste, and consumers were charged for its treatment and disposal; along with the German transposition of the WEEE Directive, the producers were shifted to take responsibilities to organize and finance the logistics, treatment and disposal of this waste<sup>208</sup>. In the recent study of the 2008 WEEE Review, which was supported by the United Nations University, concluded that the main concern is providing incentives for increasing collection amounts and the control over the quality of treatment<sup>209</sup>. Aiming to tackle e-waste as well, the RoHS Directive purposely targets to eliminate the hazardous substances, for the significant reduction of risks to health and the environment<sup>210</sup>.

The EuP Directive provides a framework for establishing eco-design requirements for Energy using Products<sup>211</sup>. A comprehensive European Communities' Directives and

<sup>202</sup> ISO 14040: 2006, "Environmental Management – Life Cycle Assessment – Principles and framework"; ISO 14044: 2006, "Environmental management – Life Cycle Assessment – Requirements and guidelines"

<sup>203</sup> UNEP, 2006c; UNEP, 2009a

<sup>204</sup> Directive 2002/96/EC, 2002, "Directive on Waste Electrical and Electronic Equipment (WEEE)"

<sup>205</sup> Directive 2002/95/EC, 2002 "Directive on the Restriction of the use of certain Hazardous Substance in Electrical and Electronic Equipment (RoHS)"

<sup>206</sup> Directive 2005/32/EC, 2005, "Directive on establishing a framework for the setting of eco-design requirement for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC"

<sup>207</sup> Directive 2002/96/EC, 2002, "Directive on Waste Electrical and Electronic Equipment (WEEE)"

<sup>208</sup> Deubzer, O., 2011

<sup>209</sup> StEP White Paper, 2009, "One Global Understanding of Re-Use – Common Definitions"

<sup>210</sup> Directive 2002/95/EC, 2002 "Directive on the Restriction of the use of certain Hazardous Substance in Electrical and Electronic Equipment (RoHS)"

<sup>211</sup> Directive 2005/32/EC, 2005, "Directive on establishing a framework for the setting of eco-design requirement for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC"

regulations to improve energy efficiency in energy-using products include the Eco-Design Directive<sup>212</sup>, the Directive on Labelling and Standard Product Information of Energy Consumption<sup>213</sup>, the Directive on Energy End-Use Efficiency and Energy Services<sup>214</sup>. The preparatory studies for computers and monitors, imaging equipment and standby mode energy consumption are completed, which assess the environmental aspects over the entire life cycle of the EuP (production, distribution, end-of-life management) to recommend ways to improve environmental performance of the products<sup>215</sup>. “The Regulation No 1275/2008 on the ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment” and its accompanying guideline required that, starting from 7 January 2010, for the new TVs, computers and monitors entering into the EU market, the ‘standby mode’ shall not exceed 1.00 W (0.5 W as of 2013); or 2.00 W if providing information or status display (1.00 W as of 2013); and the ‘off mode’ shall not exceed 1.00 W (0.5 W as of 2013); however, such requirements should have negative impact on the functionality and should not negatively affect health, safety and environment<sup>216</sup>.

### 3.7 Environmental and energy saving labels

To promote sustainable consumption, performance standards and mandatory labels are the most direct instruments for eliminating unsustainable products from market and changing consumption patterns. Most common are those aiming at reducing energy use indicating different household appliances with energy efficiency levels; and providing information to encourage greater involvement in the collection and recycling<sup>217</sup>. In 2007, survey of 1,500 Internet users in Australian drew the conclusion that 95% of Internet users were in favour of labelling of computers and monitors; besides, some

<sup>212</sup> Directive 2009/125/EC, 2009, “*Directive on establishing a framework for the setting of ecodesign requirements for energy-related products (recast)*”

<sup>213</sup> Council Directive 92/75/EEC, 1992, “*Directive on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances*”; Directive 2010/30/EU, 2010, “*Directive on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products (recast)*”

<sup>214</sup> COM (2006) 545 final, “*Action plan for energy efficiency: realizing the potential*”; Directive 2006/32/EC, 2006, “*Directive on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC*”

<sup>215</sup> Project Description, 2008

<sup>216</sup> Regulation No 1275/2008 Implementing Directive 2005/32/EC, 2008, “*Ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment*”; Guidelines accompanying Commission Regulation (EC) No 1275/2008 of implementing Directive 2005/32/EC, 2009

<sup>217</sup> OECD, 2008

form of endorsement labelling is positive required by the consumers<sup>218</sup>. The studies showed that sustainability effects of labelling schemes are growing with heightened consumer interest in environmental and social issues in OECD countries; however, the general weaknesses of labels still persist, including low levels of consumer awareness and criteria differences across products<sup>219</sup>. The proliferation of voluntary labels on the market has also led to consumer confusion between self-declarations and third-party certified labels<sup>220</sup>.

Eco-label identifies overall environmental performance of a product or service based on life cycle considerations, awarded by an impartial third-party to meet environmental leadership criteria to enable consumers to make informed choices, e.g., Blue Angel, Eco-Flower<sup>221</sup>. Eco-labels are key tools for achieving sustainable consumption and production, as they bridge consumption and production, to guide consumers in purchasing products with fewer adverse environmental impacts and to encourage manufacturers to supply environmentally sound products; thereby, stimulating the market-driven continuous environmental improvement<sup>222</sup>.

The Electronic Product Environmental Assessment Tool eco-label, which is available in 40 countries worldwide, helps consumers to evaluate and select electronics like desktops, laptops and monitors, based on 23 required environmental performance criteria in product life cycle<sup>223</sup>. TCO Certified is an international, third party, voluntary certification of ICT products (computer monitors, computers, keyboards, printers and mobile phones) that make it easy to choose technology designed for high usability and minimal impact on the environment; this eco-label could be found in more than 150 countries<sup>224</sup>. Energy Star is a voluntary government-backed program to helping individuals protect the environment through superior energy efficiency<sup>225</sup>.

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<sup>218</sup> E3 Team, 2007

<sup>219</sup> OECD, 2008

<sup>220</sup> Poncibo, Cristina, 2007

<sup>221</sup> Regulation (EC) 1980/2000, 2000, "*Regulation on a revised community eco-label award scheme*"; GEN, 2009

<sup>222</sup> UNEP 2007 Annual Report

<sup>223</sup> Ecolabel Index, EPEAT, 2010; EPEAT, 2011

<sup>224</sup> Ecolabel Index, TCO, 2010; TCO certified, 2012

<sup>225</sup> Ecolabel Index, Energy Star, 2010

Starting July, 2007, the US Environmental Protection Agency put into effect new Energy Star standards for computers and related equipment, including improved efficiency across all modes of a computer's operation, and requiring use of highly efficient internal and external power supplies; on average, a qualified computer meeting the new Energy Star specification is 30-65% more efficient than conventional models; qualified televisions use about 40% less energy than standard units<sup>226</sup>. Appendix 4 briefly summarizes the eco-labels relevant to computers and monitors.

### 3.8 Resource and energy efficiency

In the report of “Factor Four: doubling wealth halving resource use” to the Club of Rome, it qualitatively and quantitatively emphasizes the importance and benefits of the resource and energy efficiency<sup>227</sup>. As the ICT products getting more closely related to human being's life, the decoupling of growth in production and consumption of ICT products from resource depletion and environmental degradation is urgent. UNEP's medium-term strategies 2010-2013 take Resource Efficiency as the strategy to pursue Sustainable Consumption and Production, with the objective to ensure natural resources are produced, processed and consumed in a more sustainable way<sup>228</sup>. In this context, the International Panel for Sustainable Resource Management and the International Conference on Resource Efficiency aim to establish an international sound material-cycle society to reduce environmental impacts of life-cycle resource uses<sup>229</sup>. To increase the efficiency of ICT products' consumption, it is to minimize the energy use and GHG emissions both in use phase and disposal phase, e.g., to certify best in class energy efficiency (e.g., Energy Star); minimal standby losses; Flat Panel Display (FPD) versus CRT monitors; guaranteed take-back and recycling; design for recycling and dismantling<sup>230</sup>. A case study in California presented that with the increasing penetrations of energy efficient laptop and FPD, the annual primary energy

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<sup>226</sup> Energy Star, 2011

<sup>227</sup> Weizsäcker, E.U.v., Lovins, A.B. & Lovins, L.H., 1998

<sup>228</sup> UNEP Medium-term Strategy 2010-2013, 2007, “*Environment for Development*”

<sup>229</sup> Resource Panel; OECD-UNEP, 2008

<sup>230</sup> EC ISMDG, 2008



use and GHG emissions are expected to decline<sup>231</sup>.

ICT appliances are covered within the product category of Energy Labelling Directive 92/75/EEC and its recast version 2010/30/EU, which requires appliances be labelled for consumers to promote utility of energy efficient appliances<sup>232</sup>. The European Communities' 'Towards Sustainability' Decision proclaimed the priorities are to support rational use of energy; to internalize the costs; to encourage consumer awareness in energy-saving; and to provide energy efficiency labelling<sup>233</sup>. International Energy Agency analyzed the mandatory labels programmes of residential equipment (including fridges, clothes washers and air conditioners) in Europe, U.K., the US, Australia and Japan shows that all products have experienced a decline in real prices of between 10% to 45%, while energy efficiency increased by 10% to 60% over the periods when data was collected; though there appears no correlation between price and energy efficiency and the average price of appliances has been falling consistently, there is evidence that the most efficient products in some categories are more expensive than products which are less efficient<sup>234</sup>. Development of Environmental Performance Indicators for ICT Products on the example of Personal Computer Project provides environmental performance indicators for ICT products, like computers, based on a "life-cycle thinking" approach<sup>235</sup>. The US EPA's Energy Star Savings Calculators and Electronics Environmental Benefits Calculator quantify and qualify the lifecycle environmental benefits of the computers and monitors<sup>236</sup>.

### 3.9 Sufficiency of consumption

To manage growing demands for material on a finite planet, "green" products with high efficiency and sound disposal are just the tip of the iceberg and toothless against

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<sup>231</sup> Horvath, A. & Masanet, E., 2007a

<sup>232</sup> Council Directive 92/75/EEC, 1992, "Directive on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances"; Directive 2010/30/EU, 2010, "Directive on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products (recast)"

<sup>233</sup> Decision No. 2179/98/EC, 1998, "Decision in relation to the environment and sustainable development 'Towards Sustainability'"; Regulation (EC) No 106/2008, 2008, "Regulation on a community energy-efficiency labelling programme for office equipment"

<sup>234</sup> IEA, 2007

<sup>235</sup> EPIC-ICT

<sup>236</sup> Energy Star Calculator; Socolof, M.L., Dillon, P. & Geibig, J., 2006

the problem of exploding global resource consumption, if the throw-away mindset is not changed. Economic growth drastically needs to be de-linked from environmental and social degradation; consumer choices of individual should be re-orientated towards more sustainable lifestyles and purchasing decisions<sup>237</sup>. Recently, the World Resource Forum Declaration initiates process to rethink lifestyles and help develop consumption patterns based on sufficiency and careful use of natural resources: efficiency and resource productivity targets should be combined with sufficiency to avoid the rebound effect and other problems, benefiting to the global ecosystem protection and resources preservation for future generations in a sustainable way<sup>238</sup>. Sufficiency strategies support externality reduction in energy use via consumption reduction without the potential problems identified for efficiency and clean energy; therefore, sufficiency strategies need to prominently complement efficiency and clean energy strategies<sup>239</sup>.

A combination of the following four strategies which are reducing the externalities of energy use is most promising for sustainable energy systems<sup>240</sup>:

- increasing technical efficiency (providing energy services with lower energy input);
- increasing economic efficiency (internalizing external costs, ‘get the prices right’);
- using ‘clean’ energy sources with lower external effects;
- strategy of sufficiency (identifying ‘optimal’ energy service levels) which playing only a minor role currently;

Therefore, besides efficiency, sufficiency plays an important role in saving energy and the emphasis should be given to ensure sustainable consumption<sup>241</sup>. Consumers need to be encouraged to reduce the number of appliances they buy; to purchase appliances with ‘sufficient’ functionality (e.g. TVs with smaller screen sizes); and to change the

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<sup>237</sup> Hoballah, A., Lugt, C.v.d. & Sonnemann, G., 2008; Randers, J., 2012

<sup>238</sup> WRF, 2009; Muller, A., 2009

<sup>239</sup> Muller, A., 2009; eceee 2006

<sup>240</sup> Muller, A., 2009

<sup>241</sup> De Almeida, A., Fonseca, P., Bandeirinha, R., Fernandes, T., Araújo, R. and Nunes, U., 2008; Coleman, M., 2011

pattern of use (e.g., to reduce individualized and simultaneous use of appliances)<sup>242</sup>.

Sufficiency, which was defined as ‘more well-being from less products and services’ and perceived as one of the fundamental principles of sustainable development, does not mean less availability; but rather, a new mindset for the consumption of product and services<sup>243</sup>. The sufficient lifestyle of consumption is to consume at the levels of ‘enough’ that determined by the understanding of externalities from consumption, with one’s own notion of a ‘good life’ and a sense of responsibility for one’s actions; in particular, including the global externalities from consumption decisions, which traditionally are not in the focus of responsibility for the effects of one’s actions<sup>244</sup>.

In the recent report of the Club of Rome “2052 – A Global Forecast for the Next Forty Years”, it is stated that: *“While the process of adapting humanity to the planet’s limitations has started, the human response could be too slow. The main cause of future problems is the excessively short-term predominant political and economic model, resulting in a slow societal response to challenges, which need long-term solutions and investments. To handle the long term challenge and modify the market, it is necessary to have some stronger solution than ‘free market, regulation, political leadership, or public education’; moreover, it is essential to realize the root of the problem – human’s short-term nature, that is, their tendency to disregard the long term consequences of current action. Probably something at the supranational level is needed to temper the short-termism of the nation state”*<sup>245</sup>. Merely to raise or agree with the sufficiency concept is not enough to break the current purchase pattern and economic development trend; however, targeting to sufficiency for the long term may assist to challenge and shift the current short-term political and economic model to the efficient solution in the capacity limited planet.

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<sup>242</sup> Coleman, M., 2011

<sup>243</sup> Korsunova, A., 2005

<sup>244</sup> Muller, A., 2009

<sup>245</sup> Randers, J., 2012

### 3.10 Practice – reuse of household ICT appliances

The importance of the Reduce Reuse Recovery for enhancing resource productivity was recently underlined by the OECD<sup>246</sup>. Cumulative energy consumption studies suggest that, within the optimal lifetime, the production of an mobile phone, laptop computer, or TV, needs mostly more energy than the energy it will use during its operational time, it makes environmental sense to extend the life of devices and equipment<sup>247</sup>. Recent LCA study on desktop computers concluded that, end-of-life strategies hierarchy is reasonable, that is, unit reuse is most environmentally friendly followed with components reuse and material recovery<sup>248</sup>. Lifetime extension of PCs in consumer to consumer secondary markets is identified advantageous from an environmental perspective<sup>249</sup>. In the waste strategy hierarchy context, reuse of the whole products or its components has been commonly regarded as better than material recovery, incineration and landfilling, from environmental protection and resource conservation point of view within the capacity of the planet itself <sup>250</sup>. A recent LCA case study uses the diagram with iso-environmental-load lines to represent various replacement conditions of household electronic appliances; the analysis of the scenarios shows that<sup>251</sup>:

- early replacement of laptop computer is not the best option, longer use and reuse within optimal lifetime is preferable in terms of lower total energy consumption;
- early replacement of TVs (at five years) is difficult to estimate, due to different use period and monitor type (CRT and FPD); longer use and reuse of TVs is preferable; after approximately 11-12 years of use, it should be replaced with new products;

It is widely acknowledged that reuse can play a very positive role in reducing the huge

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<sup>246</sup> Gurria, A., 2008

<sup>247</sup> Williams, E., 2004; IVF, 2007; Scheidt, L.-G. & Dempsey, M., 2007; Kiatkittipong, W., Wongsuchoto, P., Meevasana, K. & Pavasant, P., 2008; James, P. & Hopkinson, L., 2009

<sup>248</sup> Lu, B. & Yang, J., 2008

<sup>249</sup> Hickey, S. & Fitzpatrick, C., 2008; Böni, H., Streicher-Porte, M., Marthaler, C. & Camacho, A., 2008

<sup>250</sup> Truttmann & Rechberger, 2001; Graedel & Allenby, 2003; Mazhar, M.I., Kara, S., Kaebernick, H., 2005; King, A. M. , Burgess, S. C., Ijomah, W. & McMahon, C.A., 2005; Nasr, N. & Thurston, M., 2006; Schmidt, J.H., Holm, P., Merrild, A. & Christensen, P., 2007

<sup>251</sup> Tasaki, T., Motoshita, M. & Sasaki, S., 2008

amounts of e-waste and in making use of EEE more sustainable<sup>252</sup>. Reuse may offer essential household items for people with low incomes to raise their standards of living and to participate in social activities, bridging digital divide or delivering necessary means of communication<sup>253</sup>. However, Gartner found that in developing regions demand for used computers continues to exceed supply, such as Eastern Europe, the Middle East, Africa, Latin America and parts of Asia-Pacific region; while, in developed economics, both consumer buy and sell potential of the used ones are rather low<sup>254</sup>. Ideally, well organized reuse activities to close the life-cycle of ICT products, largely save resources, reduce environmental pollution, provide jobs in local community, and balance economic affordability and urgent need in education, medical care, and communication, for low income homes, schools or developing markets<sup>255</sup>. Regionally, the reuse, refurbishment and remanufacturing markets with well controlled system for product take back in place are forming, including established international business players, SME's, social enterprises and Non-Governmental Organizations (NGO)'s<sup>256</sup>, such as, the regional network of Reuse and Recycling EU Social Enterprises in Europe<sup>257</sup>, ReUse-Computer Network in Berlin<sup>258</sup>, Austria Multi-Lifecycle Centre<sup>259</sup>. In Germany, the BFL-IT Index (Büro-Fachhandel-Leasing Information Technology Index) for Trade-in Value of used desktop computers, monitors and laptop for both reuse upstream and downstream activities<sup>260</sup>, which is comparable as the "Schwacke-Liste" for the used cars, reflects the transparent and fair market value, guarantees the benefit of the involved consumers<sup>261</sup>. Currently, it is only applied for the Business-to-Business transaction, not for private consumers; however, it provides a solid reference for setting the transparent price in the reuse of second-hand IT products.

To ensure the product reusability, a broad range of factors influencing the pros and

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<sup>252</sup> Brühl-Kerner, H., 2008a

<sup>253</sup> RREUSE, 2006

<sup>254</sup> Michaud, C. & Lierena, D., 2006; Hickey, S. & Fitzpatrick, C., 2008

<sup>255</sup> OECD, 2004; Herrmann, C. & Luger, T., 2008

<sup>256</sup> Scheidt, L.-G. & Dempsey, M. 2007

<sup>257</sup> Eisenriegler, S., 2008

<sup>258</sup> Becker, F., 2008

<sup>259</sup> Kopacek, B., 2008

<sup>260</sup> BFL-IT Index, 2009/2010

<sup>261</sup> BFL-IT Index, 2011

cons of reuse should be evaluated, composed of technical, quantitative, value, time, innovation, disposal, compatibility and regional availability, competing or cooperation with producers, market behavior, liability, personal data safety and software reliability<sup>262</sup>. According to a study by the UK National Audit Office, the optimum time to refresh hardware of computer for the best financial return is three years<sup>263</sup>. While, some producers have asset recovery service program to manage equipment with good condition and residual value of computers in age profile of 3-5 years<sup>264</sup>.

### **3.11 Summary**

This chapter comprehensively reviews practice, legislations and regulations in product design and end-of-life treatment, life-cycle-thinking concept, environmental and energy labelling, resource and energy efficiency, sufficiency of consumption and the practice of reuse household ICT appliances. The best available technology and management system contributes to promote sustainable consumption for a long run on this resource and ecological capacity limited planet. For example, the household energy monitoring smart meter that timely provide electricity consumption feedback could help to facilitate energy saving by raising consumers' awareness<sup>265</sup>. However, just as what the socio-technical study of household ICT appliance electricity consumption in UK highlighted, the energy waste cannot be completely avoided without changes in householders' behavior, even appliances designed with higher levels of energy efficiency<sup>266</sup>. For instance, household ICT appliances' energy waste still occurs if consumers did not purchase the energy efficient appliances or they leave the energy efficient laptops active on when not in use. Thus, influencing consumer's behavior of purchase, usage and disposal of household ICT appliances is fundamental for energy saving in consumption. In the following chapter, the literature review and discussion will focus on the social research of the consumer behaviors.

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<sup>262</sup> BBC Real Story, 2006; Brüning, R., Rosemann, B. & Enderle, B., 2008; Hickey, S., Fitzpatrick, C., & O'Connell, M., 2008

<sup>263</sup> National Audit Office, 2007

<sup>264</sup> Perry, J., 2008

<sup>265</sup> Thøgersen, J. & Grønhoj, A., 2010

<sup>266</sup> Coleman, M., 2011

## 4 Literature Review 3: social research on consumer behaviors

### 4.1 Introduction

The challenges of household ICT appliances consumption presented in Chapter Two explicitly emphasize the importance of consumer behavior and consumption pattern in sustainable consumption. Basically, there are behavioral and technical methods to reduce the energy waste of household ICT appliances; by changing to the best available technology and best practice with the improved operational knowledge and awareness, households can reduce electricity consumption of about 48% per year<sup>267</sup>. Taking the ICT appliances' electricity consumption as an example, it is suggested that *“simple changes in user behavior could lead to major reductions in standby power consumption”*<sup>268</sup>. In this Chapter, the literature review will focus on the social research on consumer behavior, including, the related factors (section 4.2); paradoxes and challenges of sustainable consumption behavior (section 4.3); household ICT appliances' consumption engaged stakeholders (section 4.4); necessity to develop efficient indicators of consumer behavior for sustainable consumption (section 4.5); last but not least, the survey and statistical research background (section 4.6).

### 4.2 Factors related to consumer behavior

Consumer behavior consists of the psychological and social processes people undergo in the acquisition, use and disposal of products, services, ideas, and practices; in detail, psychological factors that influence an individual's decision to make a purchase are further categorized into the individual's motivation, perception, learning, personality and attitudes; while, social process include promotions, brand loyalties, risk aversions, and peer pressures<sup>269</sup>. Consumption is also a way of expressing status and identity; well-being these days seems to depend largely on how much people earn and possess; and material possessions influence how a person is perceived by others<sup>270</sup>. The

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<sup>267</sup> De Almeida, A., Fonseca, P., Bandeirinha, R., Fernandes, T., Araújo, R. and Nunes, U., 2008

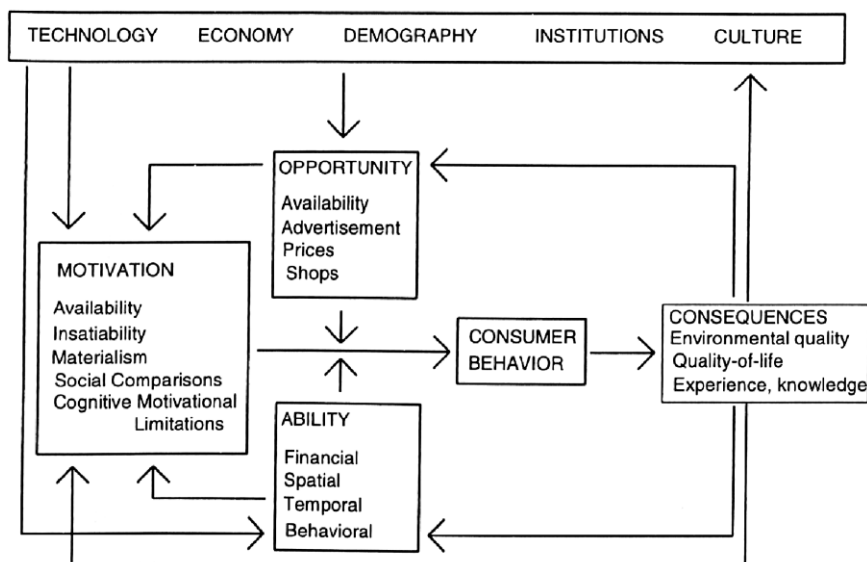
<sup>268</sup> MTP, 2009

<sup>269</sup> Bagozzi, R.P., Gürhan-Canli Z. & Priester, J.R., 2002

<sup>270</sup> Gatersleben, B. & Vlek, C., 1997; OECD, 2006

experience gained through evaluation of alternatives, in turn affects consumers' psychological attributes<sup>271</sup>. Lifestyles, which link social structure to attitudes and behavior, are group specific forms of how individuals live and interpret their lives in a social context, revealing the socio-cultural diversity of societies<sup>272</sup>. Consumption patterns and lifestyles are driven by economic forces, technological progress, political settings, environmental issues, sociological and cultural contexts and psychological determinants<sup>273</sup>. Consumers often lock into unsustainable patterns of consumption behavior by social expectations, cultural norms or peer pressures<sup>274</sup>.

At macroscopic level, technological, economic, demographic, institutional and cultural developments of the society all together have influenced household consumer behavior by affecting motivation, opportunities and abilities of individual consumers (Figure 3). Motivational component consists of several internal individual psychological factors. Both the opportunity and the ability component are external stimulating and limiting factors. Opportunity includes a set of facilitating conditions to perform; while, ability is the capacity of individual or household to carry out behavior<sup>275</sup>.



**Figure 3** Macro-level factors of household consumer behavior<sup>276</sup>

<sup>271</sup> Schiffman, L.G. & Kanuk, L.L., 2000

<sup>272</sup> Reusswig, F., Lotze-Campen, H. & Gerlinger, K., 2003

<sup>273</sup> UNEP, 2008

<sup>274</sup> Darnton, A., 2004

<sup>275</sup> Gatersleben, B. & Vlek, C., 1997

<sup>276</sup> Gatersleben, B. & Vlek, C., 1997



Household purchase decision has a role to play in achieving sustainable consumption. For designing efficient policy and strategy, the factors that should be taken into account include income level, age, gender, household size, biases, attitudes, awareness, rationality and general consumer behavior, and the context of culture norms which shapes consumption patterns and determine consumer values and preferences<sup>277</sup>. Consumers not always act rationally to maximize their benefits in the purchase of goods and services; they are impulsively and influenced in cognitive and emotional aspects by family and friends (socio-cultural environment); by advertisers (company's marketing efforts); by mood, situation and emotion<sup>278</sup>. Nielsen 2007 global survey reveals that "recommendations from consumers" for consumption choice ranks much higher than advertisements; Internet is increasingly regarded as a trusted source of peer-generated information; blog is considered as a reliable information source<sup>279</sup>. Though some products are certified by internationally recognized and respected organizations, many consumers are confused about the meaning of different labels<sup>280</sup>. Consumers usually are not willing to spend time to understand these issues and are rarely willing to pay more for sustainable products<sup>281</sup>. In OECD consumer surveys, consumers rank quality first, then price, followed by look and design, brand, and environment friendliness<sup>282</sup>. One of the most important factors influencing sustainable consumption is income; in general, richer households always engage in higher levels of consumption and are far more likely to purchase sustainable products, while, people with low income may lack available resources to invest sustainably, though they are not less willing to be responsible for their actions than better-off consumers<sup>283</sup>.

Price, performance, aesthetics and service were important issues in household ICT appliances purchase decisions; however, despite general financial and environmental concerns, it is revealed from a recent case study in UK that before purchasing household ICT appliances, energy efficiency was rarely cited as a consideration and

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<sup>277</sup> Timmer, V., Prinet, E. & Timmer, D., 2009; Coleman, M., 2011

<sup>278</sup> Schiffman, L.G. & Kanuk, L.L., 2000; Coleman, M., 2011

<sup>279</sup> Nielsen, 2007; WBCSD, 2008

<sup>280</sup> WBCSD, 2008

<sup>281</sup> BSR/Forum for the Future, 2008

<sup>282</sup> OECD, 2007

<sup>283</sup> OECD, 2008

not largely included from information gathering activities<sup>284</sup>. Australian consumer survey identified that most consumers are not aware of the energy consumption magnitude of TVs and computers; the emotional needs often dominate the purchase decision; other factors to consider include type, size, quality, brand, price, appearance, and compatibility with peripherals; for computers purchase, determinate factors consist of type, intended use, speed, memory, price, screen quality, warranty, brand and peripherals, etc.; for both TVs and computers, the seldom considered factors are standby and on-mode power, cost of operation and energy efficiency<sup>285</sup>. The majority of household ICT appliances end users buy the products predominantly for communication and entertainment<sup>286</sup>. Household socio-demographic (e.g. age, gender, level of education, income) and physical factors (e.g. dwelling size, dwelling type, location) can influence the energy consumption pattern<sup>287</sup>. Factors such as higher annual income and greater numbers of householders are found to be positively correlated to increased total electricity consumption<sup>288</sup>. Furthermore, it was concluded by researches that attitude and knowledge are positively related to energy savings<sup>289</sup>, that is, saving effort depended on self-efficacy factors, and the improved knowledge through feedback could motivate households to reduce energy consumption<sup>290</sup>.

### 4.3 Sustainable consumption behavior paradoxes and challenges

#### 4.3.1 Value-action Gap

The 2008-2012 Greendex global tracking survey figured out that environmental concern is widespread among the consumers studied<sup>291</sup>. According to recent studies of Eurobarometer on consumer attitudes in developed markets, awareness of environmental and social issues enters the mainstream – 96% of Europeans say that

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<sup>284</sup> Coleman, M., 2011

<sup>285</sup> WSRS, 2008

<sup>286</sup> Peireira, F., 2008

<sup>287</sup> Lutzenhiser, L., 1993; Boardman, B., Favis-Mortlock, D., Hinnells, M., Lane, K., Milne, G., Palmer, J., Small, E., Strang, V. and Wade, J., 1995

<sup>288</sup> Coleman, M., 2011

<sup>289</sup> Abrahamse, W., Steg, L., Vlek, C., Rothengatter, T., 2005; Thøgersen, J. & Grønhoj, A., 2010

<sup>290</sup> Coleman, M., 2011

<sup>291</sup> Greendex 20012

protecting the environment is important for them personally<sup>292</sup>. A global survey found that consumers in most countries are becoming more aware of and willing to act on environmental concerns<sup>293</sup>. However, consumers have not yet well prepared for environmentally conscious buying decision making<sup>294</sup>; that is, most of them have not yet made the same shifts in behaviors, lifestyles and purchasing decisions, that is the so called “value-action gap”, between people’s environmental, social, economic or ethical concern and the lifestyle or purchasing decisions that they make in practice<sup>295</sup>.

The McKinsey survey of consumers in Brazil, Canada, China, France, Germany, India, UK and the US showed the gap between consumer attitudes and behavior that “people don’t always act on environmental and social concerns”, for instance, 53% were concerned about environmental and social issues, but not willing to pay more<sup>296</sup>. Most respondents of recent online survey in China agree that “consumption is the enemy of environmental protection” and “it is everyone’s duty to protect the environment”<sup>297</sup>; however, in another survey of “whether hotels should continue supply disposable items for free”, 77% respondents opposed the action, complaining of inconvenience<sup>298</sup>. The technical and social research in UK energy consumption reported that, despite of widespread concern for the environment, none of the householders reported that they regulated their active household ICT appliance use<sup>299</sup>. Therefore, this 'value-action gap' suggests that sustainable consumption policy must do more than tackle attitudes and hope that behavioral change will follow<sup>300</sup>.

### 4.3.2 Summary of the relevant challenges and paradoxes

Households are complex systems of interconnecting and interdependent parts, which in turn, are constrained and enabled by other systems, e.g., social networks, infrastructure

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<sup>292</sup> Eurobarometer, 2008

<sup>293</sup> WBCSD, 2008

<sup>294</sup> Lückefett, H.-J., 2008

<sup>295</sup> Blake, J., 1999; SCR, 2006a; Timmer, V., Prinnet, E. & Timmer, D., 2009

<sup>296</sup> WBCSD, 2008

<sup>297</sup> 21CN, 2009

<sup>298</sup> People web, 2009

<sup>299</sup> Coleman, M., 2011

<sup>300</sup> Jackson, T., 2005

and institutional rules<sup>301</sup>. Besides the value-action gap, there are some other paradoxes, constraints and challenges regarding sustainable consumption behavior<sup>302</sup>:

- **Consumption clusters require different interventions:** policy instruments and tools that are effective in one domain are not necessarily transferable to another;
- **Distributional concerns:** policy instruments can have a disproportional impact on the more vulnerable and marginalized people and households in society;
- **Limitations of market-based approaches:** economic instruments are powerful but they can be backfired or be limited in addressing the necessary cultural shift;
- **Unrealistic time horizons for impact:** time delays of the policy instruments' effectiveness are not always taken into account in the design or assessment;
- **Incremental steps to revolutionary change:** a small commitment or behavior change made by households does not necessarily lead to significant changes in consumer behavior;
- **Rebound effect:** gains in reducing unsustainable household consumption can lead to unanticipated, increased consumption in other areas that counteract sustainable development;
- **Overemphasis on individual choice and on shifting household demand:** the influence of structural constraints and embedded behavior is always underplayed, so that individual households are often the focus of blame and interventions;

To address the paradoxes and challenges, there are possible policy tools or instruments that governments can employ to accelerate the behavior shifts in households. For instances, to **close the value-action gaps**, the government could take the interventions to create environment to mainstream sustainable consumption into consumers' current lifestyle; make sustainable choice easy to implement, practical and financially attractive; and, the unsustainable consumption less accessible and costly through taxes or regulation; mix instruments (e.g., labels) to avoid isolated using; and to create community to support households to take action around sustainability issues. To

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<sup>301</sup> Timmer, V., Prinet, E. & Timmer, D., 2009

<sup>302</sup> McKenzie-Mohr & Smith, 1999; Jackson, T., 2005; Homer-Dixon, T., 2006; Andersen, M. & Tukker, A., 2006; WWF-UK, 2007; OECD, 2008; WWF-UK, 2008; Timmer, V., Prinet, E. & Timmer, D., 2009; Berg, A., 2009

respond to the **distributional concerns**, government should protect the basic needs of low-income families with financial support and tax reduction; provide subsidies to energy efficient appliances; and consider the related expenditures of intervention for both low- and high-income households. For the **unrealistic time horizons for impact**, government could specify clear indicators to measure longer-term progress and provide the basis for adaptive management and improvements over time; as well, pilot different interventions simultaneously to assess short and long-term effectiveness<sup>303</sup>

In summary, to overcome the above outlined paradoxes and find out efficient solutions for sustainable household consumption requires a system thinking perspective. The internal and external driving forces in the whole system and their interactions are crucial for the analysis, research and policy making in the long-term. Finding leverage points out: understanding system dynamics provides insight into priority action areas in the complex system, where small shifts lead to cascading effects that influence household consumption behaviors. The complexity of the household requires the collaborative engagement of stakeholders, including the public sector, private sector, retailer, civil society, media, research institutes and household consumers, with government taking the lead. It is essential to establish targets and indicators and to monitor results to learn and adapt interventions over time to influence sustainable household consumption<sup>304</sup>.

#### **4.4 Household ICT appliances' consumption engaged stakeholders**

In Chapter Two and Three, it addresses that the “skyrocketing” consumption of this era urgently calls for sustainable culture and sufficiency, especially, the advocates of consumers’ sustainable consumption – “how much is enough?” However, the point is “are consumers really the ones who could decide how much is enough for them?”<sup>305</sup> Of course, consumers’ needs and wants are the basis for the increasing production; however, it is just a response to the ever-increasing demands, as the needs of the

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<sup>303</sup> OECD, 2008; Timmer, V., Prinet, E. & Timmer, D., 2009; Berg, A., 2009; Rubik, F., Scholl, G., Biedenkopf, K. & Kalimo, H., 2009

<sup>304</sup> Timmer, V., Prinet, E. & Timmer, D., 2009

<sup>305</sup> Korsunova, A., 2005

consumers are all significantly created and shaped by such external forces as the press, industry and shopping malls<sup>306</sup>. In the similar perspective, the definition of sustainable development by the Brundtland Commission is commented that it takes human needs as given and fails to acknowledge the role of businesses and markets to shape them<sup>307</sup>. Therefore, it is necessary to explore the connection and the influence that businesses and other actors exert on consumption, so as to make real progress in sustainable consumption and to promote the sufficient consumption pattern<sup>308</sup>. “Unsustainability in all its forms (e.g., over-consumption) is the archetypal example of gross market failure”<sup>309</sup>. The example of German awareness raising campaign (Initiative Energie-Effizienz) stresses that it is crucial to ensure all the engaged stakeholders involved, in order to achieve the best dissemination results<sup>310</sup>.

Consumers generally would like to act sustainably if it does not impinge on their key priorities and cause them inconvenience<sup>311</sup>. As the participants confessed in UK Sustainable Consumption Roundtable that: ‘Well, I do not mind if we collectively sacrifice, but I do not want to sacrifice – me and my family – when the next door is not’<sup>312</sup>. Business as providers of those products and services has a critical role and is appealed to run in more sustainable ways; however, to the constraints of competitive markets and the challenges of sustainable consumption, it’s difficult for the companies to act alone and they will respond defensively to threaten the profitability. The social research on both the business world and citizens concluded that “*they are increasingly willing to embrace key aspects of a smarter, more sustainable lifestyle, but on one reassurance: that others act likewise, whether neighbour at home or competitor in business, – ‘I will if you will’*”<sup>313</sup>. The notion also reflects the importance of co-production and state-community-individual partnerships in delivering successful

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<sup>306</sup> Pantzar, M., 1996; Korsunova, A., 2005

<sup>307</sup> Michaelis, L., 2003

<sup>308</sup> Korsunova, A., 2005

<sup>309</sup> Dresner, S. & Ekins, P., 2004

<sup>310</sup> Coleman, M., 2011

<sup>311</sup> Holdsworth, M., 2003

<sup>312</sup> SCR, 2006a

<sup>313</sup> SCR, 2006a

policy outcomes<sup>314</sup>.

Multiple stakeholder involvement is important because diverse actors, e.g., businesses, governments, NGOs and consumers, collaboratively all have a role to play in shifting consumption patterns. **Businesses** (producers and their suppliers, retailers, recyclers and waste management companies) choose how resources are extracted, processed, sold and managed at the end-of-life; and these choices are influenced by the shopping and lifestyle of consumers, as well as by financial institutions (through lending policies and ratings) and governments (through laws, taxes, regulation and guidance)<sup>315</sup>. **Government** policies and practices send important signals about public priorities, as well, social and cultural preferences; however, unfavourable or inconsistent policy signals can undermine the best efforts of government to motivate sustainable consumption<sup>316</sup>. **Consumers** may feel a moral responsibility to live sustainably, however they cannot do so without effective support from governments, **NGOs** and businesses with which they interact.

Role of governments and regulators	Role of businesses	Role of consumers	Role of civil society (NGOs)
International agreements	Economic development	Purchasing decisions	Independent assessment
National policies, laws and regulations	Legal compliance	Lifestyle choices	High profile public campaign
Fiscal structures and incentives	Ethical practices	Political support	Critique or endorsement
Infrastructure and services (transport, recycling, etc.)	Sustainable sourcing, production and distribution	Peer-to-peer influencing	Thought leadership
Guidance for businesses & consumers	Eco-efficiency & waste reduction		Choice influencing
Monitoring	Consumer choice editing		
Enforcement	Consumer choice influencing		
	Innovation		
	Example-setting		

**Table 1** Governments, consumers and business in fostering sustainable consumption<sup>317</sup>

Consumers play an essential role to interact with government and business to drive change through their purchasing patterns and life-style choices<sup>318</sup>. Consumers want to

<sup>314</sup> Halpern, D., Bates, C., Mulgan, G., Aldridge, S., Beales, G. & Heathfield, A., 2004

<sup>315</sup> WBCSD, 2008

<sup>316</sup> Jackson, T., 2005

<sup>317</sup> WBCSD, 2008

<sup>318</sup> EC ISMDG, 2008

ensure that the interventions are fair and not open to abuse by free-riders<sup>319</sup>; as well, they need to be assured that they act in collaboration rather than isolation, without an individual sacrifice for non-guaranteed outcome or benefit<sup>320</sup>. Businesses, governments and civil society must be aligned with these values since they depend on the spending and votes of individuals (Table 1)<sup>321</sup>. For example, the main external drivers of eco-design include government legislation, peer competition, supplier relationship, industry sector initiatives and customer demands<sup>322</sup>.

To lead sustainable lifestyles based on informed purchasing decisions and changes in behavior, business plays an important role in fostering sustainable consumption by<sup>323</sup>:

- Innovation: increasing the availability of more sustainable-valued products and services to society and consumers through integrating sustainability into product life cycle design process not to compromise quality, price or performance;
- Creating a market and business models to demonstrate that sustainable products and lifestyles deliver superior performance at the best prices. Using marketing communications to influence consumer choice and behavior;
- Editing out unsustainable products, components, processes and business models in partnership with other actors in society such as policy-makers and retailers.

Government and business must focus fairly on mainstream consumers, rather than expecting the minority of heroic green consumers to shop the society's unsustainable way out<sup>324</sup>. Based on lesson learned from the 19 case studies in consumption choice editing for sustainability in UK, the *Looking forward, looking back* survey observed that: to change mainstream product markets, the green consumers may only play a role as early adopters, but the translation to the mainstream depends on other factors for the product to perform, up to the expectation of the relevant market; if sustainable products are to be mainstreamed, they need to be a close equivalent to the norm in

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<sup>319</sup> Holdsworth, M., 2003; Halpern, D., Bates, C., Mulgan, G., Aldridge, S., Beales, G. & Heathfield, A., 2004

<sup>320</sup> Halpern, D., Bates, C., Mulgan, G., Aldridge, S., Beales, G. & Heathfield, A., 2004; Jackson, T., 2005; SCR, 2006a

<sup>321</sup> WBCSD, 2008

<sup>322</sup> ECOLAS/RPA, 2007

<sup>323</sup> WBCSD, 2008

<sup>324</sup> SCR, 2006a



price, quality or availability; otherwise, government intervention is needed<sup>325</sup>. The underlying role of pleasure and comfort in current consumption lifestyle suggests that the existing patterns are difficult to change without more far-reaching policies to alter the society's values and the structures that support them<sup>326</sup>. In a consumer society and a market economy, government takes the role of facilitating collective responses to collective problems that cannot be solved by individual choice<sup>327</sup>.

Governments take the leading role in advancing sustainable household consumption, particularly in shaping the socio-cultural framework and institutional rules to govern household choice making, creating visions and stretching targets to establish the parameters of the long-term goals<sup>328</sup>. Governments should adopt integrated strategy (Table 2) to exemplify, enable, encourage and engage commitment towards sustainable household consumption, with qualitative guidance on sustainable lifestyle, standards, stakeholder engagement, economic incentives, and clear regulatory frameworks. As attitudes and behaviors change take time, and the approach evolves; nevertheless, government could start to put the four 'E's into practice, from where people are, to make sustainable habits easier to achieve and more attractive to do<sup>329</sup>.

Catalyst: is it enough to break a habit and start the change?			
Exemplify	Enable	Encourage	Engage
Leading by example	Remove barriers	Tax system	Community action
Achieving consistency in policies	Give information	Expenditure – grants	Co-production
	Provide facilities	Reward schemes	Deliberative fora
	Provide viable alternatives	Recognition/social	Personal contacts/enthusiasts
	Educate/train/provide skills	pressure-league tables	Media campaigns/opinion
	Provide capacity	Penalties, fines and	formers
		enforcement action	Use networks

**Table 2** Four E (exemplify, enable, encourage, engage) commitment of government in sustainable development strategy<sup>330</sup>

<sup>325</sup> SCR, 2006b

<sup>326</sup> Coleman, M., 2011

<sup>327</sup> SCR, 2006a

<sup>328</sup> Timmer, V., Prinet, E. & Timmer, D., 2009

<sup>329</sup> SCR, 2006a

<sup>330</sup> HM Government, 2005

## 4.5 Efficient indicators of consumer behavior for sustainability

### 4.5.1 Going beyond GDP

Gross Domestic Product (GDP), developed in the 1930s, has become a standard benchmark used by policy makers and the best known measure of macro-economic activity<sup>331</sup>. However, it does not cover the measurement of the long-term accumulation of wealth (natural, economic and social), the levels of life expectancy, literacy, and education and the negative impact of pollution and resource degradation<sup>332</sup>. European Social Survey Round 3 data reported, even during the peak of the economic boom in 2006, 61 % of people in 20 European nations felt that ‘in their country life was getting worse’<sup>333</sup>. Prosperity goes beyond material pleasures, residing in the quality of lives; health and happiness of families; strength of relationships and trust in the community; satisfaction at work and sense of shared meaning and purpose; potential to participate in the life of society; overall, the ability to flourish within the finite planet<sup>334</sup>.

EU recognized that the economic crisis should also be taken as an opportunity to set economy more firmly on the path to a low-carbon and resource-efficient economy<sup>335</sup>. 2008 Eurobarometer poll showed that more than 2/3 of EU citizens feel that social, environmental and economic indicators should be used equally to evaluate progress. Only just under 1/6 prefer evaluation based mostly on economic indicators<sup>336</sup>. The United Nations Development Programme has developed a Human Development Index to benchmark countries based on combined measurement of GDP, health and education<sup>337</sup>. The Ecological Footprint, which measures how fast human beings consume resources and generate waste, has been formally recognized as a target for environmental progress<sup>338</sup>. France set up Commission on the Measurement of Economic Performance and Social Progress to identify the limits of GDP and to

<sup>331</sup> COM (2009) 433 final, 2009, “*GDP and beyond – measuring progress in a changing world*”

<sup>332</sup> IP/07/1718, 2007, press release “*Measuring progress, wealth and the well-being of nations*”

<sup>333</sup> ESS3, 2006

<sup>334</sup> Jackson, T., 2009

<sup>335</sup> COM (2008) 800 final, 2008, “*A European Economic Recovery Plan*”

<sup>336</sup> Eurobarometer, 2008

<sup>337</sup> UNDP, 2009

<sup>338</sup> GFN, 2009

consider additional information<sup>339</sup>. In the long term, integrated environmental, social and economic accountings are beneficial in supporting the promotion of well-being and progress<sup>340</sup>. Therefore, it's necessary to have more inclusive markers to replace the mere indicator of GDP growth, so as to concisely incorporate social and environmental achievements and losses.

#### 4.5.2 Practice – Greendex: consumer choice and environment

“Greendex 2012: Consumer Choice and the Environment – A Worldwide Tracking Survey” measures consumer behavior in areas relating to housing, transportation, food and consumer goods. It ranks average consumers in 17 countries according to the environmental impact of their consumption patterns in 65 areas relating to these four major categories, and is the only survey of its kind<sup>341</sup>. The scores of each respondent are based on the consumption patterns they report in the Internet survey; the weighting factors are based on both the direct and indirect impacts of consumption within each category, housing (30%), transport (30%), food (20%) and goods (20%); altogether, which is indicative and provides an estimate, not claiming scientific precision; consequently, the overall rankings of countries are generated by comparing their average scores<sup>342</sup>. This research project differs from other environmental surveys in that it goes beyond attitudes and concerns to focus on actual behavior and material lifestyles across 17 countries<sup>343</sup>. *“In the short term, the Greendex is to encourage sustainable consumption by increasing consumer awareness and providing consumers with global reference points for comparing their own consumption patterns. Over time and with subsequent waves of the survey, it tracks changes in sustainable consumption at global level and within specific countries. The Greendex also provides governments and corporations with the insights they need to facilitate or encourage sustainable consumer behavior, through government legislation, product development, or other*

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<sup>339</sup> Stiglitz, J., Sen, A. & Fitoussi, J.P., 2008

<sup>340</sup> IP/07/1718, 2007, press release “*Measuring progress, wealth and the well-being of nations*”

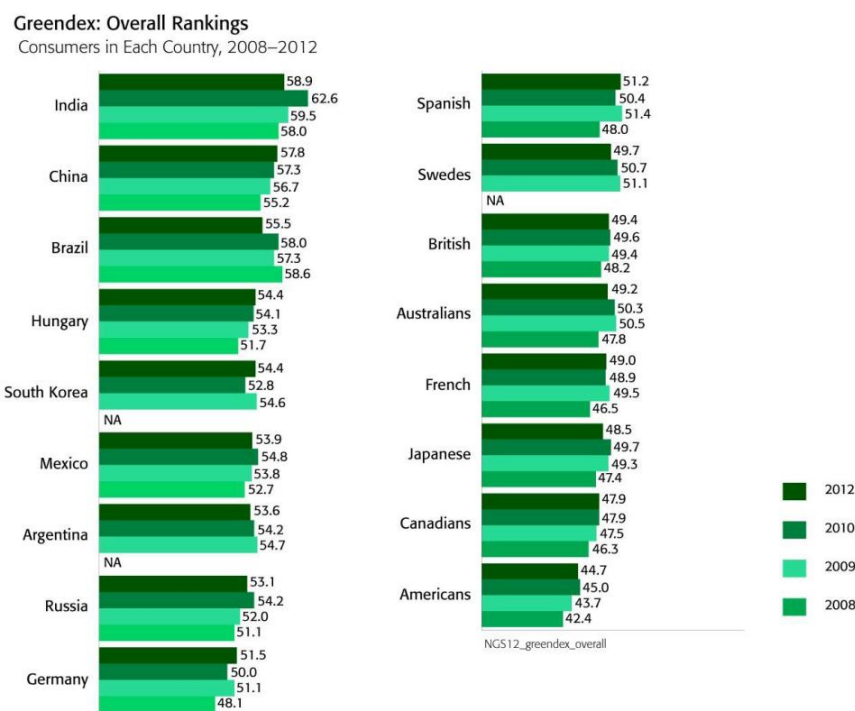
<sup>341</sup> Greendex 2012

<sup>342</sup> Greendex 2008; 2009; 2010; 2012

<sup>343</sup> Greendex 2012

sustainability initiatives”<sup>344</sup>. The key objectives are to provide regular quantitative measures of consumer behavior and to promote sustainable consumption<sup>345</sup>.

The 2008 survey took samples from 14 countries, which represent 55% of the world’s population and include 7 of the 11 most populous nations; and accounted for 75% of the global energy consumed in 2007<sup>346</sup>. They are Australia, Brazil, Canada, China, France, Germany, UK, Hungary, India, Japan, Mexico, Russia, Spain, and US; starting 2009, Argentina, South Korea and Sweden were included, that is 17 countries in total<sup>347</sup>. Consumers in developing nations (e.g., India, China, Brazil are in the first tier) continue to rank in the top; while the bottom nine countries are all industrialized, out of which, American and Canadian consumers rank as the last two<sup>348</sup> (detailed scores of 2008-2012 will be found in Appendix 5 and in Figure 4).



**Figure 4** Greendex total scores of 17 countries and comparison in 2008-2012<sup>349</sup>

Individual scores are averaged to create a mean score for each country; as the Greendex measures the impact of the average consumer in each country surveyed; it

<sup>344</sup> Greendex 2010

<sup>345</sup> Greendex 2012

<sup>346</sup> Greendex 2008

<sup>347</sup> Greendex 2009

<sup>348</sup> Greendex 2012

<sup>349</sup> Greendex 2012

does not measure environmental impact of a total country<sup>350</sup>. Consumers in developing countries with the highest Greendex scores are the most likely to “feel guilty about the impact they have on the environment”; whereas, consumers with low Greendex scores who demonstrating the least sustainable behavior respond to this argument oppositely<sup>351</sup>. Consumers in developing countries are more concerned about issues like climate change, air and water pollution, species loss, and shortages of fresh water; in general, they are likely to report that environmental problems have negative impact on their health<sup>352</sup>. Consumers that have the Greendex 2012 versus 2010 largely increases are the South Koreans and Germans, followed by Spanish and Chinese<sup>353</sup>. Through the cross-cultural comparison, each variable reflects the collective situation of the countries, e.g., in ‘Goods’ category, 69% of respondents from China agree that they “prefer to repair it first when it is broken rather than replace it first”, which takes the largest percent among the 17 countries<sup>354</sup>. The results show that both of the cost considerations and environmental concerns motivated consumers to adopt more environmentally sustainable behavior over the past year<sup>355</sup>. Consumers in North America and Western Europe are the most likely to report that they recycle materials; actions such as avoiding environmental-unfriendly products or buying environmental-friendly products are most common in developing countries<sup>356</sup>. 75% of Germans “all of the time” or “often” ‘recycle electronic items’, which ranks the first in the 17 countries and shows an obvious increase than 2010 value (69%); meanwhile, 49% Americans (2010: 51%) and 37% Chinese (2010: 40%) do so, which all have slightly decreased compared with the Greendex 2010 frequency<sup>357</sup>. 11% of Americans have ‘4 or more’ computer owned, rented, or leased by household members, 14% have ‘3’<sup>358</sup>. When asked to what extent ten different factors discourage them from behaving more environmentally friendly than they do now, the largest proportion across the 17 countries said because companies make false claims about the environmental impacts

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<sup>350</sup> Greendex 2010 Highlight

<sup>351</sup> Greendex 2012 Highlight

<sup>352</sup> Greendex 2012 Highlight

<sup>353</sup> Greendex 2012; Greendex 2012 Highlight

<sup>354</sup> Greendex 2012

<sup>355</sup> Greendex 2010 Highlight; Greendex 2012 Highlight

<sup>356</sup> Greendex 2010 Highlight; Greendex 2012

<sup>357</sup> Greendex 2010; 2012

<sup>358</sup> Greendex 2012

of their products; the second most commonly cited obstacle was that further individual efforts are not worth it if governments and industries do not take action<sup>359</sup>, which just reflect the “I will if you will” mentality and the importance of stakeholder engagement for moving on towards sustainable consumption that has been discussed in section 4.4.

#### 4.6 Survey and statistical research background

Social research consists of the ordered major steps: formulation of research problem, preparation of research design, measurement, sampling, data collection and processing, data analysis and interpretation. In general, it is undertaken for three broad purposes<sup>360</sup>:

- **Exploratory study** is undertaken if there is no clearly delineated independent and dependent variables and, no preset categories of observation and analysis;
- **Descriptive study** focuses on relatively few dimensions of well-defined entity to measure systematically, with structured and detailed numerical descriptions;
- **Explanatory study** is conducted to test and describe relationship among variables, formally seeking to seek the answers to problems and hypotheses.

Quantitative, qualitative and mixed method are three research approaches that frame the following three elements differently, they are, *knowledge claims* – philosophical assumptions about what constitutes; *strategies* – general procedures of research; and *methods* – detailed procedures of data collection, analysis and writing<sup>361</sup>. Research collects and uses valid data justifiably to produce findings<sup>362</sup>. Social survey is a systematic method for gathering information from a sample of entities to facilitate quantitative analysis of the attributes of entire population, involving interviews or questionnaires and statistical analysis<sup>363</sup>. Web surveys or online surveys, with more varied and user-friendly design, are faster, cheaper and more attractive to collect large amounts of data than mail survey and interview. However, coverage and selection errors may have impact on the quality of the outcomes. If given sound basis as

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<sup>359</sup> Greendex 2010 Highlight; Greendex 2012 Highlight

<sup>360</sup> Singleton Jr., R.A. & Straits, B.C., 2005

<sup>361</sup> Creswell, J.W., 2008

<sup>362</sup> Denscombe, M., 2002

<sup>363</sup> Groves, R.M., Fowler, Jr.F.J., Couper, M.P., Lepkowski, J.M., Singer, E. & Tourangeau, R., 2004; Preece, E. & Curran, S.R., 2006

probability sampling and correction techniques, online survey will produce accurate and reliable information<sup>364</sup>. In the questionnaire, closed questions are usually preferred – dichotomous, multiple choice, Likert scale<sup>365</sup>.

Examples of descriptive study are the various censuses conducted periodically at the local and national levels<sup>366</sup>. Survey-based data collection procedures have become a standard means of collection comparative data systematically at the level of individuals and households, for example, the Eurobarometer, US General Social Surveys, World Value Survey and the GlobeScan Greendex Survey<sup>367</sup>. EU i2010 – European Information Society 2010 – benchmarking framework provides a group of indicators<sup>368</sup> and surveys to monitor ICT usage in households and by individuals focusing on Internet and mobile phone access and use, as well as, specific models like, e-government, skills and digital literacy, e-commerce and trust, advanced services and security<sup>369</sup>. Flash Eurobarometer carried out the fieldwork interviewing with randomly selected around 1,000 participants from each Member States countries, to examine EU citizens' perceptions about the potential impact of ICT on certain aspects of their lives, e.g. their relationships with family members and friends, their work or leisure activities<sup>370</sup>. The most of household consumers use TVs, computers and mobile phones to keep informed and get contacted; almost 9 out of 10 citizens watched TV on a daily basis and used mobile phone; two-thirds of the surveyed citizens had used the Internet for personal use at least a few times in the last three months; men, younger respondents, the more educated ones, those living in large cities or urban areas, employees and the self-employed were the most likely to regularly use the Internet and mobile phone<sup>371</sup>. ITU ICT Opportunity Index, based on ten indicators, is composed of the info-density indicators (network and skills indicators) and the info-use indicators (uptake and

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<sup>364</sup> Bethlehem, J., 2009

<sup>365</sup> Gomm, R., 2004

<sup>366</sup> Singleton Jr., R.A. & Straits, B.C., 2005

<sup>367</sup> Bohmstedt, G. W. & Knoke, D., 1994; Harkness, J.A., Van de Vijver, F.J.R. & Mohler, P.Ph., 2003; Greendex 2008

<sup>368</sup> i2010 High Level Group, 2009

<sup>369</sup> Seybert, H., 2007; Eurostat, 2008; Löff, A., 2008; Wirthmann, A., 2008

<sup>370</sup> Flash Eurobarometer, 2008

<sup>371</sup> Flash Eurobarometer, 2008

intensity indicators)<sup>372</sup>. ICT indicators are commonly used in sustainable development frameworks; out of which, the most frequently found and mostly easily obtainable indicators are supply side access indicators collected by the ITU. A holistic picture needs to be provided for measuring the access, usage and impact of ICTs across countries, rather than just a focus on supply side indicators, with different tools such as household surveys<sup>373</sup>.

#### **4.7 Literature review summary**

The literature review in Chapter Two, Three and Four provide theoretical foundation and identify the gaps of knowledge, preparing for the empirical research. Consumption of household ICT appliances is crucial to the economic, environmental and social development, by practice, assessment and legislation. However, current most available data and information related to household ICT appliances are only focusing on one part of consumption, or lack of consideration of at least one dimension of sustainability; furthermore, no global reference points for consumers and the engaged stakeholders to compare their own consumption patterns. Obviously, there is lack of information and understanding of the household consumption pattern of the ICT appliances in a more systematic and holistic “life-cycle thinking” approach – purchase, usage, to end-of-life, in environmental-social-economic three dimensional perspective; this deficiency could lead to ineffective policy programmes. In summary, the three literature review chapters have presented that there are gaps in existing knowledge:

- There is lack of concrete model, systematic research findings and “real world” data on the global and regional consumers’ overall choices and behaviors of household ICT appliances’ consumption – purchase, usage, end-of-life; moreover, lack of underlying behavioral factors that influence ICTs’ sustainable consumption in worldwide and national level;
- The information currently available to policy makers are largely from market and manufacturer data sources, which is very limited and could not offer a clear and comprehensive understanding of the factors influencing changes in consumption

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<sup>372</sup> UN ITU, 2007b

<sup>373</sup> Stork, C., 2007



- patterns that can only be gained by examining detailed end-use assessments<sup>374</sup>;
- The most influential indicator to benchmark the national development is GDP; worldwide, there is lack of an inclusive indicator to measure and benchmark the national profile of the household ICT appliances' consumption, in a three-dimensional balanced consideration – economy, environment and society;
  - Besides the most obtainable ICT supply side indicators, *“there is no concrete method to measure the access, usage and impact of ICTs across countries, for example, with household surveys”*<sup>375</sup>;
  - Approach to advocate sustainable consumption of household appliance should go beyond the common practice of promoting “energy efficient products” to point out the importance of “sufficiency in consumption”. It eventually will touch the root of the problem but might go against the normal consumption pattern, lifestyle, business target, and policy orientation. On this area, there is lack of overall scheme, measurement and benchmarking system to reflect current situation and progress;
  - Regarding the electricity consumption, the UK Market Transformation Programme highlights that at present there is “little data on behavior of appliance users”<sup>376</sup>.
  - The review of WEEE Directive implementation, focusing on total environmental, economic and social impacts reported that *“lack of available data and information did not allow for a systematic and quantitative assessment of the Directive’s impacts on the day-to-day quality of life of individuals and communities”*<sup>377</sup>.
  - The German research of the EEE end-of-life take-back collection identified that, *“for potential improved municipal collection quality, no reliable data sources exist”, “no reliable data exists for the consumer behavior after the consumer decided to end the usage of a product”*; and *“it is not yet systematic researched how the end consumer can be motivated to bring the still fully functional product right away to a remarketing/refurbishment collection system”*<sup>378</sup>.

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<sup>374</sup> Ellis, M., 2009

<sup>375</sup> Stork, C., 2007

<sup>376</sup> MTP, 2009

<sup>377</sup> Huisman, J., Magalini, F., Kuehr, R., Maurer, C., Ogilvie, S., Poll, J., Delgado, C., Artim, E., Szlezak, J., Stevels, A., 2008

<sup>378</sup> Scheidt, L.-G. & Dempsey, M., 2007

Generally speaking, it is challenging to fully understand the dynamic complexity of the sustainable consumption of household ICT appliances', which is embedded in the social and cultural background, shaped by the political orientation, media, enterprises' strategy, and the admired lifestyle. Moreover, it's lack of a holistic picture for the overall understanding of national or regional situation to figure out the improved and improvable aspects with global reference points.

#### 4.8 Research questions

Based on the above identified gaps in knowledge, in this dissertation, the definition of 'consumption' is selected as "*referring to a sequence of choice and actions by household consisting of the selection, purchase, use, maintenance, repair and disposal of any product or service*"<sup>379</sup>, in a "life-cycle thinking" perspective. The gaps obviously reveal the necessity to develop the model of "ICT consumption specific index" to measure end-consumers' choice and behavior. These data will provide the reference to benchmark the national and regional situation, progress and gaps; contribute to knowledge for the further research, legislation, product development, and other sustainability initiatives. Correspondingly, as the consumers' behavior are highly context-dependent, the qualitative and quantitative tracking of consumption pattern also reflect the whereabouts of the engaged stakeholders; therefore, assist to identify what are the improved and improvable aspects for the further collaborative efforts. Based on literature reviews, the following research questions were developed:

- ◆ how to qualitatively and quantitatively describe the current situation and progress of consumer behavior of consuming household ICT appliances, in various facets – e.g., globally, cross-culturally, nationally; currently, annually in years sequence;
- ◆ what variables and concrete model could be applied to gain the holistic information on consumers' behaviors of purchase, usage and end-of-life activities;
- ◆ to what extent patterns of purchase, usage and end-of-life behavior contribute to overall ICT appliances' consumption in a sample of global or regional households;
- ◆ globally or nationally, what are the underlying factors that largely influence the

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<sup>379</sup> Campbell, C., 1998

purchase, usage, end-of-life as a whole or in any stage;

- ◆ what are the global or regional crucial and improvable aspects in household ICT appliances' consumption for the engaged stakeholders to efficiently collaborate.

## **5 Development of the SCIndex model**

### **5.1 Introduction**

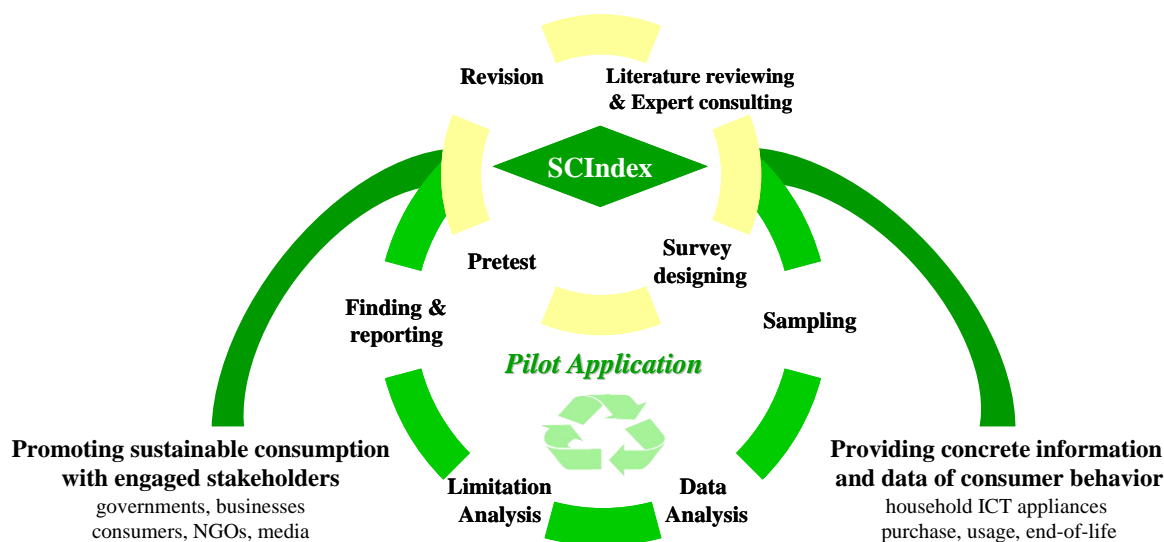
This chapter outlines the methodology applied to this study to meet the aim and objectives of this dissertation and answer the research questions presented in Chapter Four. This chapter begins with a description of the research design and the multilayer of the SCIndex model development (section 5.2). In the following, the structure and scoring scheme of SCIndex are described (sections 5.3). A description of SCIndex pilot application is presented, including survey design, pre-test, sampling and data collection (section 5.4). Finally, it is a summary of the multilayer implementation (section 5.5).

### **5.2 Research design**

Based on the literature review in Chapters Two, Three and Four, it is identified that there is lack of information and understanding of the household consumption pattern of ICT appliances in a more “life-cycle thinking” approach (from purchase to disposal), and in a environmental-social-economic three dimensional perspective. The current most available data and information related to household ICT appliances’ consumption are only focusing on one part of consumption (purchase, usage, or disposal), or lack of consideration of at least one dimension of sustainability (economy, society and environment); as well, there are no global reference points for consumers and the engaged stakeholders to benchmark their own consumption patterns. Furthermore, it is difficult for both the national and regional improvement and holistic management of the rapid developing and increasingly popular EEEs – household ICT appliances.

In the dissertation, the exploratory and descriptive study is therefore designed, aiming to close the above mentioned gaps, to targeting to the research questions and provide empirical basis for the further research and application. The model of “ICT consumption specific index” for a systemic measure of household ICT appliances’ consumption named “Sustainable Consumer Index (SCIndex)” is developed. Through

a pilot application, it is tested, evaluated and optimized, targeting to provide a concrete model for the future formal research to qualitatively and quantitatively understand the consumers' choices and behaviors; so as to promote sustainable consumption with engaged stakeholders (SCIndex model development multilayer in Figure 5).



**Figure 5** SCIndex model development multilayer

The tentative survey design, structure, variables, scoring scheme, sampling, and data analysis are all practically implemented through this pilot application. With the best available time and budget, it turns out to be a qualitative study, taking sample in a less formal scope of around 1000 respondents, to evaluate and optimize the preliminary SCIndex model, to increase the feasibility of the proposed global tracking survey – SCIndex of household ICT appliances' consumption. It is:

- identifying the most appropriate sampling method and sample size, through exploratory on-field data collection and analysis, preparing for the formal survey;
- exploring the data analysis method, variable relationships, and the feasibility of the scoring schemes; furthermore, describing the results and findings;
- evaluating the tentative SCIndex model, focusing on analyzing the indicators' Specificity, Measurability, Achievability, Relevance, Time-bounding (SMART) and the limitations;
- improving the questionnaire structure (questions and options), scoring scheme,

online survey design, database and analysis; moreover, giving recommendations

### 5.3 Structure and scoring scheme of SCIndex

“**Sustainable Consumption**” in the context with household ICT appliances was defined in section 2.3, as:

- A. meeting consumers’ needs and providing increased quality of life while at the same time minimizing the negative impacts of ICT consumption on health and environment, to the benefit of a fair and global development;
- B. a site and problem-specific norm; as well, a dynamic concept that indicates the direction and sometimes magnitude of change, and that can evolve over time; related to the process of purchasing, using and disposing of ICT appliances;
- C. smarter and cleaner consuming, concerning people’s lifestyle, buying behavior, how to use and dispose of household ICT appliances sustainably;

In view of the definition, legislation, research and practice in the previous chapter, purchase, usage, and end-of-life of ICT appliances are the essential life cycle phases, where private consumers have influence on the sustainability of the household ICT appliances consumption. These three life cycle phases hence form three pillars of the SCIndex – purchase, usage, and end-of-life of household ICT appliances. The fourth pillar is the general awareness of sustainable consumption and production, reflecting the consumers’ value priority and orientation that leads to the choices and behaviors.

Within the first sub-indices “**purchase**”, the following issues were found to be of importance with respect to sustainable consumption:

- Consumer’s purchase behavior in general, like, motivated by advertisements (section 2.3; 3.2; 4.2), sufficiency of consumption (section 3.2; 3.9)
- Influential factors for the purchase decision, e.g., function, energy consumption (section 1.3; 2.3; 3.9; 4.2)
- Reasons and frequency for replacement by a new appliance, e.g., the old one is outdated; to replace mobile phone once a year (section 2.5; 3.9; 3.10)

- Role of environmental and energy saving labels in the purchase decision for ICT appliances, like, ‘have ever bought a labelled computer’ and the reason (section 3.7; 3.8; 4.2)

These different aspects are covered by the following six points:

- Agreement to the statement about the general purchase behaviors (Q4)
- Factors that influence your decision to buy household appliances (Q5)
- Reasons for buying a new mobile phone or computer for private usage (Q6.2)
- How often you have replaced mobile phone and computers on average? (Q6.3)
- Have ever heard about environmental or energy saving label? (Q7.1)
- Have ever bought an environmental or energy saving labelled TV, mobile phone, computer or printer? Preference of labelled appliances (Q7.2)

For the second sub-indices “**usage**” of household ICT appliances, the important issues in the terms of sustainable consumption include:

- Quantity of the electronic appliances, both being used and lying idle (section 1.2; 1.3; 3.2; 3.9 )
- Usage duration of the appliances, e.g., 1-2 yr, 3-5 yr (section 2.3; 3.9; 3.10)
- Usage frequency of the household appliances, e.g., everyday, once per week (section 1.2; 2.4; 4.6)
- Electricity consumption pattern, like, ‘after using the computer, leaving it on or automatically stand-by’ (section 2.4; 3.8; 4.1)
- Electricity conservation practices and choices, like, ‘the price of electricity is going up, so saving makes a lot of sense to me’ (section 3.8; 3.9; 4.1; 4.2)
- Use second-hand appliance, like, ‘have ever used any second-hand appliance’ (section 2.5; 2.6; 3.10)

The following questions are raised to figure out the issues:

- At current residence, how many household electronic appliances are being used and lying idle (Q1)

- What are the ages of TV, mobile phone, computers and printers in use? (Q2)
- How often are these appliances being used at current residence? (Q3)
- When finish using computers, what state to set it? (Q8)
- How to response to saving electricity when using household ICTs? (Q9)
- Have you ever used any second-hand household electronic appliance? (Q12)

The third sub-indices “**end-of-life**” is composed of choices and behaviors as below:

- Casual disposal: discard with garbage; throw it on road side (section 2.5; 2.6)
- Responsible disposal: take it to recycling centre; donate it (section 2.5; 2.6; 3.6)
- Lifetime extension: repair it first rather than replacement (section 2.5; 3.9)
- Reuse awareness or value retention: timely resell it, or reuse components (section 2.5; 2.6; 3.10)

The summary of the above disposal practice is generated from the literature review, consumer interview and expert consulting. All the elements regarding to disposal of household ICT appliances are listed in Q10, under the same question with 16 options of 5 degree options (always to never): “During the past five years, how did you deal with your outdated or damaged TV, mobile phone, computer and printer?”, e.g.:

- If broke down, I prefer to repair it first, rather than to immediately replace it
- I prefer to reuse the still functional components
- I discard it with the garbage
- I throw it on the road side
- I take it to a recycling or collection centre
- I prefer to simply store it, rather to take effort to bring it to collection centre
- As long as collector pays, regardless of the price, I sell it to him to clear up

“**General awareness**” of the sustainable consumption and production in Q11 guide the consumption orientation, choices and behaviors of the consumers (section 1.4; 2.2; 3.2; 3.4; 3.8; 4.2; 4.3), e.g.:

- If environmental-friendly product has reasonable higher price, it’s acceptable



- Uncontrolled treatment of used electronics threatens safety and health severely
- Production of household appliances adds heavy burdens to the environment
- Consumption contributes to environmental pollution
- I'm willing to consume less, under the scarcity of resource

Learning from the *Greendex*, which is the global tracking measure of environmentally sustainable consumption, to close the information and knowledge gaps of the worldwide sustainable consumption of household ICT appliances in life-cycle-thinking orientation, the SCIndex is therefore tentatively designed. Based on literature review in Chapters Two to Four, the importance of the variables for measuring of consumers' choices, decisions and consumption behavior are tentatively streamlined as the SCIndex scoring scheme: the three sub-indices (purchase, usage and disposal) are assigned with the same weight – 30% of each, for they are showing the overall equal importance with respect to the sustainable consumption of ICT appliances; while, the general awareness weights 10% to complement the holistic profile of the consumers (the sub-indices, detailed indicators and the corresponding scores' percent are presented in Table 3).

Sub-Indices	% of Total Scores		Key Words	Questions
<b>Purchase</b>	<b>30%</b>	9%	Rational consumer, purchase behavior	Q4
		6%	Purchase decision	Q5
		9%	Consumption pattern, replacement frequency	Q6
		6%	Environmental & energy saving label	Q7
<b>Usage</b>	<b>30%</b>	5%	Quantity: being used & lying idle	Q1
		5%	Usage duration	Q2
		5%	Usage frequency	Q3
		9%	Energy consumption pattern	Q8
		6%	Electricity conservation	Q9
		0%	Use secondhand appliance	Q12
<b>End-of-Life</b>	<b>30%</b>	30%	Disposal alternatives: reuse, recycling or storage	Q10
<b>General</b>	<b>10%</b>	10%	Consumption and production related statements	Q11
<b>Case study</b>			Acceptance of reusable secondhand laptop	Q13, 14
<b>Concerns</b>			Recently top-of-mind issues	Q15
<b>Personal data</b>			Residence, age, gender, profession, etc.	Q16

**Table 3** Household ICT appliances SCIndex – structure and scoring scheme

The detailed scoring scheme is spiral-like developed applying mechanisms such as, equal distribution, increment and elimination. It is a tentative scoring scheme of the SCIndex model, to be evaluated and optimized by the pilot application. The scores of each variable is top-down assigned; that is, the 30 scores of each sub-indices is distributed on each question – a group of key elements, furthermore, to each variable, according to the overall importance evaluated from literature review, expert consultant and author's two years' working experience with international rating/ reporting systems and assessment methodologies for the sustainable management and performance (Global Reporting Initiative, Sustainability – Global Reporters, Dow Jones Sustainability Index, Carbon Disclosure Project, etc.). As mentioned above, similar as the SCIndex model itself, the scoring scheme is under construction and should be improved, which is tentative and rather general, so that the scores of the same variable might be different if designed by another reviewer. The optimal solution is to carry out comparison study of a group of possible schemes to find out the most applicable one. However, for the exploratory and descriptive study, the data analysis and results in Chapter Six verify the scoring scheme and give remarks and suggestion to improve it. The following briefly describes how the scoring scheme is developed and the details of assigning the scores for some variables in different cases.

Both Q4 and Q6 have 30% of weight to measure '**purchase**', that is, full score of 9; while, Q5 and Q7 have 20% in the purchase sectional score, 6 scores for each. Based on the previous literature review in section 2.3, 3.2, 3.9 and 4.2, the first two questions of Q4 are scored with maximum 2, that is, the influence of 'advertisements and promotions' and 'fast emerging new technology' on the consumers' behavior; the maximum score of 'satisfaction after getting new products' and 'actual usability' are 1; while, the 'leisure time on shopping' and 'sufficient own possessions' are scored 1.5. Reviewing the literature on 'reasons to buy an appliance in section 1.3, 2.3, 3.9 and 4.2, the scores of the options in Q5 is generally categorized into three cases: 'promotion/advertisement', 'performance/outlook' and 'status/reputation' driving factors (if any, then 1 score); 'environmental and social consciousness' factors

(durability, environmental certificate and electricity consumption, etc.; if one or two of these selected, then 4 score; if three or more, then 6 score are obtained); and the other factors (2 score for 1-2 were selected; 3 score for 3 or more). Likewise, the replacement reasons in Q6 vary from the 1, 2, 4 and 6 scores based on the selections (section 2.5, 3.9 and 3.10 discuss on these arguments).

In the ‘usage’ stage, Q1 asks for the total amount of ten appliances at current residence; Q2 and Q3 respectively focus on usage duration and frequency. These three questions all have maximum score of 5; while, the grading of the options applies the exclusive mechanism, that is, to approve the consumers with moderate amount, usage duration and frequency. For example, considering the benefits of the ICT appliances on one hand; on the other hand, the over-consumption of ICT appliances affects a lot; the quantity of household ICT appliances is assigned with different scores, learning from the literatures in section 1.2, 1.3, 3.2 and 3.9. Consumers’ energy consumption pattern after using computer (Q8) and electricity saving (Q9) all together take up 50% of the usage sectional score, 9 and 6 individually. The five options of Q8 are scored with different weight, due to the various influences of the behavior and pattern on the electricity consumption (based on the literature review in section 2.4, 3.8, 4.1). For example, if a consumer answers that he ‘always’ ‘unplug it, after turning off’, he will obtain 2.5 scores for this option. As it is stated in section 2.4, to set on the stand-by mode still consumes energy, and the most saving practice is to shut down after using, then unplug it. In Q9, taking the literatures in section 3.8, 3.9, 4.1 and 4.2 as reference, if the consumer proclaimed ‘don’t like to be under the pressure of saving’, ‘as long as affordable, I use as much as I want’, or ‘I don’t care about how much electricity my household appliances consume’, he gains none score. If he said, ‘the price of electricity is going up, so saving makes a lot of sense to me’ or ‘would like to save electricity, but don’t know how to be efficient’, he has 3 scores. For the last option, ‘I’m already used to saving electricity in my daily life and I enjoy this pattern’, it is assigned 6 scores, if and only if this option is selected. For this multiple choice question Q9, if more are selected, then take the average score.

Q12 is about the reuse experience, taking that of laptop computer as an example, which prepares for the case study (Q13 and Q14). For the household ICT appliances' consumer and Internet user, it's not necessarily to have uniformed experience of 'ever used any second-hand appliance'. Therefore, this question goes without any score. However, the difference of consumers' 'ever used or not' is one of the determinant factors to influence the laptop reuse downstream market in the case study (details is shown in Chapter 6). Moreover, case study on the acceptance of a given second-hand laptop is designed to increase the knowledge of understanding the challenges and opportunities of the ICTs' reuse practice, learning from section 2.5, 2.6 and 3.10.

The sectional score of '**disposal**' is 30; and out of which, almost each option has maximum score of 2 for a distinct answer 'always' or 'never'. Exception is the two cases of 'resell it' and 'give it to relatives or friends', both have a maximum score for 'sometimes' – the moderate frequency. The reason is, to provide still functional appliances for reuse is a recommended practice; whereas, the rebound effect of 'always' doing so which might stimulate the excessive and irresponsible purchase is not advocated. **General awareness** is designed in the SCIndex model to quantitatively measure the agreement to the five statements, with maximum 2 score for each.

## 5.4 SCIndex pilot application

### 5.4.1 Online questionnaire and pre-test

Similar as Greendex, the SCIndex is also to *“measure the impact of average consumer in each country surveyed (individual scores are averaged to create a mean score for each country); not to measure the environmental impact of a total country”*.<sup>380</sup> Any form of the survey has its advantages and disadvantages, regardless of mail, telephone, interview or Internet survey. Internet panels have limitations in providing thoroughly representative sample of the general population. In some developing countries, even though the technical accessibility to the Internet has constraint, especially the remote rural area, yet it is convinced that the preferences of the consuming public could be

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<sup>380</sup> Greendex 2010

determined through Internet research, as long as sufficiently large panels are used<sup>381</sup>.

Cultural behavior and individual behavior are typically conceptualized in cross-cultural comparative study, which covers a wide field of quantitative and qualitative research methods and perspectives, at individual (person) and case (nation) levels; to design, implement and interpret a multicultural survey to be comparable, valid and reliable, it should be more thoroughly interdisciplinary on four specific phases: question development, pre-testing, data collection, and data analysis<sup>382</sup>. Demographic background, social cognition and cultural context of respondents provide independent and assorted information where respondents live and act<sup>383</sup>. Survey translations should “Ask-the-Same-Question”, integrating psychology, educational testing and social sciences into study design<sup>384</sup>. Designing of the survey is composed of selecting indicators, establishing the holistic scoring scheme, drafting questionnaire, pre-testing, designing webpage, setting up database, and revision after iterative testing. This cycle keeps on running even during the website design, with repeatedly pre-tests and revisions. Pre-testing is crucial in constructing the questionnaire, consisting of review by knowledgeable colleagues and analysts, interview to evaluate cognitive and motivational quality, pilot study and final check<sup>385</sup>.

The original questionnaire was drafted in English and translated into German, Chinese, French, Spanish and Portuguese by native speakers (the reason to have these languages is they are widely use in more than one country); and independently crosschecked. In order to reach more consumers, it is maybe necessary to have their own language; however, due to the budget and time constraints, the loose sampling of the pilot application was only done with the six languages version, lack of comprehensive coverage of all the contacted countries. Pre-test mainly consists of three methods, expert consulting, consumer interview, and pre-test workshop. Eight students coming

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<sup>381</sup> Greendex 2009

<sup>382</sup> Verba, S., 1971; Van der Vijver, F.J.R., 1998; Harkness, J.A., Van de Vijver, F.J.R. & Mohler, P.Ph., 2003; Van de Vijver, F.J.R., Van Hemert, D.A. & Poortinga, Y.H., 2008

<sup>383</sup> Braun, M., 2003a; Schwarz, N., 2003; Braun, M. & Mohler, P. Ph., 2003

<sup>384</sup> Van der Vijver, F.J.R. & Hambleton, R.K., 1996, 2004; Hambleton, R.K. & Patsula L., 1998; Harkness, J.A. & Schoua-Glusberg, A., 1998; Harkness, J.A., 2003

<sup>385</sup> Dillman, D.A., 2000

from Germany, Brazil, Pakistan and Greece participated in the pre-test seminar held on 15 January 2009 in Germany. Meanwhile, there were ten students, educational staff and scientific researchers from six countries returned their feedback and suggestion. In China, the pre-test reached 16 consumers with diversified age levels and professions. Discussion and revision proposal in these three kinds of pre-test all extended to the details of wording, structure and whether the investigation focus of question was unambiguous. The comments contribute to the revision; furthermore, it is identified that the cross-cultural barriers and differences remain, e.g., with or without e-waste collection centre and basement for storage, cultural acceptance of pre-owned products.

Website of the online survey is [www.SCIICT.com](http://www.SCIICT.com), lasted for 6 months – from June until November in 2009. The SCIndex Internet survey webpage with the questions are enclosed in Appendix 6. The initial design was to integrate the scoring scheme into the recording program, which turned out to be time consuming design of webpage, risky data collection, inflexible for updates and optimization of the database. The precision of decimal points leads to the failure of the first sampling. The feasible approach learned from the pilot application is to record the original data with quantitative coding; then separately, to calculate the scores in data analysis with the designed score scheme. In general, webpage design is an exploratory procedure, under the condition of multi-language, cross-culture and uneven digital literacy of different countries and districts.

#### **5.4.2 Sampling and data collection**

Selection of participating countries is determined by the practical and theoretical considerations – available funding and expertise, political, cultural and methodological restrictions, for example<sup>386</sup>. Kish provides a useful outline of five alternative multi-population survey designs: periodic surveys, comparisons of distinct domains from the same survey, multinational comparisons, combination of separate samples, and controlled observations of diverse types<sup>387</sup>. The World Fertility Survey and its successor, the Demographic and Health Surveys, are highly regarded examples of

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<sup>386</sup> Van de Vijver, F.J.R. & Leung, K., 1997

<sup>387</sup> Kish, L., 1994

cross-cultural studies<sup>388</sup>. When the data is gathered from a fraction of a population being studied, sample allows the researcher to make probable inference without studying every member<sup>389</sup>. In practice, due to total survey error in design, noncoverage, and nonresponse, samples only approximate the ideal standard that sample resembles the characteristics and structure of the whole population. In cross-cultural surveys, independent samples are normally taken from each population under study<sup>390</sup>. Since there are no specific sampling designs for cross-cultural survey research, it is recommended to use the best sampling designs from mono-population studies<sup>391</sup>.

The SCIndex study adopts Internet survey; and the sampling type is snowball or chain sampling<sup>392</sup> to take the approximate quota samples for the first try application convenience. The online survey itself limits the respondent's attribute as Internet user, regardless of the seldom, frequent or addictive one. Obviously, they cannot thoroughly represent a country's population, for example, those have no Internet access, due to technical, financial and age reasons, are not included. The SCIndex pilot application is an exploratory and descriptive, without any definite selected country; the panel centres locate in China, Germany and US. Once the online access is activated, the pilot SCIndex survey website is broadly distributed to the Internet users in different countries through networks in the regional, national and local levels. Participants were randomly addressed with the support of individuals, companies and organizations. 1120 respondents from 36 countries cross six continents with 44 nationalities have completed more than 80% of the questions.

The sample size of household ICT appliances' consumers derived from the real world case could base on the quantity of both Internet and mobile phone users. The sample size is calculated with the number of current total Internet users (1,733,993,741)<sup>393</sup> in the world and the sample confidence interval, which is 1067 (95% CI +/- 3% sampling

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<sup>388</sup> Bulmer, M., 1983

<sup>389</sup> Bulmer, M., 1983; Häler, S. & Gabler, S., 2003

<sup>390</sup> Harkness, J.A., Van de Vijver, F.J.R. & Mohler, P.Ph., 2003

<sup>391</sup> Häler, S. & Gabler, S., 2003

<sup>392</sup> Häler, S. & Gabler, S., 2003; Cargan, L., 2007

<sup>393</sup> World Total, 2009

error)<sup>394</sup>. In the pilot application, it takes the conservative size of 1067 (95% CI) respondents for the data analysis; when up to this amount, the sampling is closed in the end of the fourth week. To make simplification of real case, the target groups are mainly Asia, Europe and Americas – three major continents of household ICT appliances' consumption. The latest data of the Internet user in Asia is 1,077 million, Europe 519 million, North America 374 million and Latin America 255 million<sup>395</sup>; the mobile cellular subscriptions in Asia is 3,009 million, Europe 747 million, Americas 989 million<sup>396</sup>. Based on these two sets of statistics, to obtain both the global consumers' situation, the approximate quota samples could be: 45-63% from Asia, 16-22% from Europe, and 11-21% from North & South America; as well, in each continent, there should be at least three countries included. Theoretically, to meet the sample requirement for the cross-cultural study, the size of each country should also be comparable. In fact, it is challenging to targeting at both global and cross-cultural sampling; yet in the pilot application real case, due to unequal responses from different panels and countries, the sampling could not comply with the optimal and ideal one, with the most available time and resources. However, the on-field data could still support this qualitative and exploratory study (not yet quantitative and explanatory), to test and optimize the new model for the future in-depth research.

In the 1120 valid results, there are twelve countries and districts, Austria, Belgium, Brazil, Canada, China, France, Germany, Hong Kong (e.g., Hong Kong district has distinguishable consumption capacity from mainland China), Japan, Taiwan, UK and US, with 1069 statistically meaningful respondents in total, for the comparison and further analysis. Among the 1069 samples, the valid respondents from Asia are 73.5%, Europe 17.5% and North & South America 9%. Hence, the sample of Europe basically meets the planned sampling target; that of Asia is over-represented, and of Americas is rather less. It might largely influence the generalization of the pilot application results to the status of global consumers. In each country or district, at least more than five valid questionnaires are obtained, without further screening of the consumers' profile,

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<sup>394</sup> Dillman, D.A., 2000; Sample Size Calculator, 2009

<sup>395</sup> IWS, 2012

<sup>396</sup> UN ITU, 2011



like age, income and profession. Validity of the study depends on the internal (affecting sample generalization) and external (influencing measured results) factors; reliability of an instrument is ensured when it is able to deliver consistent results repeatedly, which can be confirmed with correlation coefficient<sup>397</sup>. Survey errors may be purely random or systematic, including sampling error, coverage error, nonresponse error and measurement error<sup>398</sup>. In cross-cultural study, bias refers to the factors that challenge comparability of scores across cultural groups; thereby, quality of research is ensured by combining good theory, survey design, administration and analysis<sup>399</sup>.

### 5.5 Summary

Based on the literature review, to answer the identified research questions and to close the gaps in existing knowledge, this chapter presents the development of the SCIndex model to measure and benchmark household ICT appliances' consumption; moreover, a pilot application to test and optimize it. Targeting to these related critical but challenging issues, both globally and regionally, research is carried out in multilayer. In this dissertation, the first two steps are completed, leaving the last step together with further in-depth researches and necessary on-field applications to be done.

- **Preliminary design** of the SCIndex model: structure, variables, questionnaire, pre-test, database, scoring scheme, data collection and analysis methods;
- **Pilot application** of the model: exploratory and descriptive research, qualitative study with the best available time and budgets, targeting to the aim and objectives, through on-field practically run the model to check its feasibility and identify the improvable aspects; to test whether the variables are SMART; to describe the relationship of consumption (purchase, usage, end-of-life – any stage and total SCIndex) with variables and factors; have partially answered the research questions, contributing to further in-depth research;
- **Global household SCIndex tracking survey** of consumers' choice and behavior of household ICT appliances: descriptive and explanatory, to quantitatively close

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<sup>397</sup> Cargan, L., 2007

<sup>398</sup> Dillman, D.A., 2000; Braun, M., 2003b

<sup>399</sup> Van der Vijver, F.J.R., 2003

the knowledge gaps with concrete model and data and fully cover the research questions. To verify the validity and reliability of the model, groups of further studies and applications for comparison and optimization are necessary.

## 6. Validation and optimization of the SCIndex with pilot application

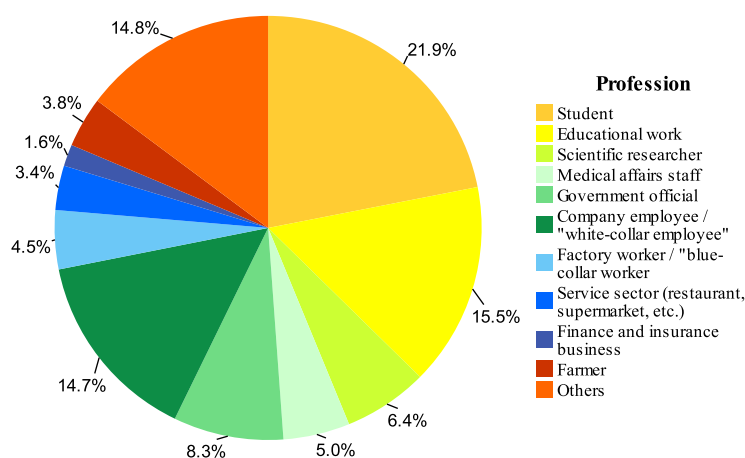
The pilot application is carried out to evaluate and optimize the SCIndex model with the on-field data and its analysis (section 6.1); reliability of the results is further tested (section 6.2); finally, overall optimization of SCIndex model is presented (section 6.3).

### 6.1 Results of the pilot application

The data analysis of the exploratory pilot application consists of four layers, including global, cross-cultural, national and case-specific, depending on data attributes, scoring scheme and variables relationships:

- \* **Global:** preliminary data processing of all respondents;
- \* **Cross-cultural:** data analysis results and SCIndex scores comparison;
- \* **National:** variables relationship analysis for the case of China;
- \* **Case-specific:** acceptance of the second-hand laptop under given assumption.

The software that is adopted for the pilot research data analysis is SPSS 17.0 version<sup>400</sup>. In all the 1120 respondents, 53.7% are male, 46.3% female; 21.9% are students, 15.5% educational workers, 6.4% scientific researchers, 5.0% medical affairs staff, 8.3% government official, 14.7% “white-collar employees”, 4.5% “blue-collar workers”, 3.4% working in service sectors, 1.6% in finance and insurance business, 3.8% farmers and 14.8% are others (e.g., retired, housewife or freelance) (Figure 6).



**Figure 6** Respondents' profession proportion

<sup>400</sup> Kulas, J. T., 2009

The major educational levels distribute in middle/high school (28.0%), undergraduate (39.6%) and graduate (24.1%), only 7.8% with higher education and 0.6% with primary or less. Respondents' in the age level of 25-35 is dominant (39.7%); following, the 36-45 (19.8%) and 18-24 (18.4%), 46-55 (8.8%), <18 (7.2), 56-65 (4.8%) and >65 (1.2%) aged Internet users. Since large part of the participants are students, or from developing countries like China, there are 31.2% with annual salary less than 1,000 €; 25.5% are 1,000-3,000 €/yr consumers; 11.0% 3,000-5,000 €/yr; 8.6% 5,000-10,000 €/yr; 5.6% 10,000-15,000 €/yr; 3.4% 15,000-20,000 €/yr; 4.9% 20,000- 30,000 €/yr; 4.4% earn 30,000-50,000 €/yr; and 5.5% >50,000 €/yr.

As section 4.2 reviewed, household size and dwelling type are related to the consumption of household ICT appliances, especially, the electricity consumption. 31.1% of the 1120 respondents live in three-member family; 19.7% live in two-member family; 19.0% have four members; 11.4% live alone; the others have five people (9.8%) or more than five people (9.0%) at the residence. The type of residence of respondents varies from house (15.0%), apartment (50.5%), dormitory (11.7%) and others (22.7%). More than a half are owned (54.4%), around a quarter are rented (28.1%), the left other forms account for 17.4%. The comparison charts of the profile of the respondents from twelve countries/districts will be found in Appendix 7, such as, education level, age level, gender, annual income level, profession, residence type, ownership of current living place and number of people in the household. These profile data are essential variables for the following exploratory and descriptive data analysis.

### **6.1.1 Analysis for all respondents and those from twelve countries/districts**

For most of the respondents, the number of the ten appliances at the current residence which are being used and lying idle, are at least one TV (44.3% have one, 29.5% have two), one fixed phone (62.6%), or one desktop computer (60.4%). Besides, more than half of the households have two (28.2%) or three (26.8%) mobile phones; most of consumers have one (44.9%) or none (31.0%) notebook computer; even less printers (47.6% do not have and 39.4% have one). The data result reflects the household ICT

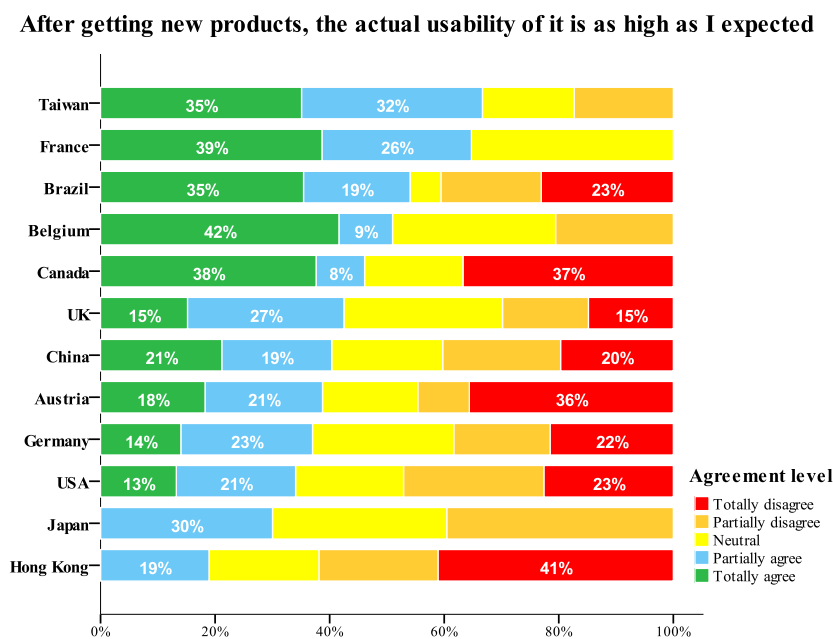
appliances penetration composition, that is, more consumers of TV and mobile phone, still less notebook computer and printer users. In the pilot application, as the sample sizes are not equal and the assumption of parametric data is violated, the nonparametric test – Kruskal-Wallis test – is therefore applied; for the large samples, Monte Carlo method calculates the exact significance value; Mann-Whitney tests could be applied to do non-parametric *post hoc* tests, together with Bonferroni correction<sup>401</sup>. The test statistics and mean rank bar charts of mobile phone and desktop computer are enclosed in Appendix 8. The amount of mp3/mp4 has no significant difference, which is proved by Monte Carlo significance value of .306 ( $>.01$ ) at 99% CI. For the other appliances' amount, the mean ranks of the twelve countries and districts are significantly different ( $.000<.01$ ). This denotes the significant differences of other nine appliances' amounts at the residence of the respondents. The multiple response sets of ages of the five appliances “that are in use” reflects the respondents' consumption and purchase profile; as well, displays the general features of these appliances' technically usable lifetime. The ages of high frequency are 1-2 years for mobile phone (42.5%), desktop computers 3-5 years (46.4%) and notebook computers 3-5 years (57.3%). The statistical result of the age of mobile phone, computers and printers is enclosed in Appendix 9.

Regarding purchase behavior and lifestyle, 41.2% of the 1120 respondents ‘totally or partially agree’ with the statement that “advertisements and promotion motivate me to buy their products”; and 26.7% agree that “fast emerging new products urges me to purchase continuously to catch up with the trends”. Only 57% of total respondents feel that “after getting new products, the actual functionality is not as high as expect”. 39% of consumers are not against this argument that “they always need to buy more, because their own possession are not sufficient”. The stacked bar charts intuitively compare the agreement levels of the samples from twelve countries and districts (Figure 7). The green and blue stacked bars reflect that the consumers from different countries got disappointed with the “actual functionality of the products” to some extend, saying ‘totally or partially disagree’. The major reason might be promotional

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<sup>401</sup> Field, A., 2005; Norusis, M.J., 2008a

advertisements which exaggerate the performance of the products (as reviewed in section 2.3 and 3.2); as well, the insufficient and unsatisfied mindsets of the consumers generated from the huge pressure of work and life, isolated relationship and the over expectation of advertised products (reviewed in section 3.2 and 3.9). In the pilot study, the samples of participant countries are largely different; while, in the future formal survey with sufficient samples of quota size and profile for comparison, it will be more reliable and valid to reveal the purchase culture, social background, even national legislations' influence among the end consumers in different countries. For all the agreement of statements on purchase, comparison charts are enclosed in Appendix 10.



**Figure 7** Agreement with statement of purchase – 12 countries/districts

For all respondents; the major factors “that influence the consumers’ decision to buy household appliances” are price (11.5%), brand (9.7%), function (9.3%), reliability/guarantee (8.5%), durability (8.5%), after-market service (8.0%), electricity consumption (7.4%) and performance/outlook (6.2%). If differentiate major factors selected by the respondents from twelve countries and districts, the crosstabulation (attached in Appendix 11) of detailed percents assists to understand the consumers’ taste, interests, for cross-cultural comparison. Participant consumers from Taiwan (87.5%), Hong Kong (83.3%) and China (72.8%), pay more attention on “after-market

service” than the other countries. “Electricity consumption” is more influential for the consumers from Hong Kong (83.3%), Brazil (64.7%), and China (62%). However, the result should be crosschecked with the follow-up study with adequate sample sizes. Besides, it provides the information to indicate both the challenges and opportunities of the reuse market of the second-hand appliances in the country. The factor which is influential to the consumers’ decision making when purchasing the new appliance, as well, speaks of itself the competition and weakness both in new products market and in the reuse market what to be aware of or being lack of.

82.6% of all participants “have ever bought at least one mobile phone, desktop computer and notebook computer in the past five years”. The major “reasons to buy a new mobile phone or computer” comprise of “it largely benefits my life, work and study” (13.0%), “the old one is broken” (11.4%), “the old one is outdated” (9.7%), and “timely and efficient to communicate and contact” (9.2%). The mostly considered reason for the consumers in China (49.8%) and Germany (47.7%) is that “it largely benefits my life, work and study”; while, for American, 52.1% of participants “buy a new mobile phone or computer” because “the old one is outdated”. 57.7% of all respondents replace mobile phone ‘every 2-4 years’, 20.9% ‘more than once a year’; 55.7% replace desktop computer and 41.5% replace laptop computer ‘every 3 years or longer’. If crosstabulate the frequency of “the reasons that buy a new one” multiple response set, the consumers who replace their mobile phone faster than ‘twice a year’, 42.7% consider that “the old one is outdated”. Likewise, both for the desktop computer consumer (66.5%) and laptop computer consumer (50%) whose replacement rate is ‘every two years’, the reason “old one is outdated” ranks the first. The replacement reasons of the consumers, especially the fastest replacing respondents, explicitly outline the consumption mentalities and lifestyle.

There are 73.5% respondents “have ever heard about environmental or energy saving label”, much more than the others that “have never heard about it” (14.5%) and even “don’t know” (11.8%). In different age levels, the respondents that “have ever heard” remains the highest percent, despite of the slight differences, for example, 77.2% at the

age of '25-35', 76.9% at '36-45' years old. Participants who are more than 65 years feature with the relatively high percent of "never heard about" (30.8%); followed with consumers of 18-24 years old (19.8%). In the light of the professional differentiation, 88.9% of staff in finance and insurance business, 81.4% of educational staff, 83.8% of company employee, 75.7% of scientific researcher and 71.4% of students "have ever heard about". The crosstabulation with education illustrates that people with higher educational level (from school, undergraduate, to graduate, and higher) have increasing percent of awareness of the labels (63.1%, 76.4%, 79.2% and 79.8% in sequence) (details in Appendix 12). When asking "have ever bought a labelled mobile phone or computer", only 42.2% answer "yes"; besides 15.2% missing value, 28.3% have "never" bought, 14.3% "don't know". For those who have ever heard about labels, 49.3% of consumers "prefer to buy products with environmental or energy label", 42.7% of them "usually do not check for environmental labels, but some products just have them". Though in both cases, the consumers finally get the labelled products, yet they behave differently in the selection of those household ICT appliances, therefore present different attitude and value towards the concept of environmental protection or energy saving and labelling itself. People living in 'owning' residence have higher tendency to use labelled appliance (57.4% bought; 29.2% no) than those in the 'renting' one (35.5% bought; 40.7% no). In Appendix 13, the further analysis of consumers' purchase behavior of labelled appliances is given, under different salary level, residence type, and household size.

The tables in Appendix 14 tabulate response percents from twelve countries and districts to the statements about the labelled appliances. The consumer behavior of selecting household ICT appliances with label largely depends on the availability of label in the cross-cultural situation, consumers' awareness of environmental and energy label, personal preference and affordability. In the household appliances market of these countries and districts, the environmental and energy saving labels are all available (see literature review in section 3.7); for the European countries, labelling is mandatory; for some of the other countries, voluntary labelling still exists. Participant consumers from Brazil (100%), France (100%), UK (85%), and Austria (84.6%) have



higher percentage of “yes, ever heard about the labels”. However, when asking whether “have ever bought the labelled ICT appliances, only 41.2% from Brazil, 25% from France, and 29.4% from UK answered ‘yes’. Though 66.7% of Austrian consumer said they “prefer to buy products with environmental and energy saving label”, yet, only 27.3% have ever bought a labelled ICT appliances; it is maybe because of the so called ‘value-action-gap’; or when they buy those ICT products, labelling is not widely applied in the local market.

The behavior after using computer reflects the energy saving consciousness of the consumers. 51.6% of all respondents answered they sometimes, usually or always “leave it on until next times, after using it”; 49.2% never “set it to standby models”; 39.2% usually or always “leave it automatically standby”; 43.3% always “shut it down”; and 64.2% usually “unplug it after turning off”. Appendix 15 contains charts of each statement, comparing the after using behaviors of respondents from 12 countries/districts. Large percent of consumers from Brazil (52%), mainland China (34%), Germany (33%) and US (32%) said they ‘usually & always’ “leave the computer on, after using it”; in Belgium (62%), Brazil (58%), and US (44%), around half of the respondents “leave it automatic stand-by”. As much as around 50% of consumers from France (62%), Hong Kong (58%) and Austria (45%) always “unplug it after turning off” (in previous section 2.4, 3.8 and 4.1, the reason of energy saving is clearly given). In the proposed formal survey, with well designed sampling, the verified questionnaire and analysis methods developed in the pilot application, the measurement of the percents and the comparison across countries will be statistically more meaningful.

On consumers’ responses to saving electricity when using computer, 32% feel they are “already used to saving electricity in daily life and enjoy this pattern”; and 25.7% saving energy due to the climbing price of electricity; 18.7% “would like to save electricity but don’t know how to make it efficient”; 9.2% “use electricity as much as they want, as long as it’s affordable; as saving is beyond their daily behavior”; and 9.1% don’t like to be under the pressure of saving, the more comfortable and convenient, the better”. The self-reported answer may not be the real case; as well, due

to different living standard of consumers in different areas, further in-depth research could think about integrating the technical approach for measuring the consumers' energy saving consciousness, learning from the socio-technical research of electrical end use pattern of household ICT appliances in UK<sup>402</sup>.

These given behaviors of e-waste end-of-life practice (reuse, recycling, donate and storage) in SCIndex survey were generated from the literature reviewing, experts consulting and on-field experiencing. 46.7% out of all respondents always “prefer to repair it first rather than immediately replace, if it is broke down”; 34.9% never “prefer to reuse the still functional components”; 61.5% never “donate it to non-profit organization”; 34.7% sometimes, usually or always “discard it with garbage”; 30.3% “throw it on the roadside”; 53.9% never “take it to a recycling or collection centre”; 44.7% “prefer to simply store it, rather to bring it to collection centre”; 60.5% have ever sold “the appliances to the collector to clear up, regardless of the price”; 48.6% never “care about where the appliance will end up after collection”; and 63.9% agree that they “have no time to think about used appliances”.

Taking the cases of the twelve countries/districts, Appendix 16 illustrates that the respondents from UK has more preference to reuse the still functional components (67% ‘always’ or ‘usually’). Consumers from Taiwan and Belgium answered they ‘always’ or ‘usually’ “prefer to repair it first, rather than to immediately replace, if it is broken”; while, those respondents from China (52% usually & always) more frequently “repair the appliance rather than immediately replace”, than consumers from Germany (19%) and US (19%). Obviously, the reuse channel of donation to non-profit organization is more accessible in US (59% ‘usually or always’) than in China (38%). In China (26%), US (24%) and Germany (24%), around 1/4 participant consumers ‘always’ “prefer to simply store it, rather to invest time and energy to bring it to collection centre”; while, more percent of German respondents are ‘never or sometimes’. Chinese consumers most frequently “sell it to the collector to clear up, as long as he pays regardless of the price” (only 18% never). Respondents from Austria

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<sup>402</sup> Coleman, M., 2011

(80%), Japan (80%) and UK (59%) said they are ‘always or usually’ “informed of national or local requirement of how to discard appliances”. Most of the participants from Brazil (77%), Austria (74%) and UK (68%) reported that they ‘always’ or ‘usually’ “care about where the appliances will end up after collection”.

As the 16 variables in Q10 about “disposal” could be categorized into groups along the latent sub-scales and the total sample size is sufficient; therefore, factor analysis is applied to reduce the dimensions and extract the factors<sup>403</sup>. For all the respondents, the KMO value of the factor analysis is .794, which means the patterns of correlations are good and relatively compact; so that the distinct and reliable factors are yield<sup>404</sup>. The analysis procedure is enclosed in Appendix 17. There are four factors of respondents’ disposal behavior of household ICT appliances, named as “casual disposal”, “responsible disposal”, “lifetime extension” and “value retention”. Table 4 rearranges the sequence of the questions to visibly locate the variables in the four subscales.

**Household ICT appliances consumer disposal behavior factor analysis - Rotated Component Matrix - all responses<sup>a</sup>**

	Component			
	Casual disposal	Responsible disposal	Lifetime extension	Value retention
If it broke down, I prefer to repair it first, rather than to immediately replace			.794	
For the mobile phone or laptop computer, I replace battery to extend the life time			.706	
I prefer to reuse the still functional components			.506	
I donate it to non-profit organization		.701		
I take it to a recycling or collection center		.623		
I store it until I have more pieces to bring them to collection center together		.641		
I am well informed of national/local requirement of how to discard appliances		.764		
I care about where the appliance will end up after collection		.708		
I resell it on-line or at a second-hand store				.734
I give it to relatives or friends				.758
I discard it with the garbage	.799			
I throw it on the road side	.742			
I prefer to simply store it, rather to invest time and energy to bring it to collection center	.730			
As long as the collector pays, regardless of the price, I sell it to him to clear up	.688			
I have no time to think much about used appliances	.717			
I'm free to dispose of my things anyway I want	.573			

Extraction Method: Principal Component Analysis.  
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

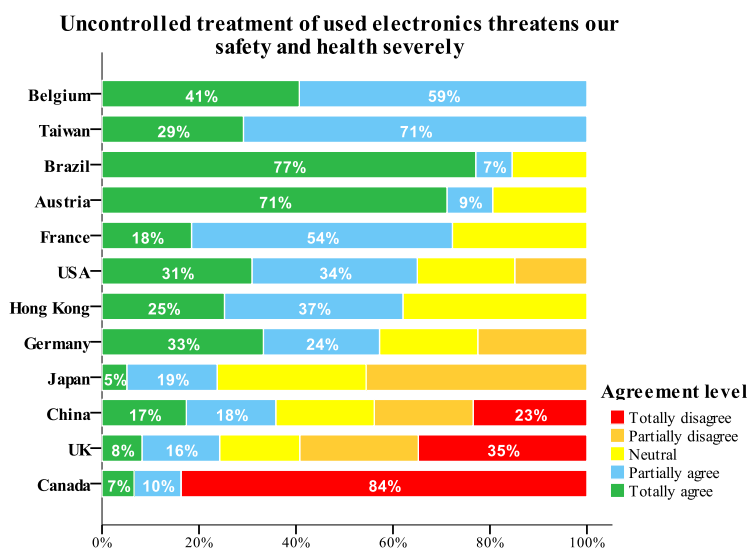
**Table 4** Factor analysis of all respondents’ disposal behavior – subscale groups

On the general awareness of the sustainable production and consumption issues, 70.5% of all participants agree (totally or partially) that “if an environmental-friendly product has a reasonable higher price, it is acceptable”. There is only a few portion to disagree

<sup>403</sup> Stevens, J., 1996; Field, A., 2005

<sup>404</sup> Kaiser, H.F., 1974; Hutcheson, G. & Sofroniou, N., 1999; Field, A., 2005

(9.3% totally or partially) with the statement that “production of household appliances adds heavy burdens to the environment”; however, the major part is neutral (34.8%), not totally agree (25.7%) or partially agree (25.0%). 53.4% of all respondents ‘totally or partially’ agree with “consumption contributes to environmental pollution”. 76.1% ‘totally or partially’ agree that “uncontrolled treatment of used electronics threatens our safety and health severely” in ‘general awareness’. Moreover, 57.6% are ‘totally or partially’ “willing to consume less for the future generations to meet their needs under the scarcity of resource”; only 9.9% disagree (totally or partially). Together with the purchase and disposal behavior measured by the other variables, the value-action gaps are obvious. For example, almost a half of participants totally agree that “uncontrolled treatment of used electronics threatens our safety and health severely”; however, as it is reported, large portion of end consumers have their own pattern to deal with the appliances, e.g., “disposal with garbage”, “simply store it”, “lay it on the roadside”, and “sell it to collectors at any price, regardless where it will end up”.



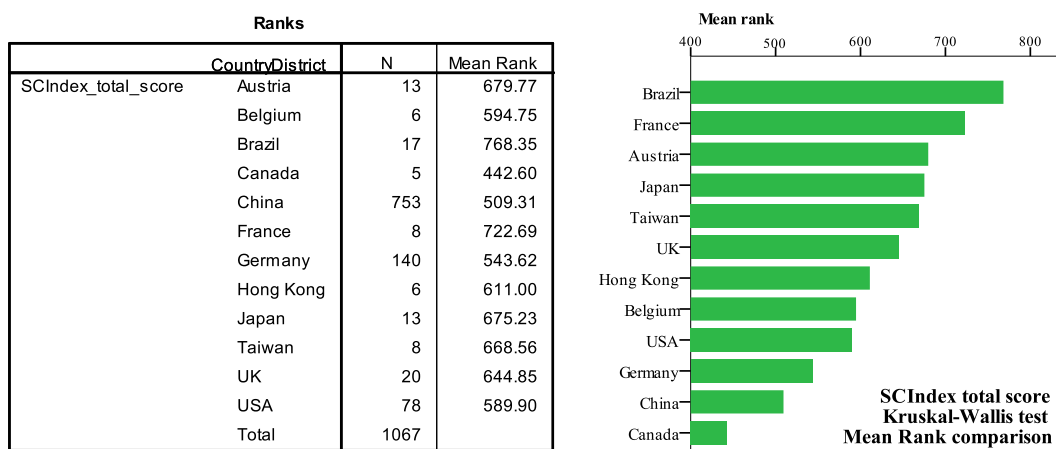
**Figure 8** General awareness – 12 countries/districts

70.5% of consumers agree that “it is acceptable, for an environmental-friendly product with a reasonable higher price”; 76.1% agree that “uncontrolled treatment of used electronics severely threatens health and safety”; 53.4% agree that “consumption contribute to environmental pollution”; and 57.6% will to “consume less for the future generations to meet their needs under the scarcity of resource”. Detailed comparisons

of the responses towards the general awareness statements among the twelve countries/districts are demonstrated with stacked bar charts enclosed in Appendix 18. Around 50% of American consumers ‘totally or partially’ agree with “production of household appliances adds heavy burdens to environment”; while, that is 64% from Germany, and 34% from China. 57% of German consumers agree with “uncontrolled treatment of used electronics threatens our safety and health severely”; while, those from China, only 1/3 agree, and the other around 1/2 disagree (Figure 8).

### 6.1.2 SCIndex scores and map

If applying the scoring scheme of the pilot application for the respondents’ answer, the score of each variable, the four sections and the total scores are correspondingly calculated. Strictly speaking, as neither the variances of each group are homogeneous nor the group sizes are equal, the non-parametric Kruskal-Wallis Test is therefore applied to get the ranks of the twelve countries/districts.



	SCIndex_total_score
Chi-Square	31.171
df	11
Asymp. Sig.	.001
Monte Carlo Sig.	.001 <sup>a</sup>
99% Confidence Interval	
Lower Bound	.000
Upper Bound	.001

a. Based on 10000 sampled tables with starting seed 303130861.  
 b. Kruskal Wallis Test  
 c. Grouping Variable: CountryDistrict

**Table 5** Kruskal-Wallis Test mean rank comparison of SCIndex total score

The mean rank of the countries and districts is significantly different (Table 5), statistically tested by Monte Carlo sig. level of .001 (<.01) at 99% CI. The non-parametric test of the four sectional scores (purchase, usage, disposal, general awareness) is shown in Appendix 19.

*Post hoc* test for the Kruskal-Wallis test is to run Mann-Whitney tests with selective comparison of pairs and Bonferroni correction to avoid inflating Type I error<sup>405</sup>. All of the detailed procedures and results of Mann-Whitney selective comparison tests for SCIndex four sectional scores and the total score are enclosed in Appendix 20.

- Three tests are done for the **purchase** stage score of Brazil to that of China, Brazil to Austria and Germany to that of US; with Bonferroni correction .0167 (.05/3). Brazil has the similar purchase stage score as China, as the null hypothesis of the same rank cannot be rejected (2-tailed Monte Carlo sig. level .076>.0167). The purchase stage score of Germany is significantly larger than that of US (.000); as well, that of Austria is larger than Brazil (.015).
- In **usage** stage, three pairs are selected; Bonferroni correction is .0167. The score of Germany is significantly larger than that of China (2-tailed Monte Carlo sig. level .003); the null hypothesis of equal ranks of France to Canada cannot be rejected (.019>.0167); scores of US is significantly smaller than Germany.
- The *post hoc* tests of **end-of-life** stage scores consist of five tests, with Bonferroni correction for Mann-Whitney tests .01 (.05/5). The score of Austria is significant larger than that of China (two tailed Monte Carlo sig. is .003) and Germany (.000). Statistically, there is no difference between Germany and US (.118>.01), Japan and Germany (.027>.01), UK and Germany (.014>.01).
- The *post hoc* tests for Kruskal-Wallis test of the **general awareness** score are three Mann-Whitney tests with Bonferroni correction .0167 (.05/3). The score of China is significantly smaller than that of Germany (2-tailed Monte Carlo sig. level .000); score of Brazil is larger than that of Taiwan (sig. level .01<.0167); score of Austria is larger than Japan (.008).

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<sup>405</sup> Field, A., 2005

- For the SCIndex **total** score, there are still three *post hoc* tests and the result is, the score of Brazil is significantly larger than that of China (2-tailed Monte Carlo sig. level .000); and no statistical difference between score of Brazil and US (.022>.0167), Germany and Japan (.115>.0167).

For the 12 countries and districts, the SCIndex total scores of the respondents could be categorized into three groups based on the above analysis. The first group with relatively higher total scores (58.6-63.0) is regarded as more sustainable in household ICT appliances consumption, including Brazil, France, Japan and Austria. Countries which are less sustainable in household ICT appliances consumption are grouped into the third category with lower total scores (50.0-54.5), they are China and Canada. The other six countries and districts are in the middle level, Taiwan, UK, Hong Kong, Belgium, US and Germany.

Analysis of Variance (ANOVA) is run to compare the means via testing the hypothesis that several means are equal<sup>406</sup>. Though the ANOVA is not robust for the pilot application respondents' data which violate the assumption of parametric, yet, in the formal survey, with large quantity of participants and the proposed equal sample size based on the pilot application, the scores of the different countries/districts are ideally analyzed with ANOVA to compare means of parametric data; therefore, the ANOVA analysis procedure and result are also demonstrated. The precision of the result should be adjusted by the above Kruskal-Wallis test. Take the SCIndex total score ANOVA test result in Table 6 for example, it is reported to have significantly heterogeneous variance as the hypothesis for homogeneity is rejected (Levene's test sig., .011<.05); and the means are significantly unequal (.000<.05, robust tests Brown-Forsythe<sup>407</sup>).

Test of Homogeneity of Variances				Robust Tests of Equality of Means				
SCIndex total score				SCIndex total score				
Levene Statistic	df1	df2	Sig.		Statistic <sup>a</sup>	df1	df2	Sig.
2.247	11	1055	.011	Welch	3.485	11	39.547	.002
				Brown-Forsythe	4.062	11	75.028	.000

a. Asymptotically F distributed.

**Table 6** ANOVA partial result of SCIndex total score

<sup>406</sup> Diamond, I. & Jefferies, J., 2001; Field, A., 2005

<sup>407</sup> Bohrnstedt, G.W. & Knoke, D., 1994; Aron, A., Aron, E.N. & Coups, E.J., 2008

95% of the 1067 participants' SCIndex total score for this pilot application locates within scores of  $53.96 \pm .688$  (Appendix 21). For the data mining and exploratory data analysis such as the case of SCIndex model, it is essential to run *post hoc* tests which consist of pairwise comparisons. Two kinds of *post hoc* tests are adopted to make multiple comparisons to test the result of one-way ANOVA for the twelve countries/districts that where the differences exist. If equal variance is assumed, Hochberg's GT2 is the applicable *post hoc* test, e.g., the case of SCIndex usage stage scores, which has a large significance level of Levene's test ( $.359 > .05$ ) to accept the null hypothesis of homogeneous variance. For the other three sectional (purchase stage, disposal stage and general awareness) scores and the total score, the assumption of equal variance is violated; the Games-Howell *post hoc* test is therefore the appropriate one<sup>408</sup>. The statistical meaning of the tests denotes the significant different scores of the twelve countries and districts from each other. Appendix 21 gives an example of Games-Howell *post hoc* test for the scores ANOVA, it indicates that the SCIndex total score of China is significantly smaller ( $-9.957$ ) than that of Brazil (sig. level  $.032 < .05$ ); while, the total scores' differences of China with the others is not statistically significant (sig. levels  $> .05$ ). The means plots of SCIndex total scores sketched out by ANOVA in Appendix 21 show the same trend with the error bar charts at 95% CI. Brazil has the distinctive high total SCIndex scores; while, statistical results of the responses from China and Canada are ranked much lower.

Appendix 22 covers the detailed 'descriptives' tables together with tests of normality and homogeneity of variance for the sectional scores, which shows different means and 95% CI for the twelve countries and districts. With the data obtained in this SCIndex pilot application, the mean plots and error bar charts at 95% CI of twelve countries and districts obviously illustrates the differences and ranks of the sectional scores (in Appendix 23). The mean rank of SCIndex total scores made by Kruskal-Wallis test is almost the same with ANOVA mean plots; except the opposite ranks of Japan and Austria due to tiny differences and the overlapped confidence intervals of these two small samples, that is, Japan has slightly larger mean but smaller 95% CI. The

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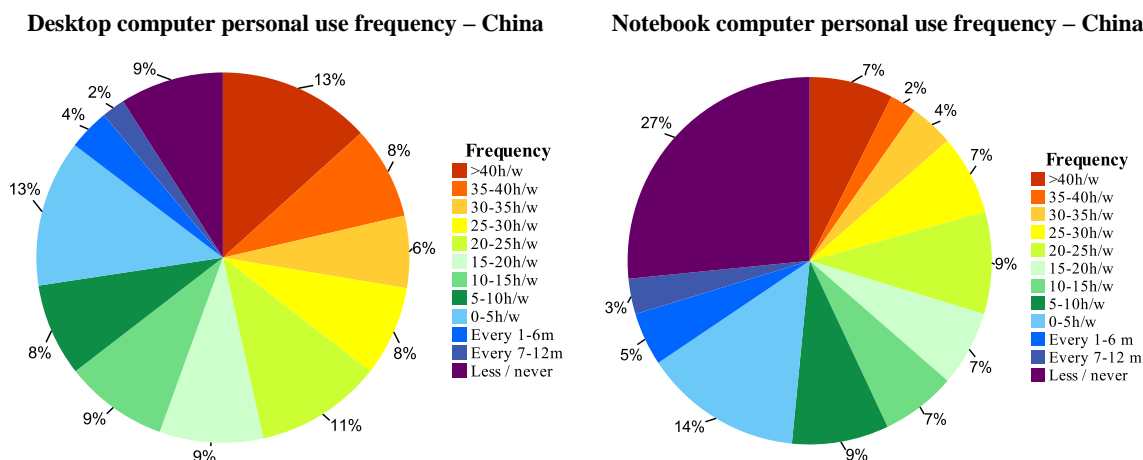
<sup>408</sup> Field, A., 2005



SCIndex total score map will be found in Appendix 24. Though the sampling of the exploratory pilot application is not sufficient and concrete to represent the true sample, yet the progress to reach the objective of the pilot to test, evaluate and optimize the SCIndex model through the empirical study and data processing is not interrupted.

### 6.1.3 Case of China

In the pilot application, the data of respondents from China feature with relatively large sample size; the diversified personal profile in profession, education, salary and age level, type of residence and ownership, number of people at current residence; furthermore, the highest uniform of nationality and current residence. Therefore, the case of China is selected for detailed analysis and modelling; in order to demonstrate the feasibility of SCIndex model for the contribution of the understanding of national consumption situation of household ICT appliances towards sustainability.



**Figure 9** Personal use-frequency pie chart of TV, mobile phone and computers

When asking the use-frequency of TV, mobile phone and computers in Q3, the twelve degrees are all covered by the respondents from mainland China, indicating a broad coverage sampling. Whereas, it does not certainly mean the sample of China in the pilot application is representative of all the ICT appliances consumers in the country. The sampling of the pilot study did not set any explicit quota caps for each country and districts. Nevertheless, the pie charts in Figure 9 intuitively display the use frequency percent of the desktop and notebook computer. Obviously, the popularity of desktop is

broader than notebook computer, with bigger portion of high use frequency.

To compare the major reasons to buy a new mobile phone or computer (Q6) among different groups, like gender or age levels, it's efficient to present the count and percent with the crosstabulation of the attributes and 'reasons to buy a new one' multiple response set (in Appendix 25). Correlation measures the association between two variables, positive, negative or no relationship; spearman's rho correlation coefficient is applied for the non-parametric data<sup>409</sup>. If the significance value is less than .05, it can be concluded that there is a significant relationship between two variables<sup>410</sup>. The variables that enter the correlation analysis largely rely on the above literature review. "Frequency to replace mobile phone", at the significance level of .01 (2-tailed test), correlates with "advertisements and promotions motivate" (Spearman's rho correlation coefficient is .216), "actual usability is as high as expected" (-.141), "own possession are not sufficient" (.207), gender (.142), education (-.147), age (-.213) and number of people at current residence (-.127); at .05 significance level (2-tailed), correlates with "fast emerging new products urges me to purchase" (.321), and "I prefer to spend leisure time on shopping" (.128). The explanation of the above data is: the younger consumers are more frequently replace their mobile phone than the older; those who always feel his own possession are not sufficient frequently replace the mobile phone; but consumers who are more easily motivated by the advertisement and promotions perform more actively in replacing the mobile phone; while, the most frequent mobile phone consumers are urged by the fast emerging new products.

	Component		
	Satisfaction & sufficiency	Stimuli oriented	Usability oriented
Advertisements and promotions motivate me to buy their products		.843	
Fast emerging new products urges me to purchase continuously to catch up with the trends		.785	
After getting new products, the actual usability of it is as high as I expected			.947
The happiness and satisfaction of my life increases with gaining new products	-.595		
I prefer to spend my leisure time on shopping	.780		
I always need to buy more, because my own possessions aren't sufficient	.767		

Extraction Method: Principal Component Analysis.  
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

**Table 7** Factor analysis subscale groups of consumer purchase behavior – China

<sup>409</sup> Field, A., 2005

<sup>410</sup> Diamond, I. & Jefferies, J., 2001; Field, A., 2005; Aron, A., Aron, E.N. & Coups, E.J., 2008

In the questions with Likert scale options (Q4, Q8, Q10), there are latent factors existing that account for the patterns of collinearity among multiple metric variables. The factors could be extracted with factor analysis and used for the multiple regression of SCIndex total score. In the factor analysis of the agreement to purchase statement (Q4), the KMO is .626, which means ‘mediocre’ for factor analysis; and the chi-square value of Bartlett’s Test of Sphericity is significant. Three factors are extracted and named according to the common characteristics in the subscales, as highlighted in Table 7, they are “satisfaction and sufficiency oriented”, “stimuli oriented” and “usability oriented” (Q4 factor analysis result for the case of China in Appendix 26).

	Component		
	Simply leave	Thoroughly turn-off	Carefully set up
After using the computer, I leave it on until next time	.899		
After using the computer, I leave it in automatic stand-by	.910		
After using the computer, I set it to stand-by mode			.855
After using the computer, I immediately shut it down		.534	.556
I unplug it, after turning off		.875	

Extraction Method: Principal Component Analysis.  
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

**Table 8** Factor analysis of behavior ‘after using computer’ – subscale groups

The KMO value of factor analysis for the behavior after using computer (Q8) is ‘mediocre’ (.532); and the chi-square value of Bartlett’s Test of Sphericity is significant. Therefore, factor analysis for the five variables is applicable; eigenvalues, scree plots and rotated matrix are enclosed in Appendix 27. The three factors are “simply leave”, “thoroughly turn-off” and “carefully set up”, which generalize the overall characteristics of the respondents’ behavior “after using computer” (Table 8).

In the factor analysis of the 16 disposal behavior variables (Q10), KMO value is .805 which mean ‘good’ for factor analysis, and the chi-square value of Bartlett’s Test of Sphericity is significant (Appendix 28). It is similar with the data analysis of all the respondents; however, the extracted four factors are different in components and names. The rotated component matrix (Tables 9) highlights the four factors, “casual disposal”, “reuse and awareness”, “responsible disposal” and “value retention”.

	Component			
	Casual disposal	Reuse & Awareness	Lifetime extension & Responsible disposal	Value Retention
If it broke down, I prefer to repair it first, rather than to immediately replace			.547	
For the mobile phone or laptop computer, I replace battery to extend the life time			.532	
I take it to a recycling or collection center			.569	
I store it until I have more pieces to bring them to collection center together			.672	
I'm free to dispose of my things any way I want			-.558	
I prefer to reuse the still functional components		.567		
I donate it to non-profit organization		.720		
I am well informed of national/local requirement of how to discard appliances		.800		
I care about where the appliance will end up after collection		.786		
I discard it with the garbage	.772			
I throw it on the road side	.819			
I prefer to simply store it, rather to invest time and energy to bring it to collection center	.790			
As long as the collector pays, regardless of the price, I sell it to him to clear up	.713			
I have no time to think much about used appliances	.695			
I resell it on-line or at a second-hand store				.764
I give it to relatives or friends				.722

Extraction Method: Principal Component Analysis.  
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

**Table 9** Subscale groups of disposal behavior factor analysis – China

Multiple regression is applied to predict the outcome variable from a combination of variables and factors. Large values of the multiple R represent a large correlation between the predicted and observed values of outcome; Durbin-Watson test statistic tests the assumption of independent errors that if the value is different enough from '2', it is cause for concern of the assumption; most of regression plots involving residual values help to exam the validity of assumptions, e.g., standardized residual histogram and P-P plots; plot of standardized residual against standardized predicted value<sup>411</sup>.

SCIndex total score could be predicted by the combination of variables and factors in the multiple regression model, based on the literature background of sustainable consumption and statistical instruments. The targets of running the multiple regression model of SCIndex total scores with the predictors orient to seek out the influential factors that increase the national SCIndex score; moreover, to figure out determinant consumer choices and behaviors, for all the stakeholders to consider and take effort when make progress in sustainable consumption. In this exploratory research, both the external (literature review, expert consulting, etc.) and internal determinants (first-hand data, analysis result of correlation analysis, etc.) all contribute to the modelling.

<sup>411</sup> Bohmstedt, G. W. & Knoke, D., 1994; Field, A., 2005; Norusis, M.J., 2008a

According to the literature review, the variables and factors, that relate to the consumers' consumption behavior and could largely explain the model, influentially reflect the consumption pattern and mindset of the consumers.

Therefore, based on both the internal and external determinants, holding "SCIndex total score" as dependent variable, six predictors are selected to enter the model with stepwise method, including "casual disposal", "reuse and awareness", "frequency to replace desktop computer", "stimuli oriented purchase", "responsible disposal" and "simply leave it, after using computer". The multiple regression coefficient R is .840, which represents a large correlation between the predicted and observed values of the outcome. The value of  $R^2$  that assesses goodness-of-fit of the model to the actual data indicates 70.5% of variation in the outcome can be explained by the model (Table 10).

Model Summary<sup>a</sup>

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.572 <sup>a</sup>	.327	.326	9.59614	.327	364.570	1	751	.000	
2	.677 <sup>b</sup>	.459	.457	8.61176	.132	182.501	1	750	.000	
3	.763 <sup>c</sup>	.582	.580	7.57064	.124	221.465	1	749	.000	
4	.792 <sup>d</sup>	.627	.625	7.15701	.045	90.078	1	748	.000	
5	.829 <sup>e</sup>	.687	.685	6.56424	.060	142.191	1	747	.000	
6	.840 <sup>f</sup>	.705	.703	6.37020	.019	47.201	1	746	.000	1.578

a. Predictors: (Constant), Casual disposal

b. Predictors: (Constant), Casual disposal, Reuse & awareness

c. Predictors: (Constant), Casual disposal, Reuse & awareness, Frequency to replace desktop computer

d. Predictors: (Constant), Casual disposal, Reuse & awareness, Frequency to replace desktop computer, Lifetime extension & Responsible disposal

e. Predictors: (Constant), Casual disposal, Reuse & awareness, Frequency to replace desktop computer, Lifetime extension & Responsible disposal, Stimuli oriented

f. Predictors: (Constant), Casual disposal, Reuse & awareness, Frequency to replace desktop computer, Lifetime extension & Responsible disposal, Stimuli oriented, Simply leave

g. Dependent Variable: SCIndex\_total\_score

**Table 10** Multiple regression of SCIndex total score to predictors – case of China

To draw conclusion about a population based on a sample regression analysis, the assumptions of the dependent variable, predictors and residuals must be true. Durbin-Watson test statistic value of 1.578 indicates the assumption of independent errors is not violated. The bell-shaped standardized residual histogram and the straight P-P plots along the diagonal in Appendix 29 means the residuals are normally distributed. The dispersed scatter plot of the standardized residual against standardized predicted value testifies the validity of the linearity and homoscedasticity assumption. Altogether, the

assumptions are well met; therefore, this multiple regression model is verified. With the data in ‘coefficients’ table, the model of SCIndex total score with the predictors (variables and factors) for the case of China could be described as below:

$$\text{SCIndex } TS = 59.506 - 4.717Cd + 4.845Ra - 3.382Fd + 2.913Ld - 2.733Sp - 1.824Sl$$

**Dependent Variable**      *TS*:    SCIndex Total Score (the case of China)

**Predictors**

*Cd*:    Casual disposal

*Ra*:    Reuse and awareness

*Fd*:    Frequency to replace desktop computer

*Ld*:    Lifetime extension and responsible disposal

*Sp*:    Stimuli oriented purchase

*Sl*:    Simply leave after using computer

This multiple regression model will provide the empirical basis for the stakeholders to make effort for sustainable consumption. The direct interpretation of the predictive model is, to efficiently increase SCIndex total score, what are the “dos” and “don’ts”, what are the particular weaknesses to strengthen and the gaps to close. Similar as the Greendex which is reviewed in section 4.5, the score and profile of the first year serves as a basis for the following years in comparison and improvement, through the annually tracking survey. Taking the result in 2009 as a reference, to improve, not merely the SCIndex total score among the peers, but the overall sustainability in household ICT appliances consumption for the long run, there are several sufficient solutions based on the predictive model.

- ♦ First of all, the challenging task is about disposal, that is, to shift the disposal manner from ‘casual’ to ‘responsible’ and to raise the ‘reuse & awareness’ of consumers, who are not isolated from the market and society. Legislative support and sustainable business model are the necessity to cultivate the consumer’s responsible disposal behavior and awareness. In China, current policy of “old-for-new” household appliances effectively boosts the domestic consumption

in the ongoing economic crisis; the used products are therefore timely salvaged through formal channel, some of which are still ‘young’ and reusable. However, the destination and treatment of the collected products, and the potential ‘throw-away’ lifestyle are indeed cause of concerns, in the current planet with limited resources and capacity. The three predictors closely relates with the leading and supportive role of government in disposal practice and legislation.

- ◆ Regarding the other two predictors – ‘frequency to replace desktop computer’ and ‘stimuli oriented purchase’ – with negative coefficients, business strategy and media assistance are the essential players. Consumers have the dual identity in the interaction with other stakeholders, to be a driver or to be driven; nevertheless, in most cases, especially the fast developing economic pattern, consumers passively orient their choice to be ‘better-off’ that embedded in the social value. Sustainable consumption cannot be achieved only with the efficient products but without the sufficient demand and lifestyle (echoing the literature review in Chapter 3 and 4).
- ◆ For the last predictor – ‘simply leave after using computer’, consumers play the crucial part; moreover, the role of NGOs and media are crucial with their positive and dynamic influence in raising consumer awareness, encouraging electricity saving behavior in daily practice, and promoting the sustainable consumption lifestyle (in purchase, usage and disposal, reuse, etc.). However, learning from the ‘I will if you will’ mindset, the support of government enables and catalyzes their vitality, largely contributing to the progress of sustainable consumption.

In one word, to increase the household ICT appliances consumption’s sustainability, which is proposed to be measured with SCIndex, all the stakeholders should base on their own responsibilities and roles, actively engaged to go ahead for a long run. For any country, which has the adequate and valid sample (at least as the case of China in this pilot application) in the formal SCIndex survey in the future, could adopt the likewise analysis method to deal with the data, in view of the above proved feasibility.

#### 6.1.4 Acceptance of the assumed second-hand laptop computer

In the pilot application, 36.6% of all the respondents “have ever used any second-hand household electronic appliance”; 58.5% have never used (the others did not answer it). Out of the consumers who have ever used, 62.8% “saving money by buying second-hand appliances”; and 51.6% “prefer the second-hand one, because don’t know how long will stay at current residence” (e.g., to have the used and bulky desktop computer). The by-product of the SCIndex pilot project is the case study of the acceptance to a pre-defined laptop, to briefly understand the consumer acceptance in the downstream of the second-hand market. It is assumed there is a “less than two years old but still functional notebook computer that meets the quality standard and has a 1/2 year guarantee with 1/3 price of the new one”. This assumption, which has almost the least age and the lowest price, is the ideal case generated from the computer reuse desk study<sup>412</sup> and the BFL-IT Index monthly newsletters<sup>413</sup>. According to the European Communities Consumer Goods Guarantees Directive (1999/44/EC), the guarantee of second-hand products may not be less than one year<sup>414</sup>; beyond European countries, some countries or districts do not have such a concrete directive on the second-hand goods’ guarantee. Therefore, to take an average and a simple assumption, the given notebook computer in this cross-national survey has a 1/2 year guarantee. Out of the 1120 respondents, 17.2% are willing to buy it; 23.5% will probably buy it, but have concerns; 38.5% will not, due to concerns. To crosstabulate the respondents’ willingness to buy the laptop with personal attributes (e.g., gender, profession, education, age, salary, ownership of residence and country), the consumers’ acceptance in details is intuitively illustrated (Appendix 30), which sketches the profile of the potential downstream market of the laptop computer reuse. For example, more than half (54.3%) of the surveyed scientific researchers will buy it; so will the 46.2% company employee and 42.6% educational worker, though some of them still have concerns. Respondents that are more willing to buy the assumed laptop are featured with education level of graduate (53.1%); 25-35 years old (45.9%); at the salary level

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<sup>412</sup> Scheidt, L.-G. & Dempsey, M., 2007

<sup>413</sup> BFL-IT Index, 2009/2010

<sup>414</sup> Directive 1999/44/EC, 1999, “*Directive on the sale of consumer goods and associated guarantees*”



of 20,000-30,000 (62%); in the rented residence (50.5%); and in the two-people-household (48.9%).

Pearson's chi-square test could be used to identify whether there is a relationship between the above pairs of two categorical variables. If the value of  $\chi^2$  is significant, indicating that the effect of the column variable on the row variable is not by chance<sup>415</sup>. Running the "Willingness and Education" chi-square test (after removing the category with expected count less than 5), the value of  $\chi^2$  and the sig. level of Cramer's V (.000) indicate that the association of these two categorical variables is significantly strong. This denotes "the willingness to buy the assumed laptop" significantly associated with the education level, eliminating the respondents of 'primary or less' and those don't need any computer (Appendix 31). Likewise, for the chi-square test of "Age and Willingness", the effect of age on 'willingness to buy' is significant ( $\chi^2$  sig. 2-tailed .006); and the association between the two variables is strong (sig. level of Cramer's V .006). Salary level has effect on the willingness to buy not by chance ( $\chi^2$  sig. 2-tailed .018) and they are significantly associated (Cramer's V sig. level is .018). Without removing any categories, chi-square tests for 'Ownership and Willingness' and 'Number of people and Willingness' indicate these two attributes of respondents have effect on the willingness to buy ( $\chi^2$  sig. 2-tailed .001 and .000 for each) and these two pairs have strong association (Cramer's V sig. level .001 and .000, respectively).

To build up the predictive model for dependent variable – the respondents' willingness to buy the assumed laptop, which is a categorical variable of more than two categories, multinomial logistic regression is applied<sup>416</sup>. Based on the above chi-square analysis, several correlated variables are suitable to enter the model, like, 'have ever used any second-hand household electronic appliances'; together with, one variable of profile – salary, number of people at residence, age, residence type, etc. After running the multinomial logistic regression, the goodness-of-fit chi-square' significance values of four models are larger than .05; so that the null hypothesis that model fits the observed

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<sup>415</sup> Norusis, M.J., 2008a; Field, A., 2005; Aron, A., Aron, E.N. & Coups, E.J., 2008

<sup>416</sup> Bohrnstedt, G.W. & Knoke, D., 1994; Field, A., 2005; Norusis, M.J., 2008b

data could be accepted. However, for all of the four tentative models, the values of Cox and Snell  $R^2$ , Nagelkerke's  $R^2$  and McFadden's  $R^2$  are relatively small, indicating the less fit of the model with observed and predicted values.

For example, the first model (Model I) with two predictors –‘have ever used’ and ‘number of people’ – is tested to adequately fit the data (Pearson  $\chi^2$  .179, Deviance  $\chi^2$  .166). The Nagelkerke's  $R^2$  is .141; and significant chi-square value of the likelihood ratio test rejects null hypothesis that all the parameter coefficients are 0. Details of the multinomial logistic regression models of the “willingness to buy the second-hand notebook computer” are enclosed in Appendix 32. The “parameter estimates” table lists the values of  $Exp(B)$ , indicating the change in odds which are resulted from a unit change in the predictor. The result is interpreted as, for the people who “have ever used the second-hand appliance” will more likely to buy it; while, most of those “will buy it, without concerns” are living in 2-3 people household, following of those in 4 people household. The classification table illustrates 79.1% of “No, I have concerns”, 43.2% of “Yes, will buy it but still have concerns”; altogether, 41.8% of overall dependent variable are correctly classified to predict the group membership with the Model I.

Besides the above Model I, there are another three models all fit the observed data: Model II-‘have ever used’ and ‘salary’, Model III-‘have ever used’ and ‘age’, Model IV-‘have ever used’ and ‘residence type’, all of them with non-significant goodness-of-fit  $\chi^2$  value to accept the null hypothesis showing that model fits. The model with the largest  $R^2$  statistic is “best” according to the definition of the measure, that is Model I and II, both of which have Nagelkerke's value .141. The finding obtained from Model II is: consumers who have used any second-hand household electronic appliances are more likely to buy it; those have yearly income 1,000-3,000 € has the highest potential to buy it, and those earn 3,000-5,000 € annually “will probably buy it, but have concerns”, which have significant  $Exp(B)$  respectively (Appendix 32).

In the globalizing household appliances' market, the price of the laptop may not vary that large in different countries, therefore, the price of the given second-hand laptop

(which has the price of 1/3 of the new one) is relatively comparable in different markets. However, the purchase power between these countries and districts distinctively depends on the individual situation. The sample of the pilot application has relatively large portion of participants from China. Therefore, the conclusion to predict the potential second-hand downstream market of the laptop which learned from the study should not be isolated from this background. That means the consumers who are most likely to buy the ‘young’ but still functional laptop are *the low-/middle-class, who are living in 2-3 people household, and have ever used the second appliances*. To ensure the precision and validity of the result, moreover, for the generalization of the conclusion to the second-hand market of the household ICT appliances in a focused country or region, it’s hence necessary to carry out the further detailed research based on this tentative study.

The consumers who are willing to buy the assumed laptop have their different agreement to the eight reasons. There is no baseline of these arguments for comparison and to explicitly define the characteristics which the consumer prefers (e.g., it’s economical), they are more similar as the ‘first impression’ when making the purchase decision. For example, out of the respondents who answered this question, 77.6% ‘partially or totally’ (same as below) agree that “it’s portable”; 85.6% consider “it’s economical”; 54.1% agree that “it’s benefit to environment”; 69% prefer it because the “certified quality”; and 61.8% agree that “it’s good for short-term use”. To analyze the result, stacked bar charts of reasons are drawn, labelled with percents for the vertical comparison and exploratory research (Appendix 33).

Since consumers’ behavior is embedded in cultural and social background; their acceptance to the second-hand goods like notebook computer is not an exception. Therefore, if the sample size permitted, it is always reasonable to figure out the relationship of responses and attributes under monocultural background. For example of the agreement to “quality certified”, among the twelve countries/districts, respondents from Hong Kong (72%), US (67%), Japan (65%) and Germany (44%), ‘totally or partially agree’ with this reason, which might indicate the profile of the

second-hand market in these countries. There are 79% of respondents from Japan totally agree that “it is benefit to the environment”; while, 74% would love to accept it as “it is benefit to the society”. Whether the data will definitely illustrate the overall acceptance of the second-hand appliances reuse in Japan, considering environmental and social benefits, should be crosschecked by the in-depth research with more representative samples.

Out of 1120 respondents, 96.3% have concerns to buy the assumed laptop, on quality (15.2%), actually functionality (10.3%), after-market service (9.0%), hardware system level (8.8%) and warranty (7.0%). For the respondents, who have ever or never used any second-hand electronic appliances, their top five major concerns are slightly different (Appendix 34). It features with more concerns on “price” for who have used (43.1%) than who never used (23.7%); and, more concerns on “actual functionality” for the experienced second-hand appliances’ consumers (59.7%) than the fresh ones (45.7%). Concern due to the “bad experience of second-hand products” for those who have ever used second-hand electronic appliances (9.8%) is twice of those who never used any (4.6%). Respondents from each country have the typical concerns on the assumed second-hand laptop, which sketches the profile and highlights the improvable aspects of the second-hand markets in the country, for example, 50% of participants from China have concerns on the “after-market service”, which is higher than others.

## **6.2 Reliability of the results and limitation analysis**

To evaluate the holistic pilot application, there are obvious limitations existing in the survey design, scoring scheme and sampling. The tentative model and methods which need to be optimized by the exploratory study make the research results and findings constrained. The improvable questions, options, and the scoring scheme determine that a certain variables may not adequately measure the real case. The reverse encoding problem from the database’s integrated scoring scheme distorts the accuracy of the original data for analysis; and largely reduces the reliability of some factors in the variables with Likert scale options. The results of this pilot application are limited, due to the uneven responses and insufficient sample sizes in some countries. Therefore, the

generalization of the results and the cross-cultural comparison are constrained.

The loose sampling of the pilot application, the mixed response of the countries and districts, and the Internet survey itself, all together determines the overall results may not precisely represent the real case. However, it is still applicable to check the reliability of the ones that run factor analysis for groups of variables, whether the scale could consistently reflect the construct, the most common measure of scale reliability is Cronbach's alpha,  $\alpha$ <sup>417</sup>. For the "disposal" behavior Question 10, the 16 variables of the four extracted factors, reliability analysis is run individually for each subscale that,  $\alpha$  of the factor "casual disposal" of six variables is .812; for "responsible disposal" is .748; that of "responsible disposal" factor is .578; and .450 for "value retention". The first three factors are reliable; the low reliability of the last two factors is mainly due to irreversible database code converting problems. In the case of China, for the Q4 factor analysis, the scale reliability of "stimuli oriented" factor is .658; whereas, for the other factors, the scaling and coding problems disable the reliability analysis. The factor analysis of the disposal behavior of household ICT appliances Q10 in China,  $\alpha$  values of the four factors "casual disposal", "reuse and awareness", "responsible disposal" and "value retention", are .837, .728, .655 and .493. The limitations of factor reliability due to the database problems are proved to exert no impact on the multiple regression model by the data analysis. In the case of China, the multiple regression model of the SCIndex total scores and six predictors has a high correlation coefficient of .840; however, it is not yet verified for all the groups.

The error bar of the SCIndex total score by ANOVA displays the confidence interval of the scores, indicating the reliability of the estimate. The respondents' data from China has the smallest confidence interval, which means the score in the pilot application is much closer to the true sample of Internet user and household ICT appliances consumers. It is followed with that Germany and US, which obviously reflects the reliability displayed with the 95% CI is positively related with the sample size. For the pilot application sample data, Kruskal-Wallis test and the *post hoc* tests are applied to

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<sup>417</sup> Field, A., 2005

compare the total and sectional scores.

The only one pilot application rather groups of study, may not prove whether the overall system could deliver consistent result repeatedly (reliability), under the internal and external factors which affecting sample generalization and influencing measured result (validity). However, the overall results, findings and contributions to knowledge obviously illustrate, the objectives of developing, applying and further optimizing an “ICT appliances specific Index” are met, providing the following optimizations.

### **6.3 Statistical optimization of the SCIndex implementation**

The on-field process of the data collection and analysis of the exploratory and descriptive pilot application is an essential preparation for the proposed formal SCIndex survey of consumer choices and behaviors of household ICT appliances in the social, economic, environmental, political and cultural context. It is suggested that the survey design, variable selection, scoring scheme, sampling and data analysis of the model should all be improved.

To analyze the data of the question “numbers of appliances that are in use and lying idle”, ANOVA is regarded as a comparable and applicable analysis method; besides, ANOVA is fairly robust when sample sizes are equal<sup>418</sup>, even if the assumption of homogeneity of variance violated. The case of China, which has the most respondents, has the smallest 95% CI; that is to say, relatively large sample ensures the result more approaching to the real case. In the other question (e.g., Q4, Q8, Q10, Q11), the case of China comprises of all the agreement levels in the stacked bar charts. Taking references of the sampling in global Greendex<sup>419</sup> tracking survey and Europe Barometer<sup>420</sup> for the comparability of the cross-cultural survey, it's suggested to have quota sampling with large and equal respondents, e.g., 1000 from each country; or at least 500 as Europe REMODECE project<sup>421</sup>. The response of the survey participants to

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<sup>418</sup> Field, A., 2005

<sup>419</sup> Greendex 2008; 2009; 2010; 2012

<sup>420</sup> Flash Eurobarometer, 2008

<sup>421</sup> De Almeida, A., Fonseca, P., Bandeirinha, R., Fernandes, T., Araújo, R. and Nunes, U., 2008

answer the “ages of the 5 appliances that are in use” reveals the misunderstanding of “in use” and “lying idle”. Therefore, in the further study, it is proposed, to focus on 5 electronic appliances (TV, mobile phone, desktop computer, notebook computer and printer), instead as broad as original 10 items in Q1; to combine the same part of Q1 and Q2 about “appliances that are being used” and its age, taking it as Q1.1; and, to ask the amount of “appliances that are lying idle” in Q1.2.

To make Q3 “the frequency of using the appliances” more accessible, avoiding the annoying calculation of the weekly average using hours, the question could be revised as “daily average using hours”; and the corresponding options are “<1, 1-2, 2-3, 3-4, 4-5, 5-6, 6-7, 7-8, >8 hour/day”; moreover, following the question provide an example, like “e.g., in average daily hours on the phone”, in order to exclude the “24 hour/day on-mode” case. In the proposed formal SCIndex survey, the use frequency pie chart profile (as Figure 10, the case of China) could be compared, with the adequate 1000 respondents’ data of each, similar as pie charts in Appendix 7. The failure of the irreversible coding of the Likert scale five degree options (Q4, Q8, Q10) leads to the suggestion of de-linking the scoring scheme from the database, to record the original data precisely and to update the total scores with the scoring scheme timely. However, for the SCIndex scoring scheme, one obvious advantage of integrating the scores with the original data is the convenient acquisition of the sectional and total scores in the database. Hereby, it is proposed to record two sets of the data when programming the database – both the original data and the integrated scores.

To obtain the precise answer of “replacement frequency” in Q3 and Q6.3, in view of the data analysis, it is suggested to revise it as “how many times did you replace it in the past two years”. The concept “replacement” should be briefly defined, whether it denotes entire changing with a new one or periodically upgrading components and accessories. When analyzing the electricity consumption behavior after using the laptop in Q8, the skewness of the respondents’ data for a certain variables is identified; hereby, the sub-questions and the option scales should be further modified. When asking about the “responses to save electricity” in Q9, for most of the countries and

districts, around 50% of respondents proclaim they enjoy their pattern of energy saving, some are even higher. Therefore, it is necessary to rectify the score of this self-evaluated question by in-depth research, maybe for example, multiplied with energy consuming factor which is proportional to national electricity consumption amount; or integrated with technical approach inspired by the Europe REMODECE project<sup>422</sup> and UK research on electrical end use pattern of household ICT appliances<sup>423</sup>.

Learning from the data analysis of Q10 disposal behavior, it is therefore proposed to have the rough screening of nationality to largely involve the native or residential consumers; which might make the sampling more complicated, yet, more information of the consumption profile and the consumers embedded context of the country will be revealed in the cross-cultural comparable study. In the first subscale reliability analysis of the Q10 factors, it is suggested to delete the variable “I’m free to dispose of my things any way I want”, so as to increase the reliability<sup>424</sup> to .814 (from .812). Rerun the factor analysis that it is shown the factors structure is not influenced. The new KMO value is .783 and the four subscales remain the same; the only change is now five variables for the first factor.

For the data collected in the pilot application which is neither normally distributed nor equally sized, the non-parametric test Kruskal-Wallis test is thus the applicable method to analyze the sectional and total scores<sup>425</sup>. If the sample data are large enough and has equal size for each group as what is proposed for the formal survey in the future (e.g., 1000 for each country<sup>426</sup>), ANOVA is the optimal method to intuitively compare means of the sectional and total SCIndex scores<sup>427</sup>. For the cases of China, the SCIndex total score is normally distributed, with significance level of K-S test .000 (<.05). It is once again proved the optimization of obtaining the large sample sizes of each group in the proposed SCIndex survey. The precondition of equal-sized sampling in the cross-cultural survey is financial permission, technical and intellectual support.

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<sup>422</sup> De Almeida, A., Fonseca, P., Bandeirinha, R., Fernandes, T., Araújo, R. and Nunes, U., 2008

<sup>423</sup> Coleman, M., 2011

<sup>424</sup> Field, A., 2005

<sup>425</sup> Field, A., 2005

<sup>426</sup> Flash Eurobarometer, 2008; Greendex 2008; 2009; 2010; 2012

<sup>427</sup> Field, A., 2005



For the acceptance of the second-hand laptop, in the chi-square test, there are two age levels (56-65 and >65) and one willingness column (“No, I don’t need any computer”) should be deleted. For further research, in order to identify the consumer acceptance of the second-hand laptop computer, it’s suggested by author based on the pilot application to specify target group to have a focused sampling among those groups who show higher willingness to buy the second-hand laptop computer. Taking the case “I’d love to buy the laptop, as it’s economical” in Q14 as an example, the stacked bar chart indicates that it’s not comparable of the acceptance to this laptop against the respondents’ annual salary level in each country, due to the same amount of money showing their various purchase power in different countries. To figure out the highest acceptance downstream consumers in the cultural, buy power and age context, it should conduct the groups of exploratory studies in parallel, taking some countries as candidates to identify the most potential ones with sufficient samples. The challenges and opportunities in the second-hand markets would be obviously revealed accordingly.

## 7. Summary of the SCIndex pilot application overall results

### 7.1 Summary of research objectives, questions and methodology

In view of current gaps in knowledge and theoretical basis, this dissertation undertakes exploratory and descriptive social research to investigate household ICT appliance consumption. Thus, the overarching aim of this exploratory study is to:

*Improve knowledge and holistic understanding of consumption patterns of household ICT appliances along the value chain in global or regional consumers' households.*

The following objectives were identified to achieve this aim:

- ◆ Develop a social research methodology for household ICT appliance consumption, with applicable variables in a concrete model to gain the holistic information on end-consumers' choices and behaviors in sample of global or regional households;
- ◆ Identify to what extent patterns of purchase, usage and end-of-life behavior contribute to the overall household ICT appliances' sustainable consumption;
- ◆ Explore the underlying factors that largely influence household ICT appliance consumption, in purchase, usage to end-of-life as a whole or in any stage;
- ◆ Understand the national profiles and situation of the improved and improvable aspects of household ICT appliances' consumption with global reference points;
- ◆ Provide recommendations with empirical basis to the engaged stakeholders to reduce the impacts from household ICT appliance consumption and to contribute to the global progress towards sustainability.

Based on literature review, targeting to the objectives, these questions were developed:

- ◆ how to qualitatively and quantitatively describe the current situation and progress of consumer behavior of consuming household ICT appliances, in various facets, e.g., globally, cross-culturally, nationally; currently, annually in years sequence;
- ◆ what variables and concrete model could be applied to gain the holistic information on consumers' behaviors of purchase, usage and end-of-life activities;
- ◆ to what extent patterns of purchase, usage and end-of-life behavior contribute to

- overall ICT appliances' consumption in a sample of global or regional households;
- ◆ globally or nationally, what are the underlying factors that largely influence the purchase, usage, end-of-life as a whole or in any stage;
  - ◆ what are the global or regional crucial and improvable aspects in household ICT appliances' consumption for the engaged stakeholders to efficiently collaborate.

Targeting to the aim and objectives, to answer the identified research questions and to close the gaps in existing knowledge, the SCIndex model of household ICT appliances' consumption is designed and carried out in multilayer:

- ◆ **Preliminary design** of the SCIndex model: structure, variables, questionnaire, database, scoring scheme, data collection and analysis methods;
- ◆ **Pilot application** of the model: exploratory and descriptive research, qualitative study with the best available time and budgets, targeting to the aim and objectives, through on-field practically run the model to check its feasibility and identify the improvable aspects; to test whether the variables are SMART; to describe the relationship of consumption (purchase, usage, end-of-life – any stage and total SCIndex) with variables and factors; have partially answered research questions, contributing to further in-depth research;
- ◆ **Global household SCIndex tracking survey** of consumers' choice and behavior of household ICT appliances: descriptive and explanatory, to quantitatively close the knowledge gaps with concrete model and data, to fully answer the research questions. This step could be carried out based on the findings and limitations of this dissertation. To verify the validity and reliability of the model, groups of further researches and applications for comparison and optimization are necessary.

## 7.2 Summary of the SCIndex pilot application results

The pilot application that adopted the rough quota sampling globally obtained 1120 valid responses; out of which, the 1069 respondents from 12 countries and districts are adopted for the cross-cultural comparison; both globally and regionally, the analysis is channels into purchase, usage and end-of-life three stages and total SCIndex. Detailed

variables' relationship analysis is carried out for the case of China which has largest response quantity, and specific case of second-hand laptop's acceptance. Aligning with the Greendex 2008-2012's grouping, India, Brazil, and China are developing countries; US, Germany, UK, Austria, Japan and Belgium are industrialized countries<sup>428</sup>. The following results are summary of pilot application data analysis, which add knowledge of the current household ICT appliances' consumption. However, due to the sampling limitation of the exploratory and descriptive study, the generalization of the results to either global or cross-cultural situation should be further crosschecked.

- **Purchase:** more than 40% of global household ICT appliances' consumers are fully or partially motivated by advertisement and promotion to purchase; 1/4 of consumers could be urged by the fast emerging new products to catch up the trends; for more than a half of consumers, after getting new products, the actual functionality is not as high as expected; almost 40% of consumers who always need to buy more are due to insufficient possessions. Top factors influence consumers' decision to buy household ICT appliances are price, brand, function, warranty, durability, after-market service, electricity consumption, and outlook. In different countries, consumers pay distinct attention to these factors, e.g., those from Hong Kong, Brazil, China, Austria and Japan care more about electricity consumption; the after-market service is more influential to those from Taiwan, Hong Kong and China. More than half of consumers replace mobile phone every two to four years and replace (desktop and notebook) computers every three years or longer. For the consumers, who replace their mobile phone faster than 'twice a year', desktop computer or laptop computer 'every two years', the major reason is 'old one is outdated'. Almost 75% of consumers have ever heard about the environmental or energy saving label; whereas, only around 40% have ever bought a labelled ICT appliance, differences even larger in some countries, obviously revealing the 'value-action gap'.
- **Usage:** at the consumers' current residence, majority has 1-2 TVs, 2-3 mobile phones, one desktop computer, and 0-1 laptop computer. Around half of

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<sup>428</sup> Greendex 2008; 2009; 2010; 2012

consumers leave computer on until next time and never set it to standby mode. About 1/4 of consumers regard saving electricity making a lot of sense to them, as the price is going up; around 1/3 are already used to their energy saving pattern in their daily life.

- **End-of-life:** More than 50% of consumers never take it to a recycling or collection centre; more than 60% never donate it to non-profit organization; around 60% have ever sold it clear up, regardless of the price; almost 50% never care about where the appliance will end up after collection; around 50% were never informed of disposal requirement of the appliances; and, more than 60% have no time to think about used appliances. According to the end-of-life behaviors and choices across the twelve countries and districts, four latent factors are extracted, ‘casual disposal’, ‘responsible disposal’, ‘lifetime extension’, and ‘value retention’. In China, consumers more frequently repair the appliance first instead of directly replacing for lifetime extension than US and German. The reuse channel of donation to NGOs is more accessible in US than in China. Most respondents from China sell it to the collector to clear up, as long as he pays regardless of the price. More respondents from Austria, Japan and UK are informed of national or local requirement of how to discard appliances.
- **General awareness:** 70% of consumers regard ‘it’s acceptable for an environmental-friendly product with a reasonable higher price’; more than 75% agree ‘uncontrolled treatment of used electronics severely threatens health and safety’; more than 50% of respondents acknowledge that consumption contributes to environmental pollution; and, more than 50% proclaim their willingness to consume less for future generations to meet their needs, under the scarcity of the resource. Compared with the consumers’ behaviors in purchase, usage and end-of-life, the ‘value-action-gap’ is again obvious.
- **SCIndex total and sectional score:** The SCIndex total scores of twelve countries and districts are calculated according to the tentative scoring scheme; furthermore, could be categorized into three groups in terms of consumers’ consumption choices and behaviors of household ICT appliances. Brazil, France, Japan and

Austria are more sustainable; China and Canada are less sustainable; Taiwan, UK, Hong Kong, Belgium, US and Germany are in the middle level. Brazil has significantly higher SCIndex total score than China. As discussed above, the further research should improve the sampling, if the budget and time permitted in the future, focusing on the target scope – global, cross-cultural or national. Therefore, the SCIndex total score of these countries and districts must be calculated accordingly so as to represent the real case, if concrete SCIndex model is set up and more representative data are collected. However, the result could be compared with the Greendex 2008-2010 results that ‘developing economies like Brazil ranks much higher than the developed countries such as US, Japan and Germany’<sup>429</sup>, the SCIndex scores of developed countries are not definitely ranks higher. One explanation could be the uneven sampling of countries; crosscheck with an equal-sized-sample pilot application (e.g., 500 samples for each country) could figure it out; the other reason is similar as Greendex result that “sustainable consumption of household ICT appliances” performs differently from economy indicator. As the SCIndex aims to measure the consumer choices and behaviors ‘going beyond GDP’, taking into full consideration of environmental and social factors. In the four sections, the twelve countries/districts rank differently, for example, consumers in Germany behave more sustainable, rational and sufficient in the purchase stage than that of US; in Austria they perform better than those of Brazil. In Germany, ICT appliances are used significantly more environmental friendly than in the US and China. In end-of-life stage, Austria consumers deal with used appliances more sustainable than those in China and Germany.

- **Reuse:** around 1/3 of consumers have ever used second-hand household electronic appliance; the major reason is to save money. Regarding the assumed laptop computer with almost the least age and the lowest price, the highest potential consumers are those in graduate educational level; 25-35 years old; low-/middle-class consumers, living in the rented residence, 2-3 members household. The top reasons to accept the laptop include ‘economical’, ‘portable’, ‘certified quality’,

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<sup>429</sup> Greendex 2008; 2009; 2010; 2012

‘good for short-term use’ and ‘benefit to environment’, which reveal both the challenges and potential opportunities of the reuse downstream market.

- **Case of China:** respondents from China have the most diversified personal profile and the sufficient sample size for the detailed analysis of variable relationships. For any country which has the similar or even larger size and variety of sample, it is applicable for adopting these data analysis methods. The SCIndex total score of China could be predicted by five factors and one variable in the multiple regression model, obviously indicating the efficient solutions for this country to contribute to household ICT appliances’ sustainable consumption. Altogether, the improvable and essential methods include – to shift the ‘casual’ disposal manner to ‘lifetime extension and responsible’ behavior; to raise the ‘reuse and awareness’; to slow down the high ‘frequency to replace desktop computer’; to cool down the emotional ‘stimuli oriented purchase’ fever; and to avoid energy consumption behavior such as ‘simply leave after using computer’.

### 7.3 Limitation analysis and the statistical reliability of the results

To evaluate the holistic pilot application, there are obvious limitations existing in the survey design, scoring scheme and sampling:

- the tentative model and methods which need to be optimized by the exploratory study make the research results and findings constrained; the improvable survey and scoring scheme lead a certain variables not to adequately measure real case;
- the reverse encoding problem from the database’s integrated scoring scheme distorts the accuracy of the original data for analysis; and largely reduces the reliability of some factors in the variables with Likert scale options; the scales of variables which are not influenced indicate high reliability; for the case of China, multiple regression model of the SCIndex total scores and six predictors has a high correlation coefficient of .840; however, it is not yet verified for all the groups;
- therefore, the generalization of the results and the cross-cultural comparison are constrained due to the uneven responses and insufficient sample sizes; the only one pilot application rather groups of study, may not prove whether overall system

could deliver consistent result repeatedly, under internal and external factors;

- Internet survey itself has disadvantages; household ICT appliances' consumers are not the same in the scope as Internet or mobile phone users in general.

However, the overall results, findings and contributions to knowledge obviously illustrate, the objectives of developing, applying and further optimizing an “ICT appliances specific Index” are met, providing the following optimizations.

#### **7.4 Overall optimizations of the SCIndex model**

By running the pilot application, the SCIndex model is comprehensively evaluated through the data and reliability analysis. Accordingly, the optimizations are given:

**Sampling:** it should be carefully designed targeting to the various domains of interest – global, cross-cultural or national. It is proposed to select the target countries or regions to collect information for at least three years, e.g., to track the progress and degradation “horizontally across countries” and “vertically over time series”.

- ✧ To obtain data for understanding **global** consumers' purchase, usage and end-of-life choices and behaviors of household ICT appliances, well designed and quantitative quota sampling in the target continents should be taken place;
- ✧ To obtain data for the further **cross-cultural** comparison, equal sized sample from each country (1000 valid respondents, or at least 500) should be collected, participants' profile quota should be considered, e.g., gender quota, age level;
- ✧ To understand **national** situation, specific underlying factors and improvable aspects, it is necessary to have quota sampling with integration of household ICT appliances end consumers' profile, according to domestic market research results, for example, adopting 1000 samples of a representative coverage of participants' profile – gender, age, income, education, and so on;

**Questions and options** of questionnaire: the accessibility of the questions and options should be improved through combination, simplification and elimination; the scoring



scheme and the database should be decoupled. Details are listed as below:

- ✧ **Combination** of Q1 and Q2, due to difficulties to distinguish “appliances being used” (Q1), its age (Q2), and those “lying idle” (Q1); there are missing values and redundancy. The solution is to combine these two questions, to regroup it into Q1.1 – asking “amounts of appliances being used and the ages”, while, Q1.2 – to select the “amounts that are lying idle and in storage”;
- ✧ **Simplification**: The two options of Q3 could be condensed as only one with more accurate and simple measurement, instead of twelve weekly frequencies, to provide five to seven durations of “using hours per day”. Likewise, Q6.3 “replacement frequency” is better to directly ask “how many times have ever replaced in three (or five) years”, to avoid the frequency calculation and ensure the accuracy of the answer. Only 3-5 timeslots for selection is enough, rather than 7 as original;
- ✧ **Elimination**: data in Q10 is applied the factor analysis; consequently, the reliability analysis suggested the last option Q10.16 to be deleted to increase the overall reliability of the scales.
- ✧ **Decoupling**: the original scoring scheme was programmed combining with database, for the convenience to get the total scores of each respondent, as long as the survey is completed. When running the data analysis, due to the decimal point precision mistakes, it led to the failure of the first data collection; furthermore, the obstacles to converse the scores into codes for the data analysis. Hence, the original data must be, first of all, accurately recorded; then, converted to the SCIndex score with the systematic scoring scheme.

## **8 Conclusions and recommendations**

### **8.1 Introduction**

ICT appliances during these years rapidly rush into household all over the world and largely benefit to economy, environment and society (Chapter 1). However, alarming problems of production and consumption go hand in hand with their contributions (Chapter 2). To achieve the economic prosperity within the environmental capacity, for the social progress in a long run, sustainable consumption of ICT appliances' life-cycle is crucial. Besides products' efficiency, sufficiency in consumption should be paid more increasing attention; as well, global measurement indicators to benchmark national progress should go beyond GDP to be more inclusive (Chapter 3). Consumers play an essential role in the value chain among all the stakeholders. Their behaviors and choices largely reveal the contexts situation which they are embedded in. Reviewing the literatures of existing research, knowledge gaps in the relevant aspects are identified (Chapter 4). Therefore, for the sustainable consumption of household ICT appliances, this exploratory and descriptive research aims at developing the SCIndex model to globally, cross-culturally and nationally measure and benchmark household ICT appliances' consumption; further optimizing the tentative model with a pilot application. The SCIndex model adopting Internet survey focuses on the consumers' behaviors and choices (Chapter 5). The data analysis results of the pilot study provide empirical information to the holistic situation of the purchase, usage and end-of-life of household ICT appliances. The variables, scores, indicators and their relationships overall obviously sketches out the improvable aspects and strengths of the countries and districts in the context of sustainable consumption. The tentative SCIndex model is optimized through pilot application (Chapter 6).

### **8.2 Summary of findings and conclusions**

Through the development and pilot application of SCIndex model, key findings in consumers' choices and behaviors of household ICT appliances could be summarized as below. The generalization of the results of the exploratory study is constrained due to

the immature model with improvable survey design, scoring scheme and sampling. Therefore, based on this trial, further in-depth studies, crosschecks and projects could be carried out. The findings and contributions to knowledge serve as an empirical basis, targeting to the overall aim and objectives by responding to the research questions.

### 8.2.1 Key findings

- at the consumers' current residence, majority has one to two TVs, two to three mobile phones, one desktop computer, and none to one laptop computer;
- regarding to the rational and sufficient purchase, the surveyed situation is: more than 40% of global household ICT appliances' consumers are motivated by advertisement and promotion to purchase; 1/4 of consumers could be urged by the fast emerging new products to catch up the trends; more than 50%, feel actual functionality of new products not as high as expected; 40% of consumers who always need to buy more – due to insufficient possessions;
- for the consumers, who replace mobile phone faster than 'twice a year', desktop or laptop computer 'every two years', the major reason is 'old one is outdated';
- 50% of consumers leave computer on until next time; never set it to standby mode; most consumers are not aware of the differences electricity consumption of status – simply leaving it on; standby; switch-off and unplug;
- higher electricity price makes about 1/4 of consumers regard saving makes a lot of sense; around 1/3 are already used to their energy saving pattern in their daily life, though 'saving pattern' practices are quite distinct between countries and regions;
- in the household ICT appliances' end-of-life, more than 50% of practices in the past five years are: never take it to a recycling or collection centre; never donate it to non-profit organization; sell it clear up, regardless of the price; never care about where the appliance will end up after collection; were never informed of disposal requirement of the appliances; and, have no time to think about used appliances;
- four latent factors of consumers' end-of-life behavior are obtained: casual disposal, responsible disposal, lifetime extension, and value retention;
- in US, reuse channel to donate appliances is more accessible; most consumers from China sell it to collector to clear up, regardless of the price;

- ‘value-action gap’ is obvious between consumers’ awareness of environmental or energy saving label and purchase of labelled ICT appliances; moreover, between environmental consciousness of general awareness to sustainable production consumption, and, actual choices and behaviors in purchase, usage and end-of-life;
- SCIndex total scores of twelve countries/districts are categorized into three groups: Brazil, France, Japan and Austria ranks in the first; Taiwan, UK, Hong Kong, Belgium, US and Germany are in the middle level; China and Canada in the last. The SCIndex scores of developed countries do not certainly rank higher;
- around 1/3 of consumers have ever used second-hand appliances; the major reason is to save money; hindrances to reuse are: quality of the products, aftermarket service, transparent price, actual functionality, honesty of the seller and warranty;
- the highest potential consumers of second-hand laptop computer are: in graduate educational level; 25-35 years old; low-/middle-class consumers, living in the rented residence, 2-3 members household; top reasons to buy include: economical, portable, certified quality, good for short-term use and benefit to environment;
- in China, critically improvable methods to make consumption of household ICT appliances more sustainable include: shift casual disposal to lifetime extension and responsible behavior; raise reuse and awareness; slow down high frequency of desktop computer replacement; cool down stimuli oriented purchase fever; avoid irresponsible electricity consumption, e.g., simply leave after using computer;

### 8.2.2 Methodology findings

- **Sampling:** targeting to the various domains of interest for comparison and evaluation, global or regional, cross-cultural or national, sufficient samples of quota size and profiles of household ICT appliances’ consumers are crucial;
- **Design and structure** of the tentative SCIndex questionnaire should be improved through: combination and simplification of questions, elimination of option; and decoupling of the database and scoring scheme. Pre-tests, pilot applications and optimizations largely contribute to the model development and improvement;
- **Data analysis methods** for the SCIndex model perform the following functions:

- ◆ **Comparison:** *ANOVA* compare means of quantity and scores, *Kruskal-Wallis tests* for non-parametric data; *pie charts* for countries' profile comparison; *stacked bar charts* to describe the Likert scale options cross-culturally
- ◆ **Extraction:** for variables with Likert scale options, *factor analysis* extracts latent factors based on the collective feature of the respondents;
- ◆ **Relationship:** *correlation analysis* checks whether two measurement variables co-vary and to quantify the strength of the relationship; *regression* expresses the relationship in the form of an equation; *Pearson's chi-square test* applied especially for two categorical variables;
- ◆ **Prediction:** *multiple regression* predict the outcome variable from a combination of variables and factors, e.g., *SCIndex* total score or score of any single stage; only for sample with sufficient size and diversified consumers' profile; *multinomial logistic regression* for categorical dependent variables of more than two categories – e.g., willingness to buy the assumed laptop;
- **SCIndex model** which is developed and optimized in multilayer, take the case of China for example, for a region or country with statistically sufficient sample, the relationships of its scores and with other factors and variables obviously reveal the strengths, weaknesses and improvable aspects, for the sustainable consumption of household ICT appliances in the region or country context.

### 8.2.3 Limitations

To evaluate the holistic pilot application, there are obvious limitations existing in the survey design, scoring scheme and sampling. The tentative model and methods need to be optimized by the exploratory study; as well, the uneven responses and insufficient sample sizes in some countries and districts. Therefore, the generalization of research results, cross-cultural comparison, and detailed analysis of variables are constrained. The single pilot application could not prove whether it could deliver consistent result repeatedly. The Internet survey itself has limitation and disadvantage; besides, the scope of household ICT appliances' consumers is not identical to Internet users.

### 8.2.4 Contribution to knowledge

A primary contribution to knowledge from this dissertation is the provision of detailed “real world” consumption measurements of household ICT appliance. This contributes to filling a current gap in the literature regarding the holistic consumption of household ICT appliances in life-cycle-thinking perspective – purchase, usage to end-of-life choices and behaviors. In addition, it has contributed to gaps in knowledge concerning underlying behavioral factors that influence sustainable consumption of household ICT appliances entirely or in any stage. Furthermore, it is proved that ‘value-action gap’ is rather obvious, in the household ICT appliances’ consumption. Despite some findings from this research already being known to scholars, the results from this dissertation add to the debate by providing empirical evidence to support modelling work and by indicating that findings of sustainable consumption and social research on consumer behavior can be applied to the household ICT appliances.

An original contribution has also been made in terms of the methodology used for this research – to develop the model of measurement and benchmarking indicator “going beyond GDP” to systematically quantify the consumers’ behavior, through a multilevel implementation. The overall consumption patterns of household ICT appliances in the developed countries are not necessarily sustainable than developing countries, if overview all the stages of consumption along the trip-bottom line. Once again, the exploratory research in this dissertation stresses the importance of setting up the concrete model to fill the gaps in knowledge, policy insufficiency and stakeholders’ responsibility. The development and implement of the SCIndex model contribute to facing the challenges and paradoxes of sustainable consumption (in section 4.3), e.g.:

- to obtain a holistic understanding of the impact on the collective households in society, not on the more vulnerable and marginalized one – *distributional concerns*
- to take environmental and social aspects into consideration, avoiding *limitations of market-based approaches* that only addressing the powerful economic instruments
- to track the progress or degradation over time series, so that the time delays of the policy instruments’ effectiveness could be taken into account – *unrealistic time*

*horizons for impact;*

- to recommend all the engaged stakeholders, in view of the structural constraints' influence and embedded behavior, not *over-emphasis on individual households' choice and on shifting household demand;*

### **8.3 Recommendation**

As discussed in section 4.4, the consumers' choices and behavior are not isolated, but actively interact with various stakeholders – government, business, civil society, media, retailer, NGOs, academia, etc. The pilot application data analysis of SCIndex model would provide empirical arguments and first-hand references of consumers' choices, behaviors and general awareness in household ICT appliances consumption, for all the involved stakeholders to understand the whole pictures and the improvable aspects, so as to have more realistic and practical action accordingly. The recommendations to the engaged stakeholders are given as below, based on the data obtained from this pilot, to efficiently promote sustainable consumption of the household ICT appliances.

#### **8.3.1 Sufficiency in purchase**

- ◆ Considering the influential effect of media to shape the consumption taste and lifestyle, media should be supported to serve as an impelling driver to foster the responsible and conscious purchase, usage and disposal choices and behaviors. Government should initiatively take the responsibility to promote and support the 'sufficient' lifestyle with the limited resources, through its 4“E” tasks top-down influencing social practices and business operation models to be sustainable.
- ◆ Regarding the environmental or energy-saving labels, producers should clearly and transparently mark the meaning of labels on the products; government and NGO could support to increase the awareness and acceptance of labelled appliances, with public propagation, campaign and financial incentive, etc.; for the end-consumers to be more aware of what the various labels stand for, how the labelled products relate to their concerned topics, for example, environmental protection, climate change, health and sanitation, energy crisis and resource shortage.

### 8.3.2 Efficient usage

- ◆ As “the ‘climbing price of electricity’ making electricity saving a lot of sense”, it is efficient in environmental protection and social development in a long run, to adopt the effective financial mechanism to internalize the external cost of electricity production and consumption.
- ◆ Scientific researchers should carry out various scenarios’ analysis of household electricity consumption of the ICT appliances, so as to provide the practical and detailed suggestion for the consumers to efficiently saving energy. The financial and legislative support from government on this issue is necessary.
- ◆ To raise the consumers’ awareness of different electricity consumption status after using ICT appliances, besides the application of the precise and accessible electric meter in the household, government may integrate these practices into public education program and energy saving campaign, adopting the assistance of media; business could briefly provide the electricity saving tips of using these household ICT appliances in the user manual or package.

### 8.3.3 Responsible disposal

- ◆ Consumers need convenience and incentives to motivate the responsible disposal. The financial stimulus (rebates and subsidies) for efficient take-back should be strong enough to enter the decision-making process to close the price gap.
- ◆ Consumers and businesses need government to set a vital example of doing the right thing, that is, to deal with the appliances properly, with the least threats to environment, health and safety, and the most benefits to resource and society.
- ◆ The local government should solve this problem through the diverting channels of regulation, facilities and financial incentives, not to block the flooding of the casually and irresponsible disposal behavior by banning or penalty.
- ◆ Government take the leading role to financially and legislatively support and supervise producers, retailers, media and consumers in the ICTs’ end-of- life treatment. The comprehensive tasks of all the engaged stakeholders include:



- ✧ establish the sound legislation system and to apply the advance technology to actively cope with the alarming amount of fast replaced ICT appliances;
- ✧ develop efficient communication with consumers and to popularize the education on responsible and environmentally sound disposal, conducted by NGO, business and media, while strongly supported by the government;
- ✧ create motivational and convenient take-back channel and financial incentive, such as, trade in, or get deposit back for return of the used household ICT appliances (e.g., 10-15 euro for mobile phone), to encourage timely take-back and responsible disposal of the used appliances; carried out by producers and retailers; supported, regulated and supervised by government;

#### **8.3.4 Smooth channels for reuse**

- ◆ Efficient economic mechanisms to internalize the social and environmental externalities of the businesses should be constructed, so that ‘value retention’ and ‘lifetime extension’ of the household ICTs within the technically optimal lifetime are enabled, instead of fast replacement and throwaway; therefore, reuse is neither to ruin the companies’ brand nor to degrade the consumers’ social statuses, but to responsibly benefit economy, society and environment in a long term.
- ◆ Social enterprises and businesses should effectively communicate with the end consumer the product values reduction over time through storage, under the cycle-economy and sustainable development regulation supported by government.
- ◆ For both the upstream and downstream consumers, the transparent and fair market value for the household ICT appliances is highly recommended (e.g., BFL-IT Index for Trade-in Value of used desktop computers, monitors and laptop in Germany, in section 3.10) for the reuse market all over the world.
- ◆ For downstream consumers, the market has more potential to be well regulated, supervised and monitored to increase the quality of the used products, after-market service and reliability; e.g., quality assurance with a specific certificate mark for tested quality, and further tracking evaluation of the consumer satisfaction.

It is challenging and rather impossible for the ‘rational’ government and business to give up the short-term economic benefits to invest for environment, resource and society in a long run. To apply the SCIndex survey model that provides empirical data from the holistic pictures assists stakeholders to make right decision for a long run before optimistically pursue economic prosperity. Altogether, government, business, media, NGO and consumer, through top-down and bottom-up effort largely contribute to the progress towards the household ICT appliances’ sustainable consumption.

### **8.3.5 Further in-depth researches and projects**

Limitations of the exploratory and descriptive pilot application of this tentative SCIndex model have been discussed in Chapter Six and Seven, including issues relating to model construction, survey design, sampling, data analysis, generalization of the results. A number of these limitations provide opportunities for future research:

- ◆ Conduct series of researches with well designed sampling and gradually optimized model, targeting to the various domains of interest, e.g., global, cross-cultural or national; crosscheck the comparability and measurability of the SCIndex model, further optimize it accordingly, to enable the model more valid and reliable.
- ◆ In view of the gaps in knowledge, projects of measuring end consumers’ choices and behaviors of purchase, usage and disposal of household ICT appliances, with the concrete and well designed model, could be carried out, with global, regional or national focus, for three-years, to track progress horizontally across countries and vertically over time series.
- ◆ In-depth studies of how to avoid the performance bias of self-evaluated social research of should be carried out. For the case of the consumption pattern of electricity consumption and end-of-life behavior, external factors, like technical method and electricity consumption, and so on, could be taken into consider.
- ◆ Further projects of to figure out potential downstream consumers and get to know their acceptance of second-hand laptop computers of any country or region could take this pilot application’s data analysis as a reference, to adopt sampling of a representative coverage of consumers’ profile.

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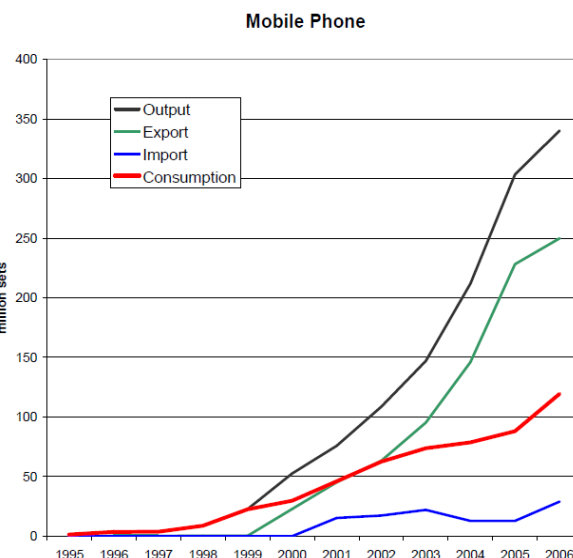
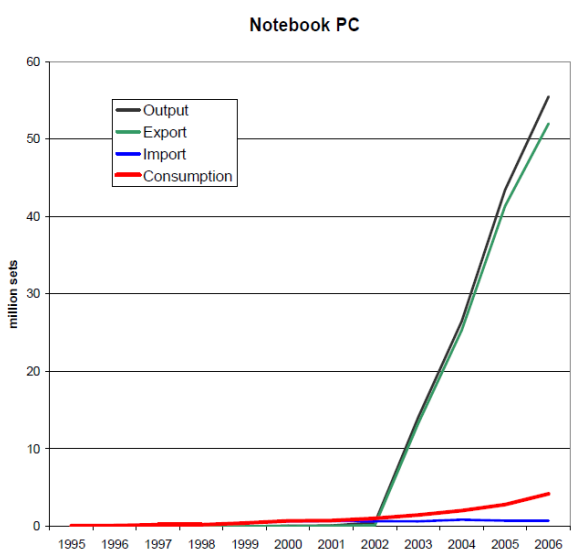
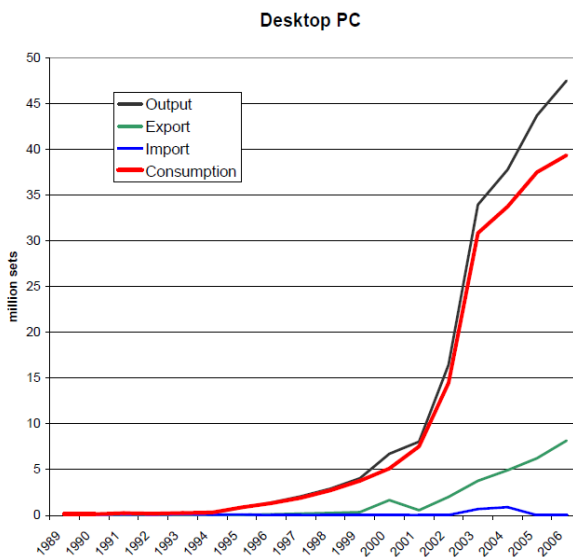
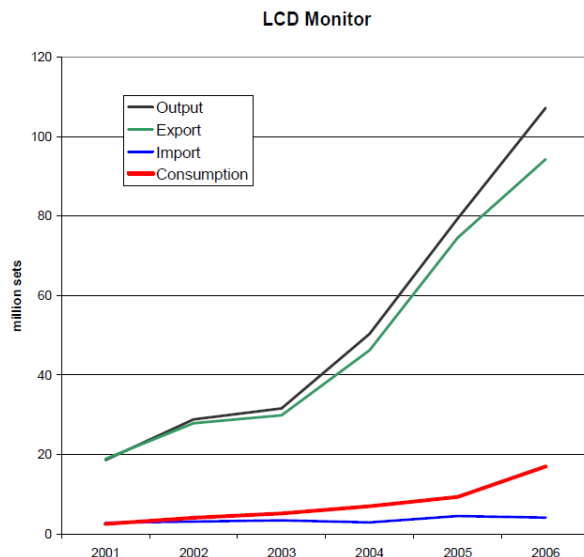
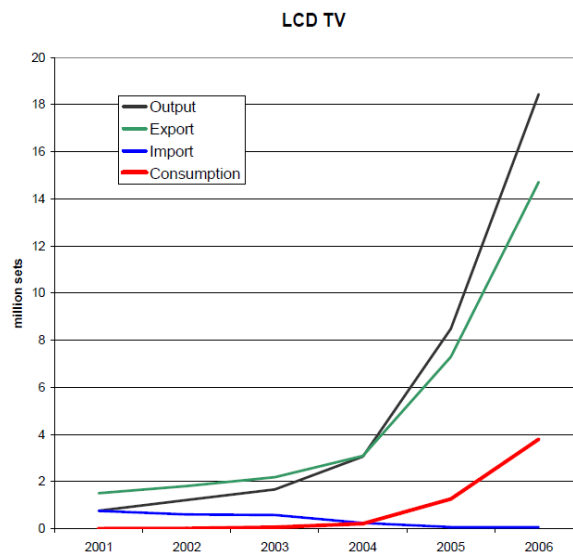
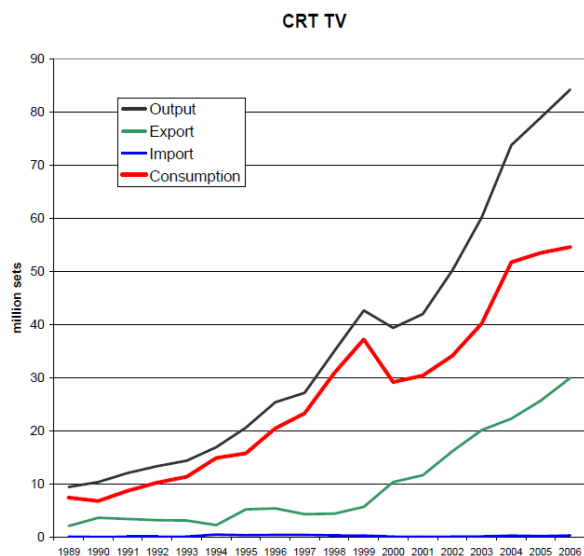
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# Appendix

## Appendix 1 Production, import, export and domestic sales data of ICTs produced in China<sup>430</sup>



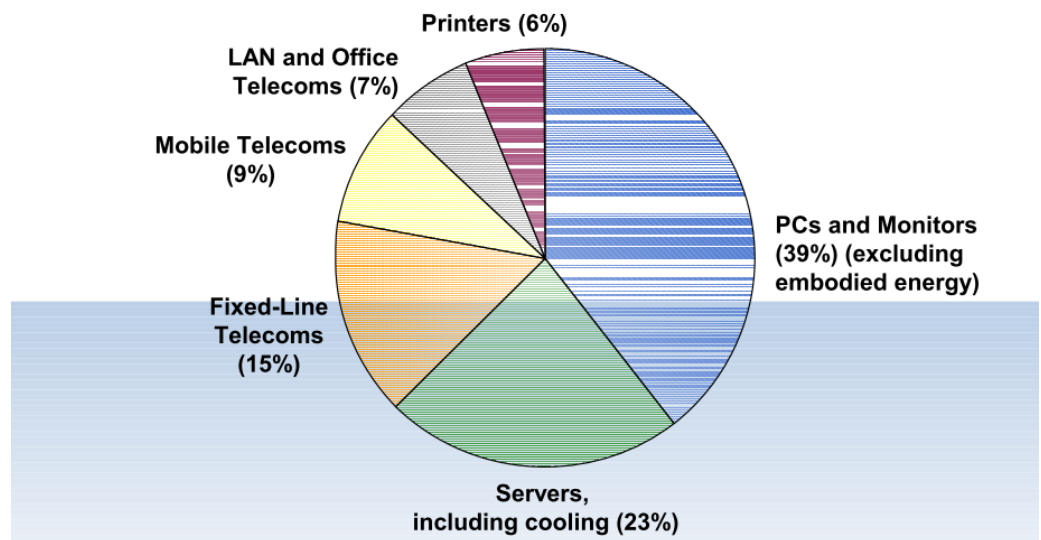
<sup>430</sup> Eugster, M., Hischier, R. & Duan, H., 2007

Appendix 2 ICT's contribution on environmental sustainability and its global CO<sub>2</sub> emission<sup>431</sup>

# The Effects of ICT on Environmental Sustainability



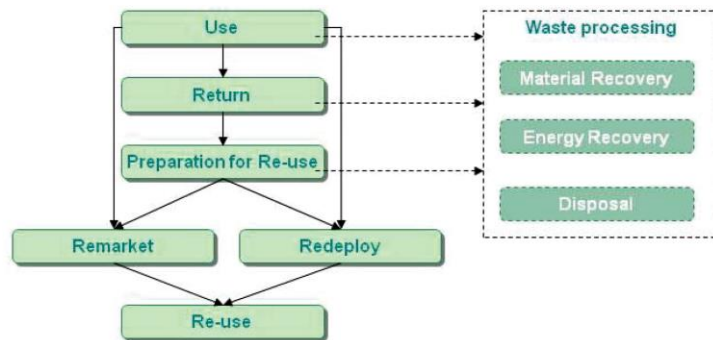
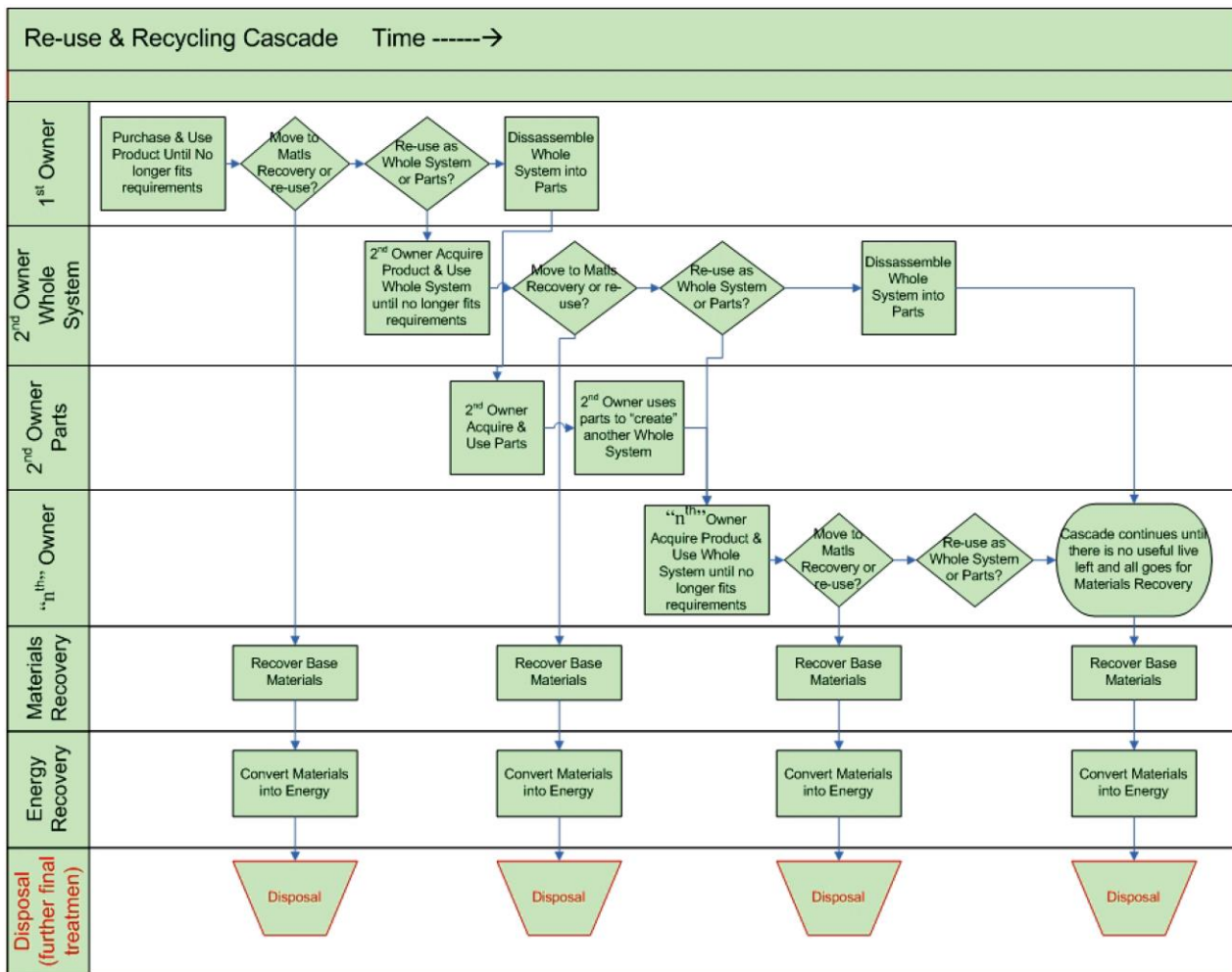
## ICT's Global Carbon Dioxide Emissions



**ICT accounts for approximately 2% of global CO<sub>2</sub> emissions.**

<sup>431</sup> Gartner Consulting, 2007

**Appendix 3** Reuse cascade; activity-oriented view on reuse terminology; and differentiation of alternative activities in preparation for reuse<sup>432</sup>



	Disassembly depth	Output specification	Degree of change in unit's composition and design
<b>Remanufacture</b>	Complete disassembly	Original functionality and reliability	May be changed significantly
<b>Refurbish</b>	Not complete, only to ensure required specification	Original functionality	Not changed significantly
<b>Repair</b>	Only to exchange or reprocess defective component	Functioning condition	Not changed significantly
<b>Upgrade</b>	Dependent on upgrade operation	Upgraded performance and /or functionality	Significantly changed

<sup>432</sup> StEP White Paper, 2009, "One Global Understanding of Re-Use – Common Definitions"

## Appendix 4 Basic summary and specifications of computer and monitor programme<sup>433</sup>

### Basic summary of computer programmes and their specifications

Programme	Country	Date	Type	Notes
Eco-label – the Flower	European Union	2005	Voluntary	PCs and notebooks – sleep 5W, Off 2W
ENERGY STAR	USA	July 2007	Voluntary	PCs - sleep 4W, Off 2W, Notebooks – sleep - 1.7W, Off 1W. Idle power depends on computer category
ENERGY STAR	EU	July 2007	Voluntary	Replica of US ENERGY STAR
TCO Label	Global	2005	Voluntary	PCs – sleep 5W, off 2W Notebooks – sleep 4W, off 2W
Nordic* Eco-labelling. The swan	The five Nordic countries	2005	Voluntary	PCs and notebooks – sleep 5W, Off 2W
Blue Angel	Germany	2006	Voluntary	PCs On (ACPI S3) 4.5W Off 2.5 – 3.5W depending upon wake up. Notebooks On (ACPI S3) 3.5W Off 2W
Group for energy efficient appliances	6 EU countries	2006	Voluntary	PC, notebook, desktop computers – Sleep 5W Off 2W Idle 70W
CECP	China	2003	Voluntary	Sleep 10W, Off 3W. Time to sleep – 30 minutes
KEMCO	Korea	2003	Voluntary	Default sleep time and maximum power <sup>14</sup>
KEMCO	Korea	2005-7	Voluntary	Energy Boy label if <1W sleep. External power supplies 0.5 – 0.75W
KEMCO	Korea	2009	Mandatory	External power supplies – Energy Star tier 1
		2010	Mandatory	1 W warning or compliance label
Executive Order 13221/ FEMP	USA	2001	Recommended for Federal purchases	Standby/off only. Desktop ≤ 2W, Integrated computer ≤ 3W, Notebook ≤ 1W, Workstation ≤ 2W
Energy Policy Act 2005	USA	Sept. 2005		Requires federal agencies to buy either ENERGY STAR products or products designated as energy efficient by the Federal Energy Management Program (FEMP).
Executive Order 13423/ FEMP	USA	2007		Requires federal agencies to activate ENERGY STAR “sleep” features on computers and monitors and mandates that federal agencies buy EPEAT registered (ENERGY STAR) products.
Top Runner	Japan	2007		The Top Runner program aims to raise energy performance of future products above that of the most energy efficient product in the current market. 2007 targets have been set for a range of computer classifications and performance is measured by the average of standby and idle power per million calculations. Compliance is measured weighted average efficiency of shipments in each classification. That is a manufacturer can supply compliant and non compliant products as long as the weighted average meets the target for the classification. Top Runner also includes specifications for hard disk drives.

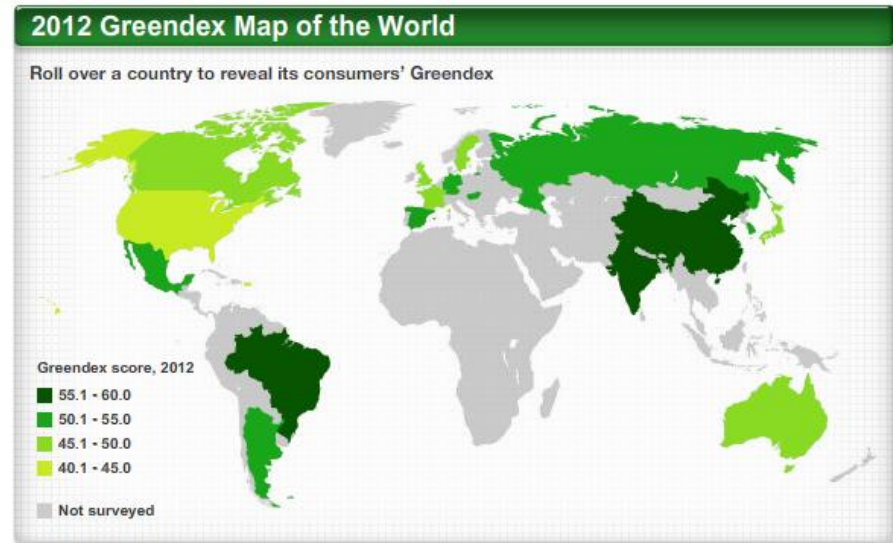
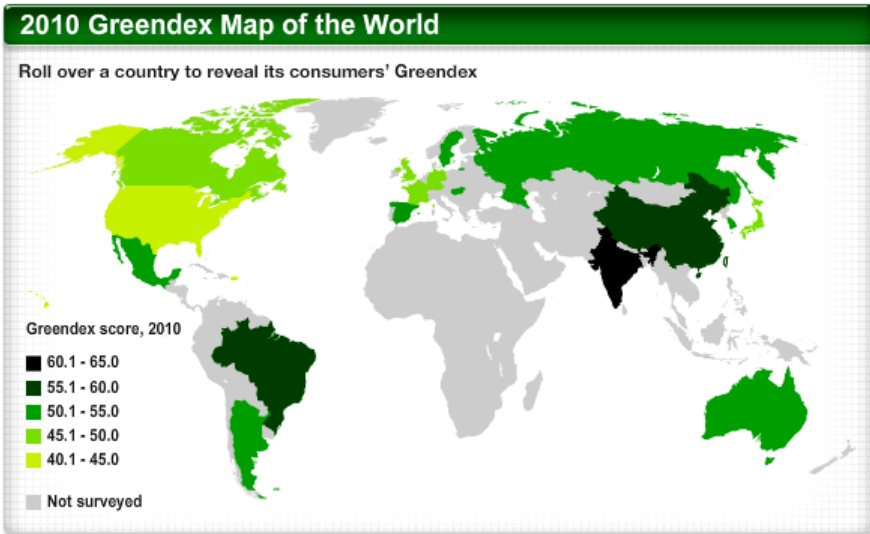
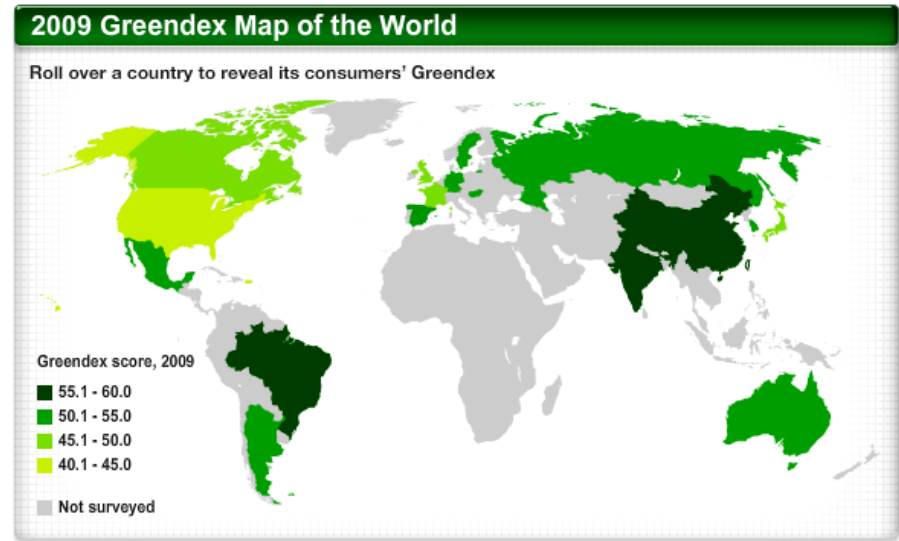
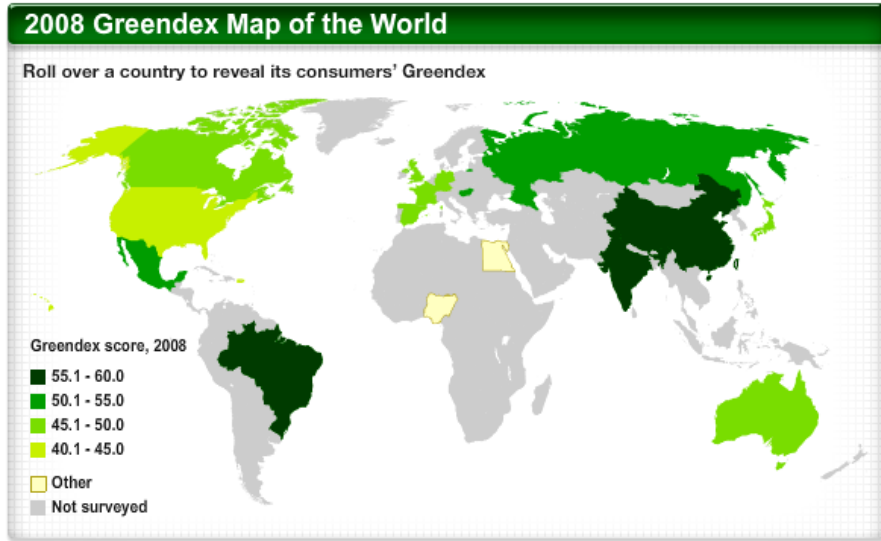
Note: \*Nordic countries include Sweden, Norway, Denmark, Finland and Iceland

### Basic summary of computer monitor programmes and their specifications


Programme	Country	Date	Type	Off	Sleep	Active
ENERGY STAR	USA	2006	Voluntary (Tier 2)	1W	2W	If Megapixels (MP) less than 1, then 23W
ENERGY STAR	EU	July 2007	Voluntary	2W	4W	
TCO Label	Global	2006	Voluntary	1W	2W	If MP greater than 1, then 28 x MP
Eco label the Flower	EU	2005	Voluntary	1W	2W	
Blue Angel	Germany	2006	Voluntary	1W	2W	
Group for energy efficient appliances	6 EU countries	2006	Voluntary	1W	2W or 2.3W with USB	
CECP	China	2003	Voluntary	2W	4W	NA
KEMCO	Korea	2004	Voluntary	2W	4W	NA
Executive Order 13221/ FEMP	USA	2001	Recommended for Federal purchases	1W	NA	NA
Energy Policy Act 2005	USA	2005				Requires federal agencies to buy either ENERGY STAR products or products designated as energy efficient by the Federal Energy Management Program (FEMP).
Executive Order 13423/ FEMP	USA	2007				Requires federal agencies to activate ENERGY STAR “sleep” features on computers and monitors and mandates that federal agencies buy EPEAT registered (ENERGY STAR) products.

<sup>433</sup> E3 Team, 2007

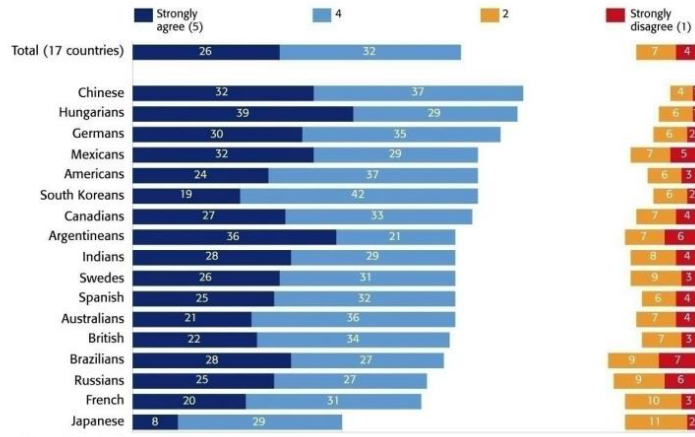
**Appendix 5** Greendex map of the world and the overall rankings 2008-2012



## I Prefer to Repair Something When It Is Broken Rather than Replace It



Percentage of Consumers in Each Country, 2012

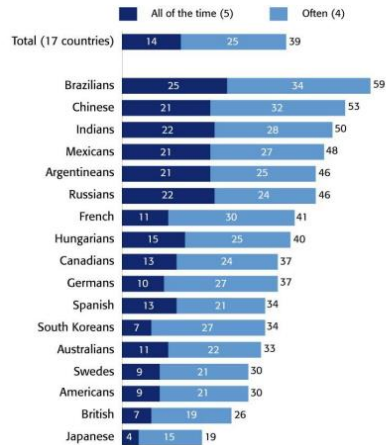


NCS12\_17Bc\_Env\_Repair

## Frequency of Buying Environmentally Friendly Products



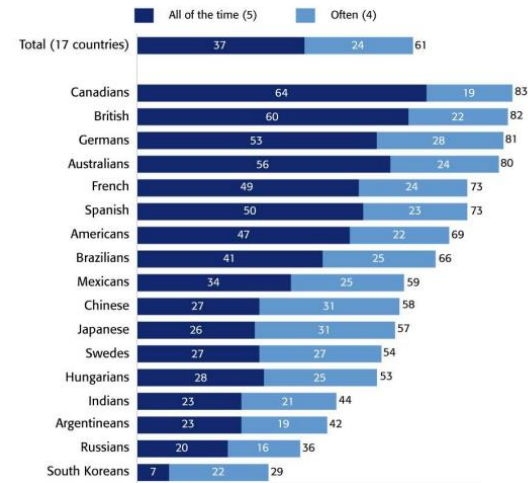
“All of the Time (5)” or “Often (4),” Percentage of Consumers in Each Country, 2012



## Frequency of Recycling Materials



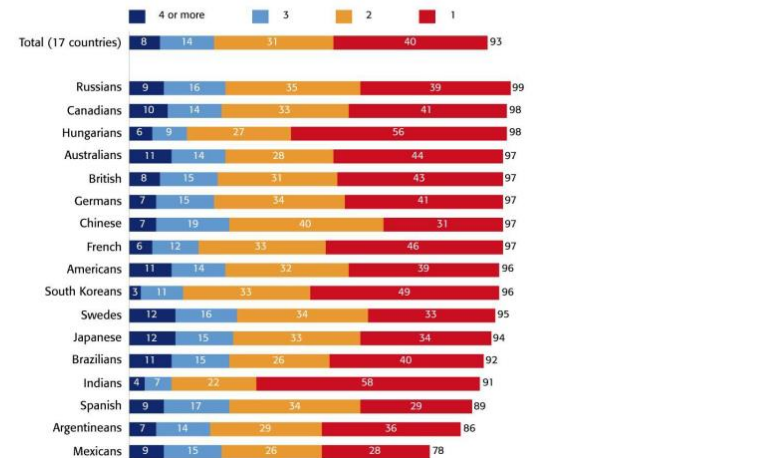
“All of the Time (5)” or “Often (4),” Percentage of Consumers in Each Country



## Average Number of Computers Owned, Rented, or Leased by Household Members



Percentage of Consumers in Each Country, 2012





## Appendix 6 SCIndex survey online questionnaire and webpage design



Index für Verbraucher-Nachhaltigkeit  
Haushaltsgeräte der Informations- und Kommunikationstechnologie (ICT)  
Alle Angaben werden anonym behandelt



Deutsch

Sustainable Consumer Index of Household  
Information and Communication Technology (ICT) Appliances  
Anonymous Survey



English

Índice de Consumo Sostenible para Electrodomésticos  
de Tecnología para la Información y Comunicación (ICT)  
Encuesta Anónima



Español

Indice de consommation durable  
d' appareils ménagers d' information et communication  
Sondage anonyme



Français

Índice do Consumidor Sustentável por residência  
Aparelhos de Tecnologia da Informação e Comunicação (TIC)  
Pesquisa anônima



Português

“家用信息与通信技术电器产品”——可持续消费者指数  
匿名问卷调查



中文





Dear Sir/Madam,

These years household Information and Communication Technology (ICT) appliances (like TV, computer, mobile phone, etc.) are becoming important components in our daily life, study, work, leisure and entertainment. This survey is to understand the general consumption pattern of household ICT appliances, and how it may contribute to three dimensional developments of economy, society and environment. It takes no more than 15 minutes to complete this questionnaire. Your help on this survey is highly appreciated.

Please fill in your answer in the corresponding blank space; or select your choices from the given options.

If you are ready, here we go!

**Q1. First, please state the total number of the following household electronic appliances at your current residence, including those that are being used and lying idle.**

Items	TV	Radio/ Stereo	VCD/ DVD player	mp3/ mp4	Digital camera	Phone		Computer		Printer
						Fixed	Mobile	Desktop	Laptop	
Amount	<input type="radio"/> 0	<input type="radio"/> 0	<input type="radio"/> 0	<input type="radio"/> 0	<input type="radio"/> 0	<input type="radio"/> 0	<input type="radio"/> 0	<input type="radio"/> 0	<input type="radio"/> 0	<input type="radio"/> 0
	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1
	<input type="radio"/> 2	<input type="radio"/> 2	<input type="radio"/> 2	<input type="radio"/> 2	<input type="radio"/> 2	<input type="radio"/> 2	<input type="radio"/> 2	<input type="radio"/> 2	<input type="radio"/> 2	<input type="radio"/> 2
	<input type="radio"/> 3	<input type="radio"/> 3	<input type="radio"/> 3	<input type="radio"/> 3	<input type="radio"/> 3	<input type="radio"/> 3	<input type="radio"/> 3	<input type="radio"/> 3	<input type="radio"/> 3	<input type="radio"/> 3
	<input type="radio"/> 4	<input type="radio"/> 4	<input type="radio"/> 4	<input type="radio"/> 4	<input type="radio"/> 4	<input type="radio"/> 4	<input type="radio"/> 4	<input type="radio"/> 4	<input type="radio"/> 4	<input type="radio"/> 4
	<input type="radio"/> >4	<input type="radio"/> >4	<input type="radio"/> >4	<input type="radio"/> >4	<input type="radio"/> >4	<input type="radio"/> >4	<input type="radio"/> >4	<input type="radio"/> >4	<input type="radio"/> >4	<input type="radio"/> >4

**Q2. Please select the approximate ages of your current household electronic appliances below that are in use( if you have more than one of any appliance at your current residence, it's applicable to select more answers).**

Items	Television	Mobile phone	Desktop computer	Notebook computer	Printer
Amount	<input type="radio"/> 0 <input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4	<input type="radio"/> 0 <input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4	<input type="radio"/> 0 <input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4	<input type="radio"/> 0 <input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4	<input type="radio"/> 0 <input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4
Ages	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years
1	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years
2	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years
3	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years
4	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years	<input type="radio"/> <1 year <input type="radio"/> 1-2 years <input type="radio"/> 3-5 years <input type="radio"/> 6-10 years <input type="radio"/> >10 years

To ensure the validity of the questionnaire, please try to fill it out completely. Thank you!

There are still 14 questions to answer, go to



**Q3. Please select how often you personally use the appliances below at your current residence (If you do not have the appliance, simply leave it blank; if you have more than one, it's applicable to select more answers). For the appliance category, please fill out the total using hours per week.**

Items \ Frequency	Television	Mobile phone	Desktop computer	Notebook computer	Printer
Everyday	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4-6 times / week	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2-3 times / week	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Once / week	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Total hours / week	<input type="checkbox"/> 0-5 <input type="checkbox"/> 5-10 <input type="checkbox"/> 10-15 <input type="checkbox"/> 15-20 <input type="checkbox"/> 20-25 <input type="checkbox"/> 25-30 <input type="checkbox"/> 30-35 <input type="checkbox"/> 35-40 <input type="checkbox"/> > 40	<input type="checkbox"/> 0-5 <input type="checkbox"/> 5-10 <input type="checkbox"/> 10-15 <input type="checkbox"/> 15-20 <input type="checkbox"/> 20-25 <input type="checkbox"/> 25-30 <input type="checkbox"/> 30-35 <input type="checkbox"/> 35-40 <input type="checkbox"/> > 40	<input type="checkbox"/> 0-5 <input type="checkbox"/> 5-10 <input type="checkbox"/> 10-15 <input type="checkbox"/> 15-20 <input type="checkbox"/> 20-25 <input type="checkbox"/> 25-30 <input type="checkbox"/> 30-35 <input type="checkbox"/> 35-40 <input type="checkbox"/> > 40	<input type="checkbox"/> 0-5 <input type="checkbox"/> 5-10 <input type="checkbox"/> 10-15 <input type="checkbox"/> 15-20 <input type="checkbox"/> 20-25 <input type="checkbox"/> 25-30 <input type="checkbox"/> 30-35 <input type="checkbox"/> 35-40 <input type="checkbox"/> > 40	<input type="checkbox"/> 0-5 <input type="checkbox"/> 5-10 <input type="checkbox"/> 10-15 <input type="checkbox"/> 15-20 <input type="checkbox"/> 20-25 <input type="checkbox"/> 25-30 <input type="checkbox"/> 30-35 <input type="checkbox"/> 35-40 <input type="checkbox"/> > 40
Every 1-6 month	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Every 7-12 month	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Less / never	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Q4. Please select the extent to which you agree with the following statements.**

My agreement:	Totally agree	Partially agree	Neutral	Partially disagree	Totally disagree
Advertisements and promotions motivate me to buy their products.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fast emerging new products urges me to purchase continuously to catch up with the trends.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The happiness and satisfaction of my life increases with gaining new products.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After getting new products, the actual usability of it is as high as I expected.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I prefer to spend my leisure time on shopping.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I always need to buy more, because my own possessions aren't sufficient.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Q5. Please select the elements that influence your decision to buy household appliances (You can select more than one).**

<input type="checkbox"/> Price	<input type="checkbox"/> Symbol of my status/reputation
<input type="checkbox"/> Brand	<input type="checkbox"/> New technology content
<input type="checkbox"/> Life span/durability	<input type="checkbox"/> Environmental certificate (e.g., ISO14001)
<input type="checkbox"/> Function	<input type="checkbox"/> Quality certificate (e.g., ISO9001)
<input type="checkbox"/> After-market service	<input type="checkbox"/> Environmental-friendly materials
<input type="checkbox"/> Reliability/Guarantee	<input type="checkbox"/> Electricity consumption
<input type="checkbox"/> Promotional advertisement	<input type="checkbox"/> Upgradability
<input type="checkbox"/> Performance/Outlook	<input type="checkbox"/> Packaging
<input type="checkbox"/> Maintenance	<input type="checkbox"/> Producers' social/environmental consciousness

**Q6.1. Within the past five years, for your private usage, have you bought at least one of these appliances: mobile phone, desktop computer or laptop computer?** Please select your answer:

Yes, I have bought at least one, within past five years.

No, I haven't. *(If you select this one, go directly to Q7)*

**Q6.2. Select your reasons for buying a new mobile phone or computer for your private usage** (You may select more than one)

<input type="checkbox"/>	I never had one	<input type="checkbox"/>	New function is cool
<input type="checkbox"/>	The old one is outdated	<input type="checkbox"/>	It's a symbol of social status
<input type="checkbox"/>	The old one is too noisy	<input type="checkbox"/>	Gift to friends or relatives
<input type="checkbox"/>	The old one consumes too much electricity	<input type="checkbox"/>	Better leisure and entertainment
<input type="checkbox"/>	Battery of the old appliance is aging	<input type="checkbox"/>	The new one is environmental friendly product
<input type="checkbox"/>	The old one is broken	<input type="checkbox"/>	I'm urged by promotion activities, like trade-in
<input type="checkbox"/>	It's affordable to replace	<input type="checkbox"/>	For the convenient e-learning or e-shopping
<input type="checkbox"/>	Quality is much better	<input type="checkbox"/>	Timely and efficient to communicate and contact
<input type="checkbox"/>	Modern image	<input type="checkbox"/>	It largely benefit my life, work and study

**Q6.3. In the past five years, how often have you replaced your mobile phone and computers on average?**

Frequency \ Items	> Twice a year	Twice a year	Once a year	Every 2 years	Every 3 years	Every 4 years	Every 5 years	Longer
Mobile phone	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Desktop computer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Laptop computer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Q7.1 Have you ever heard about environmental or energy saving label?**

Yes, I have.

I don't know.

No. *(If no, please directly go to Q8)*

**Q7.2 Have you ever bought a TV, mobile phone, computer, or printer with an environmental or energy saving label?**

Yes.

No.

I don't know.

**Your behavior:**

I prefer to buy products with environmental or energy label.

I usually do not check for environmental labels, but some products just have them.

I would like to try labeled products, but in my country I cannot find any labels.

**Q8. When you finish using your computer (including desktop or notebook computer), what state do you set it?**

After using the computer	Always      Usually      Sometimes      Seldom      Never				
	→				
Leave it on until next time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Set to stand-by mode	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Leave it in automatic stand-by	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Immediately shut it down	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Unplug it, after turning off	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Q9. What are your responses to saving electricity when using household electronic appliances? (You can select more than one)**

- I don't like to be under the pressure of saving, the more comfortable and convenient, the better
- As long as it's affordable, I use as much as I want. Saving electricity is beyond my daily behavior
- I don't care about how much electricity my household appliances consume
- The price of electricity is going up, so saving makes a lot of sense to me
- I would like to save electricity, but I don't know how to make it efficient
- I'm already used to saving electricity in my daily life and I enjoy this pattern

**Q10. During the past five years, how did you deal with your outdated or damaged TV, mobile phone, computer and printer?**

	Always      Usually      Sometimes      Seldom      Never				
	→				
If it broke down, I prefer to repair it first, rather than to immediately replace	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For the mobile phone or laptop computer, I replace battery to extend the life time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I prefer to reuse the still functional components	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I donate it to non-profit organization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I discard it with the garbage	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I throw it on the road side	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I take it to a recycling or collection center	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I prefer to simply store it, rather to invest time and energy to bring it to collection center	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I store it until I have more pieces to bring them to collection center together	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I resell it on-line or at a second-hand store	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
As long as the collector pays, regardless of the price, I sell it to him to clear up	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I give it to relatives or friends	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am well informed of national/local requirement of how to discard appliances	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I care about where the appliance will end up after collection	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have no time to think much about used appliances	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am free to dispose of my things any way I want	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Q11: Please indicate the extent of your agreement on following statements:**

	Totally agree	Partially agree	Neutral	Partially disagree	Totally disagree
If an environmental-friendly product has a reasonable higher price, it is acceptable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Uncontrolled treatment of used electronics threatens our safety and health severely	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Production of household appliances adds heavy burdens to the environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Consumption contributes to environmental pollution	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I'm willing to consume less for the future generations to meet their needs, under the scarcity of resource	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Q12. Have you ever used any second-hand household electronic appliance?**

- Yes
- No (if select this one, please directly to Q13)

	Always	Usually	Sometimes	Seldom	Never
<b>Your behavior:</b>					
I have fun collecting second-hand household electronic appliances	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I don't know how long I'll stay at current residence, so I prefer the second-hand one	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I'm saving money by buying second hand appliances	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Q13.1. Assuming that there is a less than 2 years old but still functional notebook computer that meets the quality standard and has a 1/2 year guarantee with 1/3 price of the new one, will you buy it?**

- Yes, I will.
- Yes, I'll probably buy it. But still have concerns.
- No, I have concerns. (If select this one, directly go to Q14)
- No, I don't need any computer. (If select this one, directly go to Q14)
- No, I don't need any laptop. (If select this one, directly go to Q14)

**Q13.2. Your reasons for buying this laptop:**

	Totally agree	Partially agree	Neutral	Partially disagree	Totally disagree
<b>I'd love to buy this laptop, because it is:</b>					
Portable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Economical	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Good for short-term use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Good as a back-up	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality certified	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
As a gift for my friends or relatives	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Benefit to the environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Benefit to the society	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



**Q14. What are your major concerns about buying the second-hand laptop? (You can choose more than one)**

<input type="checkbox"/>	Quality	<input type="checkbox"/>	Actual functionality
<input type="checkbox"/>	After-market service	<input type="checkbox"/>	Local informal second hand market
<input type="checkbox"/>	Warranty	<input type="checkbox"/>	Electricity consumption
<input type="checkbox"/>	Life span	<input type="checkbox"/>	My reputation/social status
<input type="checkbox"/>	Hardware system level	<input type="checkbox"/>	Hardware replacement or upgradability
<input type="checkbox"/>	Outward appearance	<input type="checkbox"/>	Unpleasant words of “second hand” , “used”
<input type="checkbox"/>	Software compatibility	<input type="checkbox"/>	Honesty of the seller
<input type="checkbox"/>	Refurbishment grade	<input type="checkbox"/>	Bad experience of second-hand products
<input type="checkbox"/>	Price	<input type="checkbox"/>	Uncomfortable feeling about the unknown pre-owner

**Q15. What are topics that you are currently most concerned with? (Please only select 1-3 answers)**

<input type="checkbox"/>	Economic problems	<input type="checkbox"/>	Career
<input type="checkbox"/>	Political problems	<input type="checkbox"/>	Health and sanitation
<input type="checkbox"/>	Environmental pollution	<input type="checkbox"/>	Energy crisis
<input type="checkbox"/>	Unemployment	<input type="checkbox"/>	Resource shortage
<input type="checkbox"/>	Social stability and safety	<input type="checkbox"/>	Food safety
<input type="checkbox"/>	Human rights	<input type="checkbox"/>	Climate change
<input type="checkbox"/>	Family or neighborhood problems	<input type="checkbox"/>	Sports and leisure





### Q16. Personal Data (Anonymous)

Country of residence	<input type="text"/>
Nationality	<input type="text"/>
Profession	<input type="text"/> <ul style="list-style-type: none"> <li>Student</li> <li>Educational work</li> <li>Scientific researcher</li> <li>Medical affairs staff</li> <li>Government official</li> <li>Company employee / "white-collar employee"</li> <li>Factory worker / "blue-collar worker"</li> <li>Service sector (restaurant, supermarket, etc.)</li> <li>Finance and insurance business</li> <li>Farmer</li> <li>Others</li> </ul>
Education level	<input type="text"/> <ul style="list-style-type: none"> <li>Primary or less</li> <li>School (middle or high)</li> <li>Undergraduate</li> <li>Graduate</li> <li>Higher</li> </ul>
Gender	<input type="radio"/> Male <input type="radio"/> Female
Age group	<input type="text"/> <ul style="list-style-type: none"> <li>&lt;=18</li> <li>18-24</li> <li>25-35</li> <li>36-45</li> <li>46-55</li> <li>56-65</li> <li>&gt;65</li> </ul>
Annual income level (in €)	<input type="text"/> <ul style="list-style-type: none"> <li>&lt;=1000</li> <li>1000-3000</li> <li>3000-5000</li> <li>5000-10000</li> <li>10000-15000</li> <li>15000-20000</li> <li>20000-30000</li> <li>30000-50000</li> <li>&gt;50000</li> </ul>
Current residence type	<input type="radio"/> House <input type="radio"/> Apartment <input type="radio"/> Dormitory <input type="radio"/> Others
Ownership	<input type="radio"/> Renting <input type="radio"/> Owning <input type="radio"/> Others
No. of people at your residence	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> >5

Please click  to complete the questionnaire

Thanks a lot for your cooperation! You've completed all the questions!

If you are interested in the final statistic result, please directly contact with:

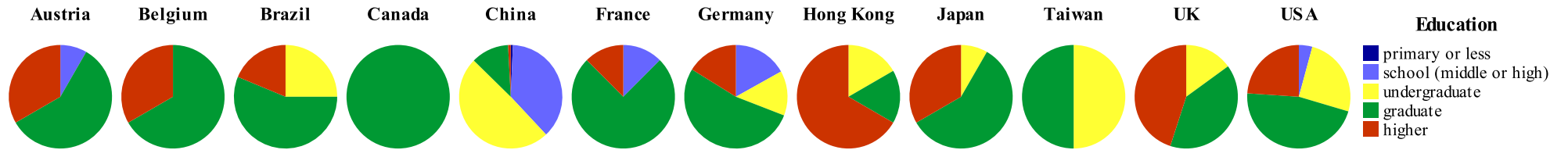
[SCIndex09@gmail.com](mailto:SCIndex09@gmail.com)



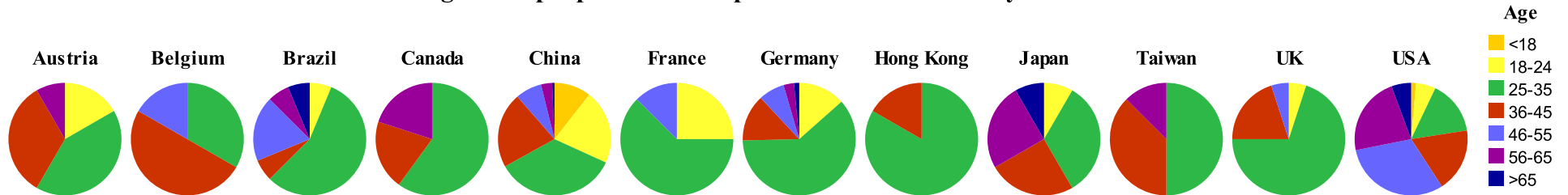


Appendix 7 Profiles of the respondents from 12 countries/districts

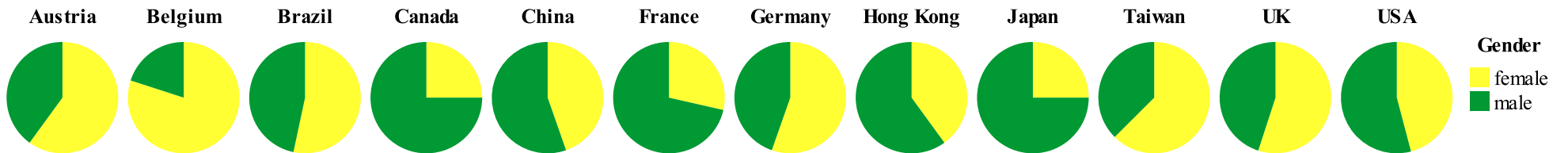
**Educational level proportion of respondents in each country/district**



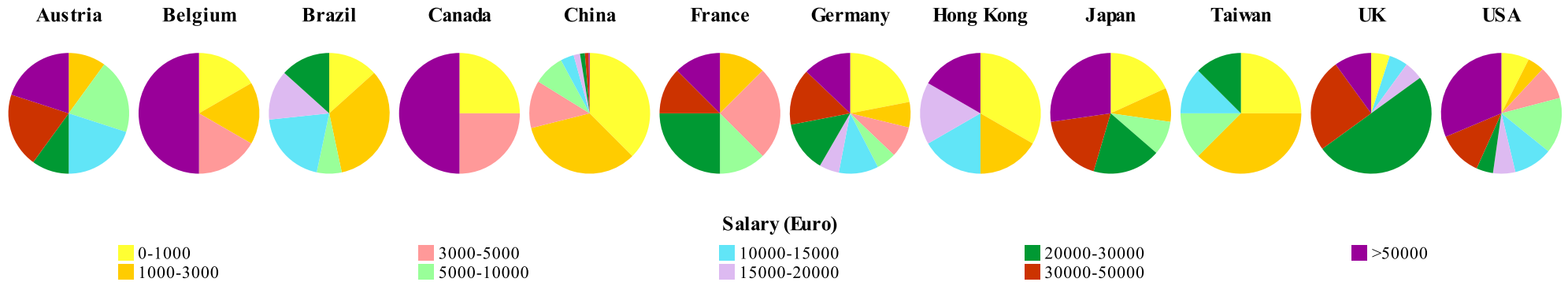
**Age level proportion of respondents in each country/district**



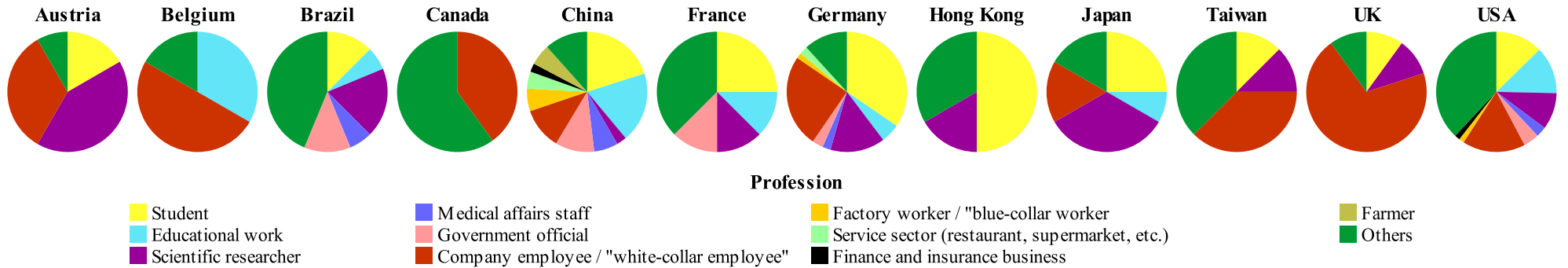
**Gender proportion of respondents in each country/district**



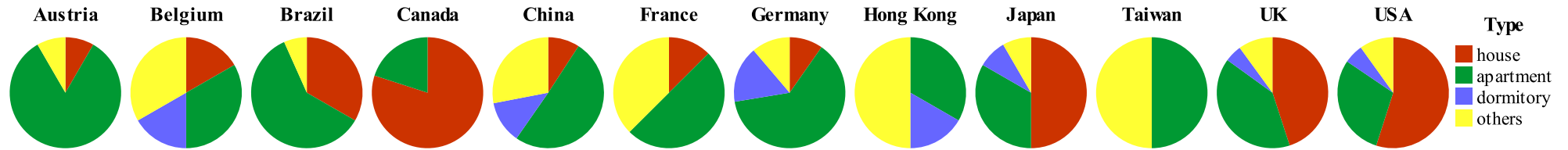
### Annual salary proportion of respondents in each country/district



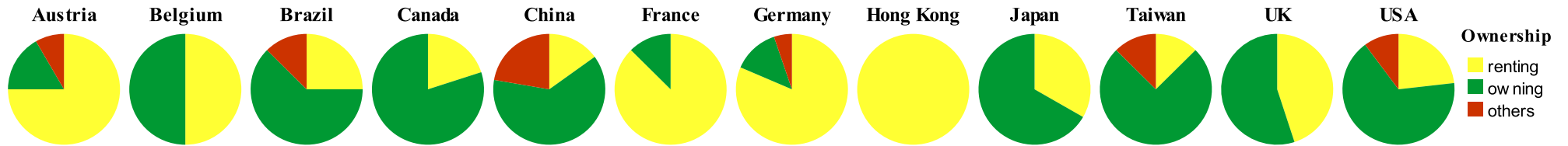
### Profession proportion of respondents in each country/district



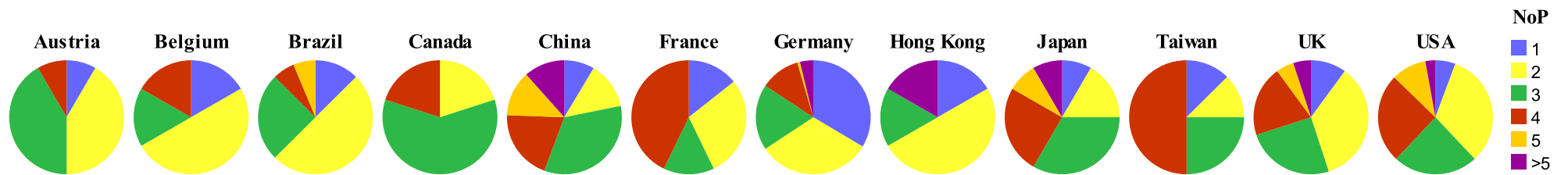
### Residence type of respondents in each country/district



### Respondents' ownership of current living place in each country/district



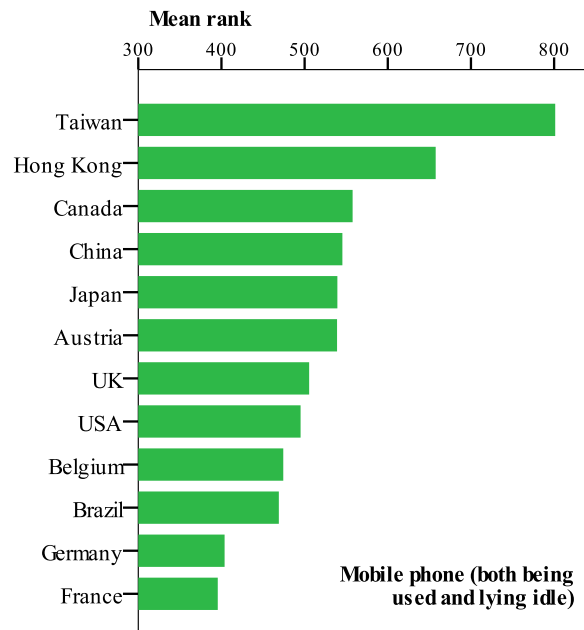
### Number of people at the residence of respondents in each country/district



**Appendix 8 Rank of the amounts at current residence - Kruskal-Wallis Test**

**Kruskal-Wallis Test - Ranks**

	Country/District	N	Mean Rank
Mobile phone (both being used and lying idle)	Austria	13	539.00
	Belgium	6	474.33
	Brazil	17	469.00
	Canada	5	557.70
	China	734	545.41
	France	8	395.56
	Germany	138	403.78
	Hong Kong	6	657.58
	Japan	13	539.38
	Taiwan	8	801.31
	UK	20	505.45
	USA	75	495.15
	Total	1043	



**Test Statistics<sup>b,c</sup>**

	Mobile phone (both being used and lying idle)	Desktop computer (both being used and lying idle)
Chi-Square	38.661	60.494
df	11	11
Asymp. Sig.	.000	.000
Monte Carlo Sig. Sig.	.000 <sup>a</sup>	.000 <sup>a</sup>
99% Confidence Interval Lower Bound	.000	.000
Upper Bound	.000	.000

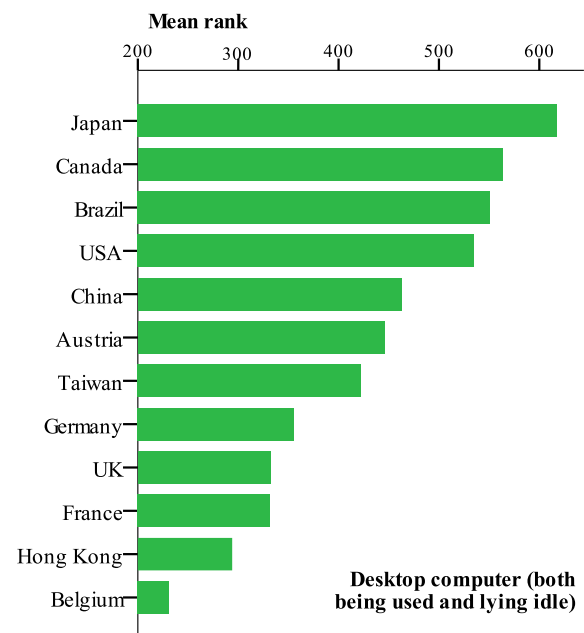
a. Based on 10000 sampled tables with starting seed 303130861.

b. Kruskal Wallis Test

c. Grouping Variable: Country/District

**Kruskal-Wallis Test -Ranks**

	Country/District	N	Mean Rank
Desktop computer (both being used and lying idle)	Austria	12	445.67
	Belgium	6	231.00
	Brazil	16	550.88
	Canada	5	563.00
	China	612	462.80
	France	5	331.80
	Germany	129	355.52
	Hong Kong	6	294.00
	Japan	13	617.62
	Taiwan	7	422.43
	UK	18	332.11
	USA	72	534.83
	Total	901	



### Appendix 9 Ages of mobile phones, computers and printers of respondents

**Ages of mobile phones that are in use - respondents' country/district crosstabulation**

		Ages of mobile phones in use <sup>a</sup>										Total
		<1 year		1-2 years		3-5 years		6-10 years		>10 years		
		Count	% within Country District	Count	% within Country District	Count	% within Country District	Count	% within Country District	Count	% within Country District	
Country/ District	Austria	4	13.3%	16	53.3%	7	23.3%	2	6.7%	1	3.3%	30
	Belgium	3	25.0%	4	33.3%	5	41.7%	0	.0%	0	.0%	12
	Brazil	13	44.8%	10	34.5%	6	20.7%	0	.0%	0	.0%	29
	Canada	5	38.5%	5	38.5%	1	7.7%	2	15.4%	0	.0%	13
	China	232	18.4%	537	42.7%	410	32.6%	69	5.5%	11	.9%	1259
	France	1	9.1%	8	72.7%	2	18.2%	0	.0%	0	.0%	11
	Germany	37	16.4%	78	34.5%	95	42.0%	15	6.6%	1	.4%	226
	Hong Kong	4	26.7%	4	26.7%	6	40.0%	1	6.7%	0	.0%	15
	Japan	3	10.3%	15	51.7%	9	31.0%	1	3.4%	1	3.4%	29
	Taiwan	4	14.3%	8	28.6%	14	50.0%	2	7.1%	0	.0%	28
	UK	12	30.0%	17	42.5%	9	22.5%	2	5.0%	0	.0%	40
	USA	18	12.7%	73	51.4%	41	28.9%	8	5.6%	2	1.4%	142
Total		336		775		605		102		16		1834

Percentages and totals are based on responses.

a. Group

**Ages of desktop computers that are in use - respondents' country/district crosstabulation**

		Ages of desktop computers in use <sup>a</sup>										Total
		<1 year		1-2 years		3-5 years		6-10 years		>10 years		
		Count	% within Country District	Count	% within Country District	Count	% within Country District	Count	% within Country District	Count	% within Country District	
Country/ District	Austria	1	7.7%	2	15.4%	5	38.5%	5	38.5%	0	.0%	13
	Belgium	2	40.0%	0	.0%	2	40.0%	1	20.0%	0	.0%	5
	Brazil	2	15.4%	5	38.5%	1	7.7%	5	38.5%	0	.0%	13
	Canada	1	14.3%	1	14.3%	4	57.1%	1	14.3%	0	.0%	7
	China	40	9.2%	115	26.4%	203	46.7%	63	14.5%	14	3.2%	435
	France	1	33.3%	2	66.7%	0	.0%	0	.0%	0	.0%	3
	Germany	11	11.3%	19	19.6%	52	53.6%	13	13.4%	2	2.1%	97
	Hong Kong	0	.0%	2	66.7%	1	33.3%	0	.0%	0	.0%	3
	Japan	0	.0%	4	23.5%	9	52.9%	1	5.9%	3	17.6%	17
	Taiwan	1	16.7%	1	16.7%	3	50.0%	1	16.7%	0	.0%	6
	UK	0	.0%	1	10.0%	5	50.0%	4	40.0%	0	.0%	10
	USA	7	8.9%	17	21.5%	36	45.6%	16	20.3%	3	3.8%	79
Total		66		169		321		110		22		688

Percentages and totals are based on responses.

a. Group

**Ages of notebook computers that are in use - respondents' country/district crosstabulation**

		Ages of notebook computers in use <sup>a</sup>										Total
		<1 year		1-2 years		3-5 years		6-10 years		>10 years		
		Count	% within Country District	Count	% within Country District	Count	% within Country District	Count	% within Country District	Count	% within Country District	
Country/ District	Austria	3	17.6%	5	29.4%	8	47.1%	1	5.9%	0	.0%	17
	Belgium	4	33.3%	1	8.3%	5	41.7%	2	16.7%	0	.0%	12
	Brazil	4	26.7%	7	46.7%	4	26.7%	0	.0%	0	.0%	15
	Canada	3	33.3%	2	22.2%	4	44.4%	0	.0%	0	.0%	9
	China	33	16.5%	66	33.0%	82	41.0%	14	7.0%	5	2.5%	200
	France	4	44.4%	2	22.2%	3	33.3%	0	.0%	0	.0%	9
	Germany	20	13.8%	44	30.3%	65	44.8%	15	10.3%	1	.7%	145
	Hong Kong	0	.0%	5	50.0%	3	30.0%	2	20.0%	0	.0%	10
	Japan	2	9.1%	7	31.8%	8	36.4%	5	22.7%	0	.0%	22
	Taiwan	3	17.6%	5	29.4%	7	41.2%	2	11.8%	0	.0%	17
	UK	5	19.2%	11	42.3%	9	34.6%	1	3.8%	0	.0%	26
	USA	16	16.0%	39	39.0%	37	37.0%	6	6.0%	2	2.0%	100
Total		97		194		235		48		8		582

Percentages and totals are based on responses.

a. Group

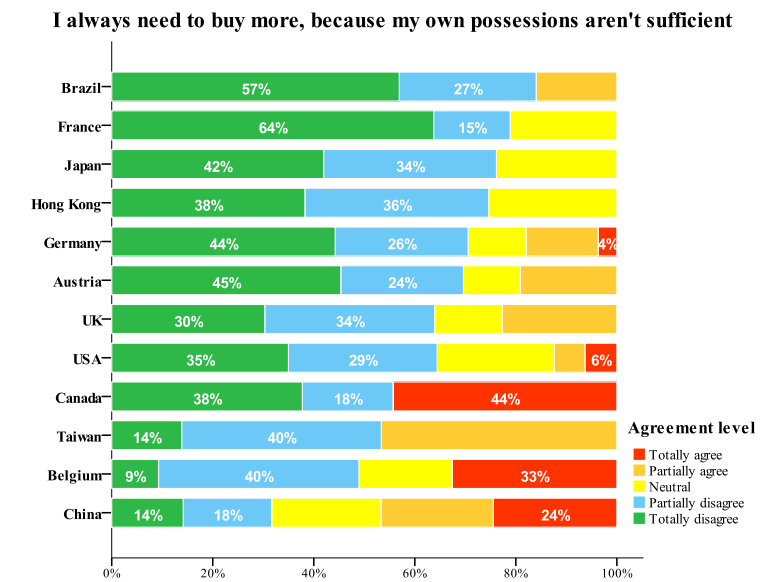
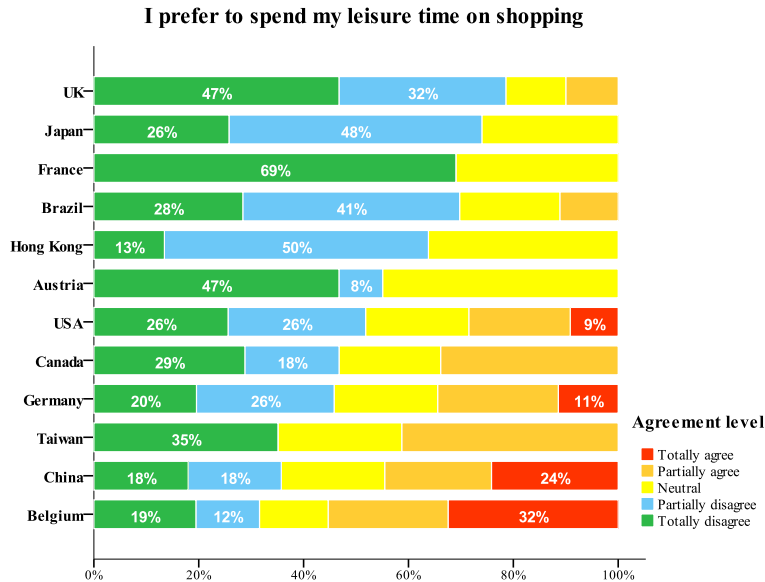
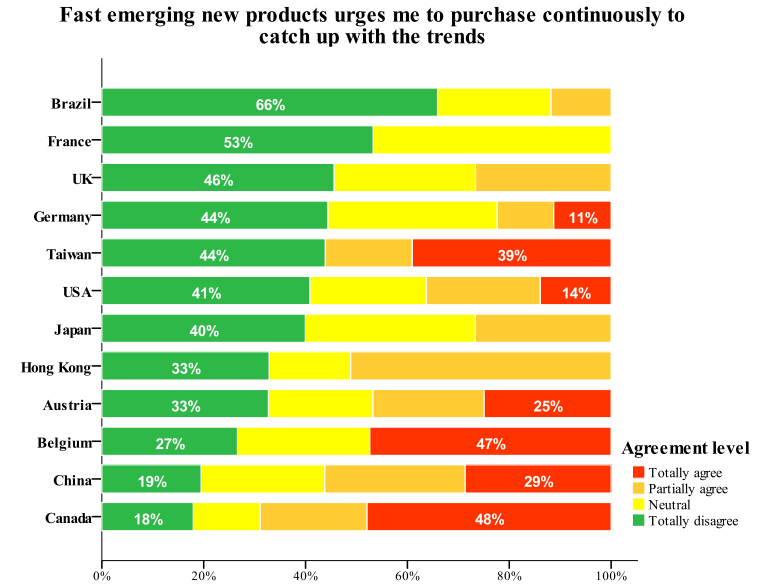
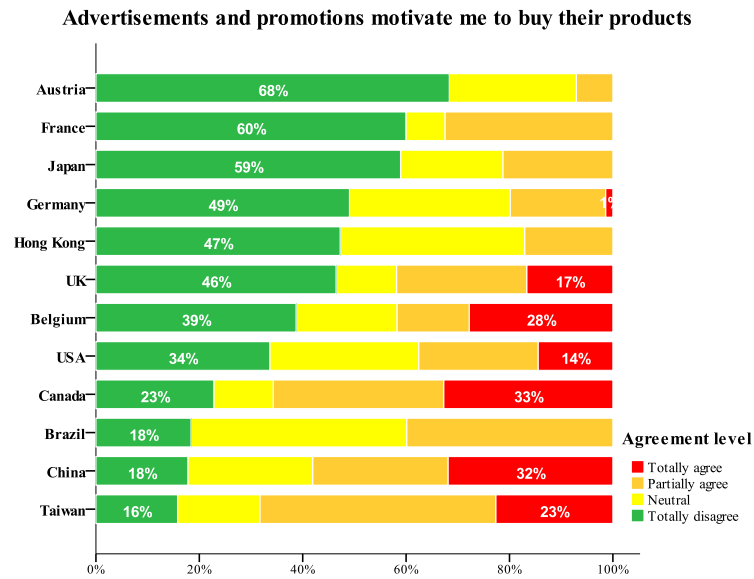
**Ages of printers that are in use - respondent' country/district crosstabulation**

		Ages of printers in use <sup>a</sup>										Total
		<1 year		1-2 years		3-5 years		6-10 years		>10 years		
		Count	% within Country District	Count	% within Country District	Count	% within Country District	Count	% within Country District	Count	% within Country District	
Country /District	Austria	0	.0%	4	28.6%	6	42.9%	2	14.3%	2	14.3%	14
	Belgium	0	.0%	2	33.3%	3	50.0%	1	16.7%	0	.0%	6
	Brazil	1	7.7%	4	30.8%	6	46.2%	2	15.4%	0	.0%	13
	Canada	0	.0%	5	71.4%	1	14.3%	1	14.3%	0	.0%	7
	China	12	9.4%	31	24.4%	62	48.8%	16	12.6%	6	4.7%	127
	France	0	.0%	2	28.6%	5	71.4%	0	.0%	0	.0%	7
	Germany	14	12.6%	29	26.1%	53	47.7%	13	11.7%	2	1.8%	111
	Hong Kong	0	.0%	3	100.0%	0	.0%	0	.0%	0	.0%	3
	Japan	2	11.1%	2	11.1%	7	38.9%	6	33.3%	1	5.6%	18
	Taiwan	0	.0%	0	.0%	5	62.5%	3	37.5%	0	.0%	8
	UK	2	14.3%	3	21.4%	4	28.6%	5	35.7%	0	.0%	14
	USA	9	11.1%	19	23.5%	38	46.9%	13	16.0%	2	2.5%	81
Total		40		104		190		62		13		409

Percentages and totals are based on responses.

a. Group

**Appendix 10** Agreement on purchase – 12 countries/districts



**Appendix 11** Influential factors for consumers to buy household appliances in 12 countries/districts

Country/district\*Elements that influence purchase decision Crosstabulation

			Country/district											
			Austria	Belgium	Brazil	Canada	China	France	Germany	Hong Kong	Japan	Taiwan	UK	USA
Elements influence purchase decision <sup>a</sup>	Price	Count	11	5	15	4	623	7	134	6	13	7	20	74
		% within CountryDistrict	84.6%	83.3%	88.2%	80.0%	82.7%	87.5%	95.7%	100.0%	100.0%	87.5%	100.0%	93.7%
	Brand	Count	6	4	13	4	563	4	96	6	7	7	12	58
		% within CountryDistrict	46.2%	66.7%	76.5%	80.0%	74.8%	50.0%	68.6%	100.0%	53.8%	87.5%	60.0%	73.4%
	Life span/durability	Count	10	4	13	4	476	7	90	3	6	4	13	57
		% within CountryDistrict	76.9%	66.7%	76.5%	80.0%	63.2%	87.5%	64.3%	50.0%	46.2%	50.0%	65.0%	72.2%
	Function	Count	12	4	12	5	490	6	116	5	9	8	15	64
		% within CountryDistrict	92.3%	66.7%	70.6%	100.0%	65.1%	75.0%	82.9%	83.3%	69.2%	100.0%	75.0%	81.0%
	After-market service	Count	6	2	3	1	548	3	52	5	3	7	6	28
		% within CountryDistrict	46.2%	33.3%	17.6%	20.0%	72.8%	37.5%	37.1%	83.3%	23.1%	87.5%	30.0%	35.4%
	Reliability/ guarantee	Count	8	4	5	4	488	6	92	5	6	5	12	53
		% within CountryDistrict	61.5%	66.7%	29.4%	80.0%	64.8%	75.0%	65.7%	83.3%	46.2%	62.5%	60.0%	67.1%
	Promotional advertisement	Count	0	0	2	2	79	0	9	0	0	5	2	15
		% within CountryDistrict	.0%	.0%	11.8%	40.0%	10.5%	.0%	6.4%	.0%	.0%	62.5%	10.0%	19.0%
	Performance/ outlook	Count	7	2	2	4	346	2	81	2	6	5	11	36
		% within CountryDistrict	53.8%	33.3%	11.8%	80.0%	45.9%	25.0%	57.9%	33.3%	46.2%	62.5%	55.0%	45.6%
	Maintenance	Count	2	1	3	2	214	1	33	2	4	3	7	37
		% within CountryDistrict	15.4%	16.7%	17.6%	40.0%	28.4%	12.5%	23.6%	33.3%	30.8%	37.5%	35.0%	46.8%
	Symbol of my status/ reputation	Count	3	0	0	1	76	1	8	0	0	2	3	0
		% within CountryDistrict	23.1%	.0%	.0%	20.0%	10.1%	12.5%	5.7%	.0%	.0%	25.0%	15.0%	.0%
	New technology content	Count	7	1	4	3	297	2	34	3	7	3	8	22
		% within CountryDistrict	53.8%	16.7%	23.5%	60.0%	39.4%	25.0%	24.3%	50.0%	53.8%	37.5%	40.0%	27.8%
	Environmental certificate	Count	3	1	6	1	244	4	26	1	1	0	6	10
		% within CountryDistrict	23.1%	16.7%	35.3%	20.0%	32.4%	50.0%	18.6%	16.7%	7.7%	.0%	30.0%	12.7%
	Quality certificate	Count	1	0	4	1	385	5	24	2	1	0	7	14
		% within CountryDistrict	7.7%	.0%	23.5%	20.0%	51.1%	62.5%	17.1%	33.3%	7.7%	.0%	35.0%	17.7%
	Environmental-friendly materials	Count	3	0	6	0	327	1	28	0	1	2	6	16
		% within CountryDistrict	23.1%	.0%	35.3%	.0%	43.4%	12.5%	20.0%	.0%	7.7%	25.0%	30.0%	20.3%
Electricity consumption	Count	7	1	11	1	467	4	71	5	7	2	6	26	
	% within CountryDistrict	53.8%	16.7%	64.7%	20.0%	62.0%	50.0%	50.7%	83.3%	53.8%	25.0%	30.0%	32.9%	
Upgradability	Count	3	3	5	1	134	2	28	0	1	0	4	10	
	% within CountryDistrict	23.1%	50.0%	29.4%	20.0%	17.8%	25.0%	20.0%	.0%	7.7%	.0%	20.0%	12.7%	
Packaging	Count	1	0	1	0	49	1	5	0	0	1	1	6	
	% within CountryDistrict	7.7%	.0%	5.9%	.0%	6.5%	12.5%	3.6%	.0%	.0%	12.5%	5.0%	7.6%	
Producers' social/ environmental consciousness	Count	4	1	4	0	149	1	17	0	3	3	3	12	
	% within CountryDistrict	30.8%	16.7%	23.5%	.0%	19.8%	12.5%	12.1%	.0%	23.1%	37.5%	15.0%	15.2%	
Total	Count	13	6	17	5	753	8	140	6	13	8	20	79	

**Appendix 12** Differences between 'ever heard about environmental/energy saving label'**Age \* Have you ever heard about environmental or energy saving label? Crosstabulation**

% within Age

		Have you ever heard about environmental or energy saving label?			Total
		Yes, I have	No, never	I don't know	
Age	<18	74.4%	15.4%	10.3%	100.0%
	18-24	65.0%	19.8%	15.2%	100.0%
	25-35	77.2%	12.7%	10.1%	100.0%
	36-45	76.9%	11.3%	11.8%	100.0%
	46-55	69.1%	14.9%	16.0%	100.0%
	56-65	75.0%	17.3%	7.7%	100.0%
	>65	61.5%	30.8%	7.7%	100.0%
Total		73.7%	14.6%	11.8%	100.0%

**Profession \* Have you ever heard about environmental or energy saving label? Crosstabulation**

% within Profession

		Have you ever heard about environmental or energy saving label?			Total
		Yes, I have	No, never	I don't know	
Profession	Student	71.4%	19.7%	8.8%	100.0%
	Educational work	81.4%	6.6%	12.0%	100.0%
	Scientific researcher	75.7%	11.4%	12.9%	100.0%
	Medical affairs staff	67.3%	21.8%	10.9%	100.0%
	Government official	64.8%	23.1%	12.1%	100.0%
	Company employee / "white-collar employee"	83.8%	6.9%	9.4%	100.0%
	Factory worker / "blue-collar worker"	65.3%	8.2%	26.5%	100.0%
	Service sector (restaurant, supermarket, etc.)	62.9%	14.3%	22.9%	100.0%
	Finance and insurance business	88.9%		11.1%	100.0%
	Farmer	69.0%	26.2%	4.8%	100.0%
	Others	67.7%	18.0%	14.3%	100.0%
Total		73.4%	14.6%	12.0%	100.0%

**Education \* Have you ever heard about environmental or energy saving label? Crosstabulation**

% within Education

		Have you ever heard about environmental or energy saving label?			Total
		Yes, I have	No, never	I don't know	
Education	primary or less school (middle or high)	66.7%	16.7%	16.7%	100.0%
	undergraduate	76.4%	11.7%	11.9%	100.0%
	graduate	79.2%	12.7%	8.1%	100.0%
	higher	79.8%	11.9%	8.3%	100.0%
Total		73.6%	14.5%	12.0%	100.0%



## Appendix 13 Differences between all respondents' ever bought a labelled ICT appliance

### Salary \* Have you ever bought a TV, mobile phone, computer, or printer with an environmental or energy saving label? Crosstabulation

% within Salary

		Have you ever bought a TV, mobile phone, computer, or printer with an environmental or energy saving label?			Total
		Yes	No	I don't know	
Salary	0-1000	47.3%	35.2%	17.4%	100.0%
	1000-3000	56.5%	32.1%	11.4%	100.0%
	3000-5000	56.5%	29.3%	14.1%	100.0%
	5000-10000	58.6%	25.7%	15.7%	100.0%
	10000-15000	45.2%	35.7%	19.0%	100.0%
	15000-20000	48.1%	29.6%	22.2%	100.0%
	20000-30000	32.6%	28.3%	39.1%	100.0%
	30000-50000	48.8%	31.7%	19.5%	100.0%
	>50000	39.2%	39.2%	21.6%	100.0%
Total		50.5%	32.5%	17.0%	100.0%

### Residence type \* Have you ever bought a TV, mobile phone, computer, or printer with an environmental or energy saving label? Crosstabulation

% within Restype

		Have you ever bought a TV, mobile phone, computer, or printer with an environmental or energy saving label?			Total
		Yes	No	I don't know	
Residence type	house	47.9%	29.4%	22.7%	100.0%
	apartment	51.9%	32.4%	15.7%	100.0%
	dormitory	43.8%	38.5%	17.7%	100.0%
	others	48.3%	35.4%	16.3%	100.0%
Total		49.7%	33.3%	16.9%	100.0%

### Ownership \* Have you ever bought a TV, mobile phone, computer, or printer with an environmental or energy saving label? Crosstabulation

% within Ownership

		Have you ever bought a TV, mobile phone, computer, or printer with an environmental or energy saving label?			Total
		Yes	No	I don't know	
Ownership	renting	35.5%	40.7%	23.8%	100.0%
	owning	57.4%	29.2%	13.3%	100.0%
	others	45.8%	34.6%	19.6%	100.0%
Total		49.8%	33.1%	17.1%	100.0%

### Number of people in your household \* Have you ever bought a TV, mobile phone, computer, or printer with an environmental or energy saving label? Crosstabulation

% within NoP

		Have you ever bought a TV, mobile phone, computer, or printer with an environmental or energy saving label?			Total
		Yes	No	I don't know	
Number of people in your household	1	31.6%	43.0%	25.3%	100.0%
	2	46.7%	31.0%	22.3%	100.0%
	3	56.9%	28.6%	14.5%	100.0%
	4	45.7%	38.8%	15.4%	100.0%
	5	54.5%	30.7%	14.9%	100.0%
	>5	48.4%	37.5%	14.1%	100.0%
Total		49.5%	33.3%	17.2%	100.0%

## Appendix 14 Responses to the statements on the labelled ICT appliances in 12 countries/districts

**CountryDistrict \* Have you ever heard about environmental or energy saving label?**  
Crosstabulation

% within CountryDistrict

		Have you ever heard about environmental or energy saving label?			Total
		Yes, I have	No, never	I don't know	
CountryDistrict	Austria	84.6%	15.4%		100.0%
	Belgium	83.3%	16.7%		100.0%
	Brazil	100.0%			100.0%
	Canada	80.0%	20.0%		100.0%
	China	72.2%	14.3%	13.5%	100.0%
	France	100.0%			100.0%
	Germany	69.3%	18.6%	12.1%	100.0%
	Hong Kong	66.7%	16.7%	16.7%	100.0%
	Japan	76.9%	15.4%	7.7%	100.0%
	Taiwan	62.5%	25.0%	12.5%	100.0%
	UK	85.0%	15.0%		100.0%
	USA	75.9%	11.4%	12.7%	100.0%
Total		73.2%	14.5%	12.3%	100.0%

**CountryDistrict \* Have you ever bought a TV, mobile phone, computer, or printer with an environmental or energy saving label?** Crosstabulation

% within CountryDistrict

		Have you ever bought a TV, mobile phone, computer, or printer with an environmental or energy saving label?			Total
		Yes	No	I don't know	
CountryDistrict	Austria	27.3%	36.4%	36.4%	100.0%
	Belgium	80.0%	20.0%		100.0%
	Brazil	41.2%	35.3%	23.5%	100.0%
	Canada	75.0%		25.0%	100.0%
	China	55.7%	31.1%	13.1%	100.0%
	France	25.0%	62.5%	12.5%	100.0%
	Germany	30.7%	43.0%	26.3%	100.0%
	Hong Kong	60.0%	40.0%		100.0%
	Japan	54.5%	36.4%	9.1%	100.0%
	Taiwan	33.3%	50.0%	16.7%	100.0%
	UK	29.4%	47.1%	23.5%	100.0%
	USA	32.9%	41.4%	25.7%	100.0%
Total		49.5%	34.2%	16.3%	100.0%

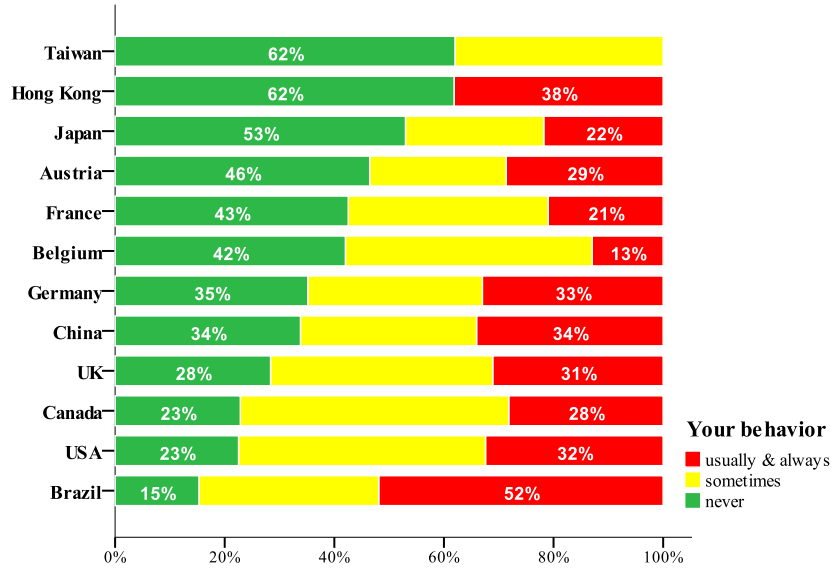
**Country/district \* Your selection of household ICT appliances with environmental or energy label**  
Crosstabulation

% within CountryDistrict

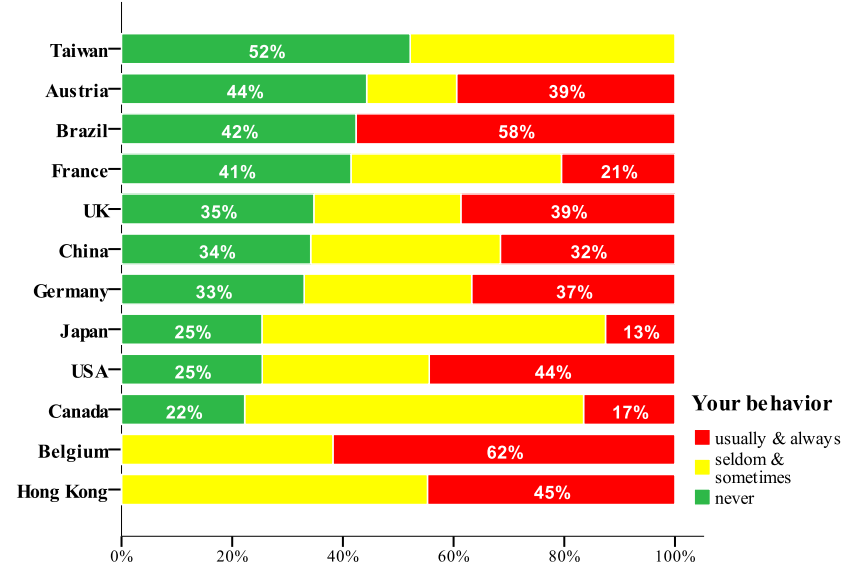
		Your behavior of selecting household ICT appliances with environmental or energy label			Total
		I prefer to buy products with environmental or energy label	I usually do not check for environmental labels, but some products just have them	I would like to try labeled products, but in my country I cannot find any labels	
Country/district	Austria	66.7%	33.3%		100.0%
	Belgium	75.0%	25.0%		100.0%
	Brazil	41.2%	41.2%	17.6%	100.0%
	Canada	50.0%	50.0%		100.0%
	China	52.7%	39.1%	8.2%	100.0%
	France	14.3%	85.7%		100.0%
	Germany	28.8%	68.2%	3.0%	100.0%
	Hong Kong	40.0%	40.0%	20.0%	100.0%
	Japan	81.8%		18.2%	100.0%
	Taiwan	33.3%	66.7%		100.0%
	UK	52.9%	35.3%	11.8%	100.0%
	USA	37.7%	53.6%	8.7%	100.0%
Total		49.3%	42.7%	8.1%	100.0%

Appendix 15 Respondents' behavior after using the computer – 12 countries/districts

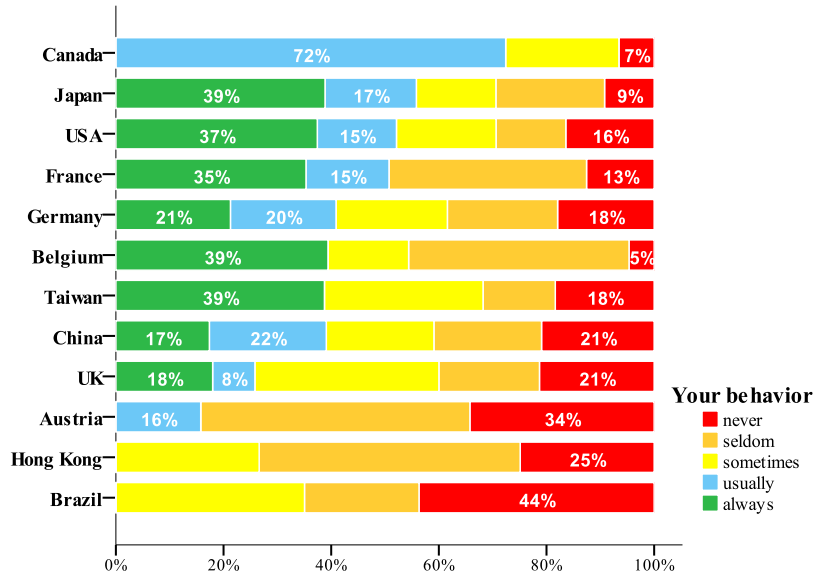
After using the computer, I leave it on until next time



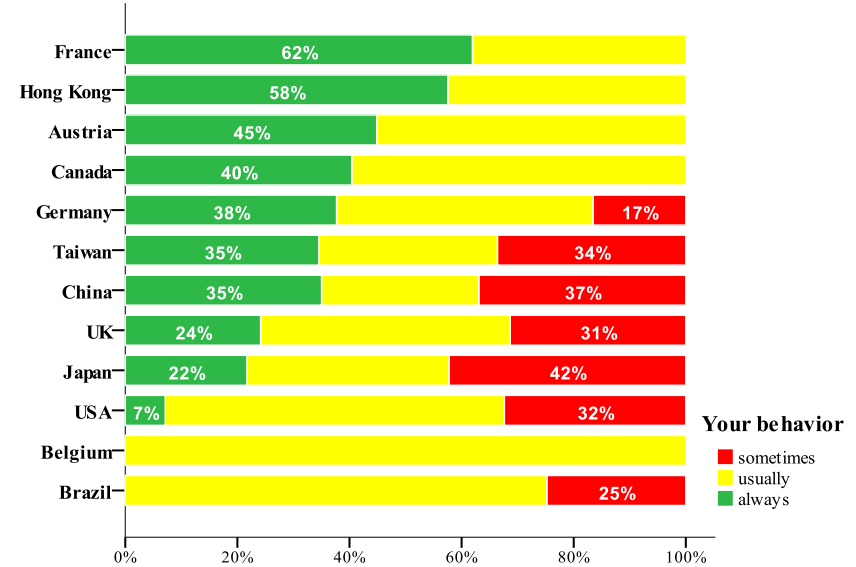
After using the computer, I leave it in automatic stand-by



After using the computer, I set it to stand-by mode

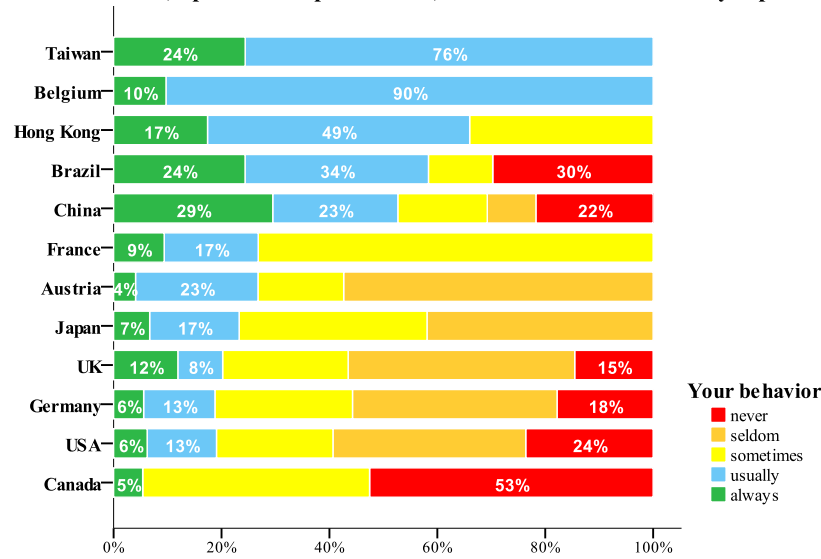


I unplug it, after turning off

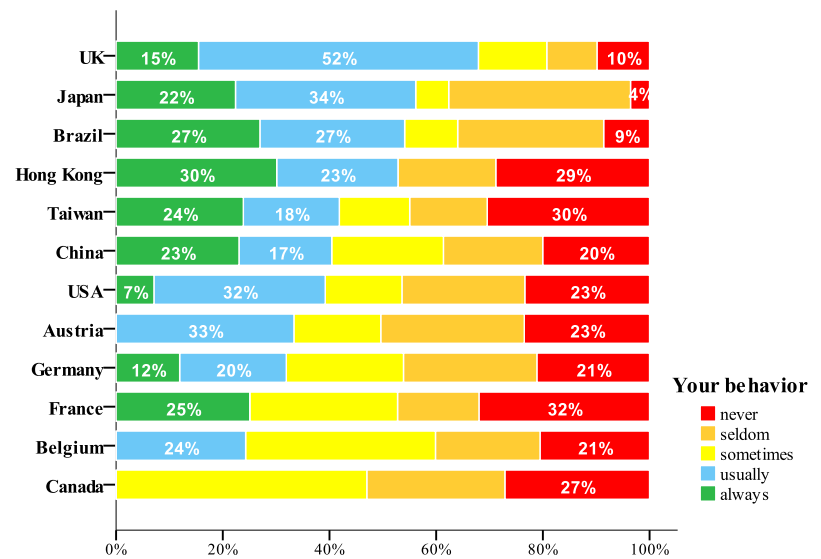


**Appendix 16** End-of-life behaviors to deal with outdated or damaged ICT appliances – 12 countries/districts

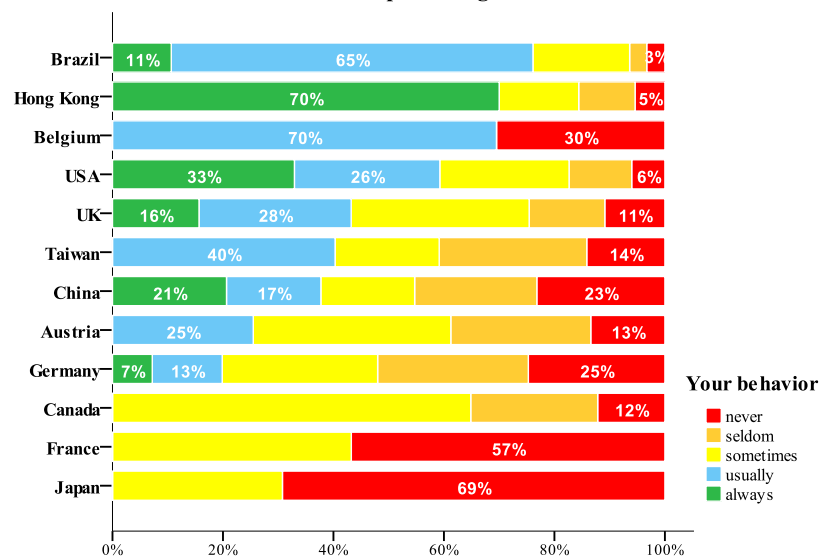
**If it broke down, I prefer to repair it first, rather than to immediately replace**



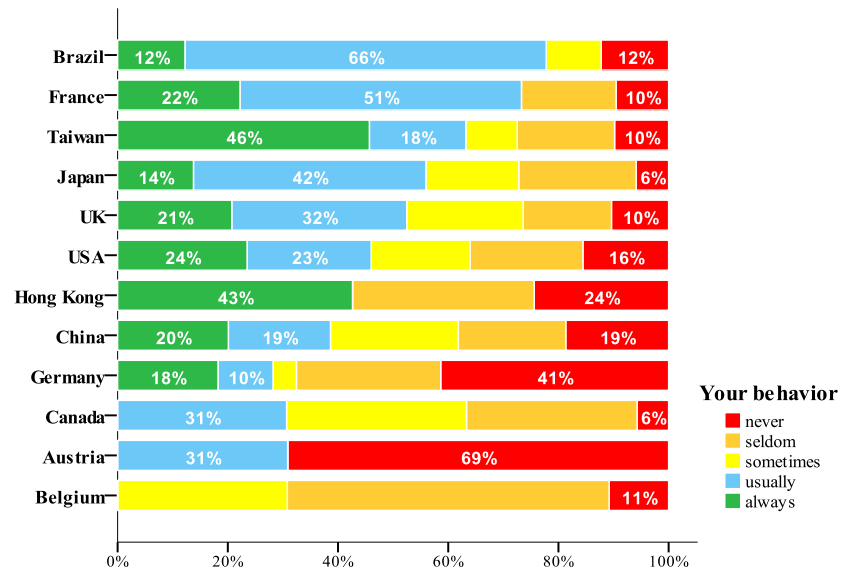
**I prefer to reuse the still functional components**



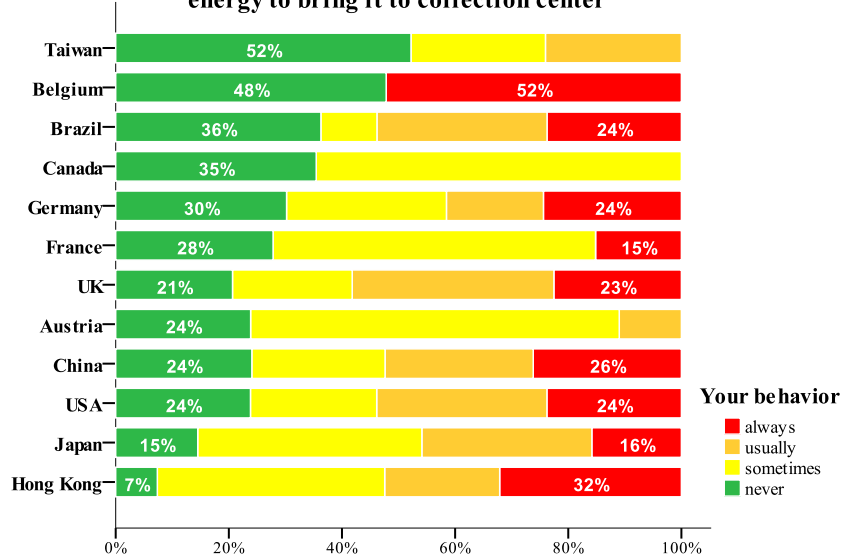
**I donate it to non-profit organization**



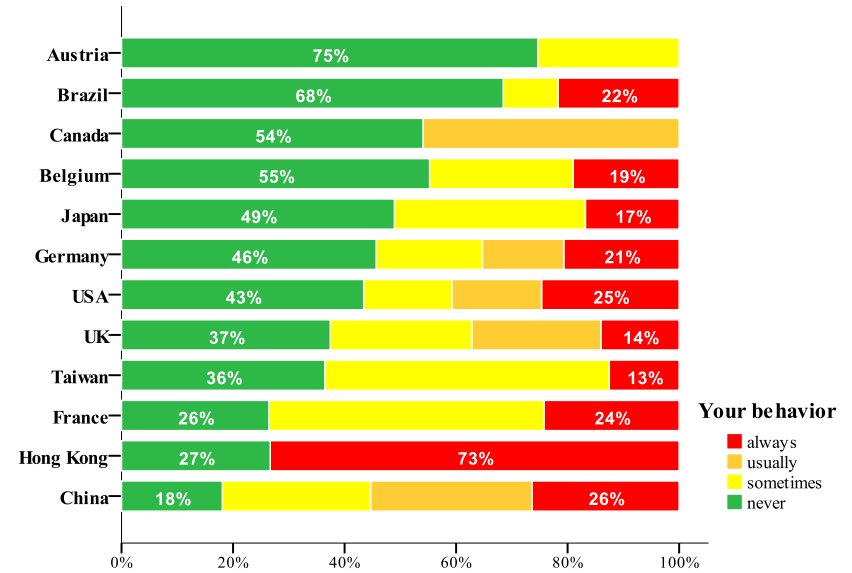
**I take it to a recycling or collection center**



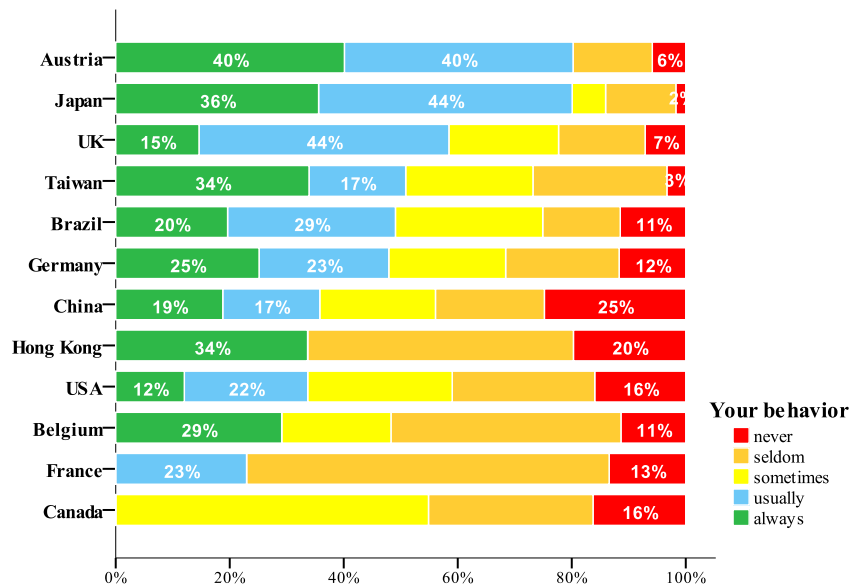
**I prefer to simply store it, rather to invest time and energy to bring it to collection center**



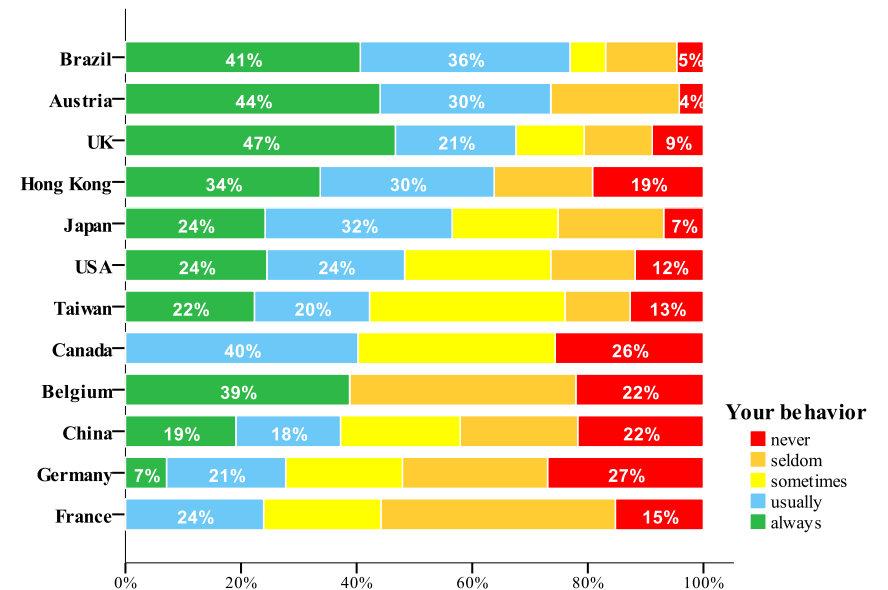
**As long as the collector pays, regardless of the price, I sell it to him to clear up**



**I am well informed of national/local requirement of how to discard appliances**



**I care about where the appliance will end up after collection**



**Appendix 17** Factor analysis of all respondents' end-of-life behavior of ICT appliances

**KMO and Bartlett's Test**

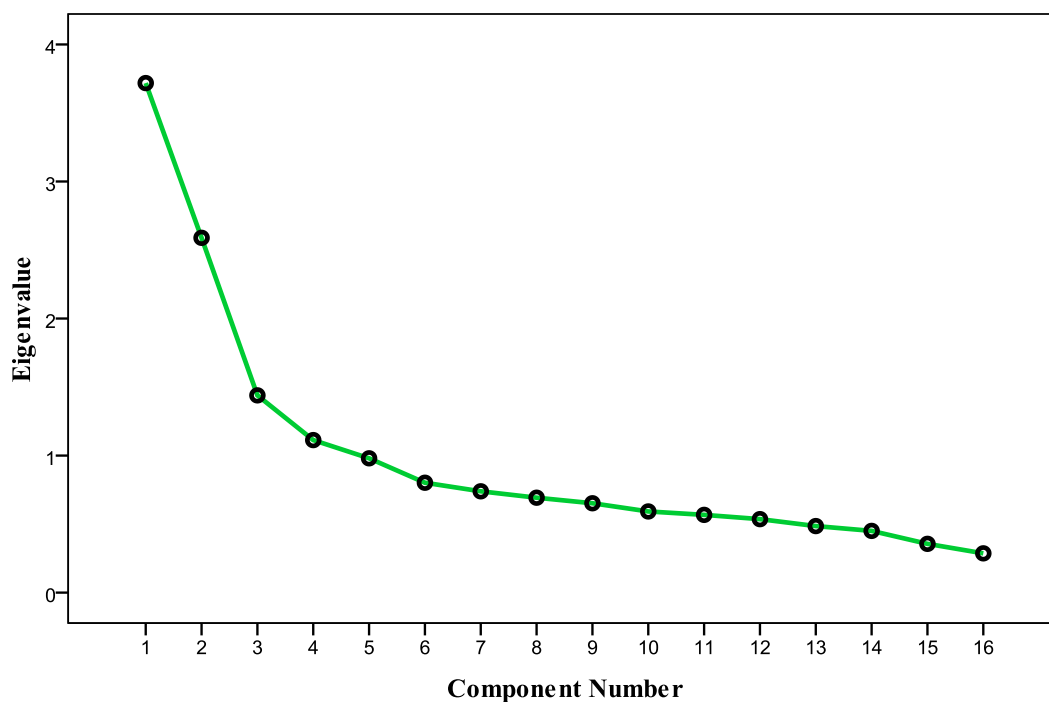
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.794
Bartlett's Test of Sphericity	Approx. Chi-Square	4582.988
	df	120
	Sig.	.000

**Total Variance Explained**

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.718	23.239	23.239	3.718	23.239	23.239	3.153	19.704	19.704
2	2.589	16.181	39.419	2.589	16.181	39.419	2.642	16.511	36.214
3	1.439	8.996	48.415	1.439	8.996	48.415	1.705	10.658	46.873
4	1.113	6.957	55.372	1.113	6.957	55.372	1.360	8.499	55.372
5	.980	6.126	61.498						
6	.802	5.012	66.510						
7	.739	4.621	71.131						
8	.693	4.329	75.459						
9	.652	4.076	79.535						
10	.592	3.702	83.237						
11	.567	3.546	86.783						
12	.536	3.351	90.134						
13	.486	3.035	93.169						
14	.450	2.815	95.984						
15	.356	2.225	98.209						
16	.287	1.791	100.000						

Extraction Method: Principal Component Analysis.

**Scree Plot**



Component Matrix<sup>a</sup>

	Component			
	1	2	3	4
If it broke down, I prefer to repair it first, rather than to immediately replace			.651	
For the mobile phone or laptop computer, I replace battery to extend the life time	-.463		.507	
I prefer to reuse the still functional components				
I donate it to non-profit organization		.640		
I discard it with the garbage	.714			
I throw it on the road side	.635	.471		
I take it to a recycling or collection center		.521		
I prefer to simply store it, rather to invest time and energy to bring it to collection center	.561	.459		
I store it until I have more pieces to bring them to collection center together		.507		
I resell it on-line or at a second-hand store				.548
As long as the collector pays, regardless of the price, I sell it to him to clear up	.515			
I give it to relatives or friends				.543
I am well informed of national/local requirement of how to discard appliances		.535		
I care about where the appliance will end up after collection	-.463	.491		
I have no time to think much about used appliances	.640			
I'm free to dispose of my things any way I want	.535			

Extraction Method: Principal Component Analysis.

a. 4 components extracted.

Rotated Component Matrix<sup>a</sup>

	Component			
	1	2	3	4
If it broke down, I prefer to repair it first, rather than to immediately replace			.794	
For the mobile phone or laptop computer, I replace battery to extend the life time			.706	
I prefer to reuse the still functional components			.506	
I donate it to non-profit organization		.701		
I discard it with the garbage	.799			
I throw it on the road side	.742			
I take it to a recycling or collection center		.623		
I prefer to simply store it, rather to invest time and energy to bring it to collection center	.730			
I store it until I have more pieces to bring them to collection center together		.641		
I resell it on-line or at a second-hand store				.734
As long as the collector pays, regardless of the price, I sell it to him to clear up	.688			
I give it to relatives or friends				.758
I am well informed of national/local requirement of how to discard appliances		.764		
I care about where the appliance will end up after collection		.708		
I have no time to think much about used appliances	.717			
I'm free to dispose of my things any way I want	.573			

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

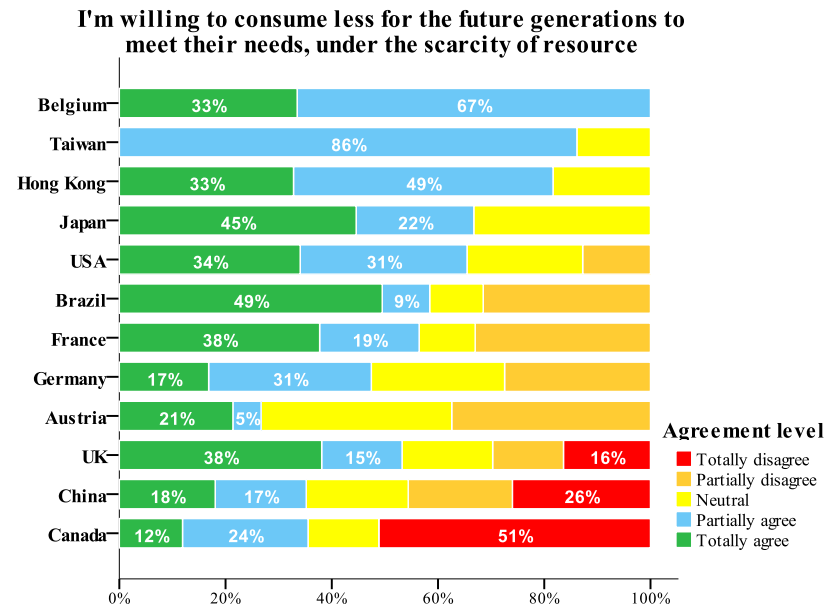
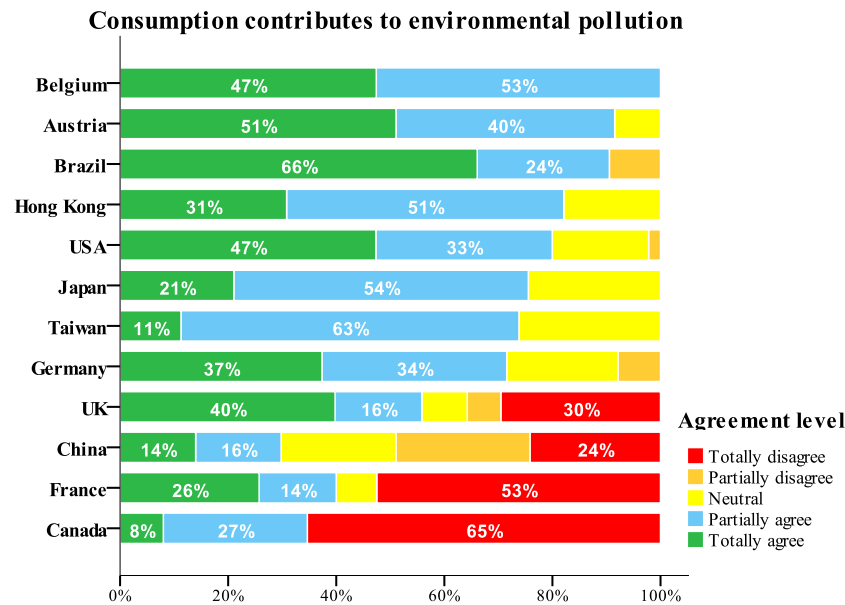
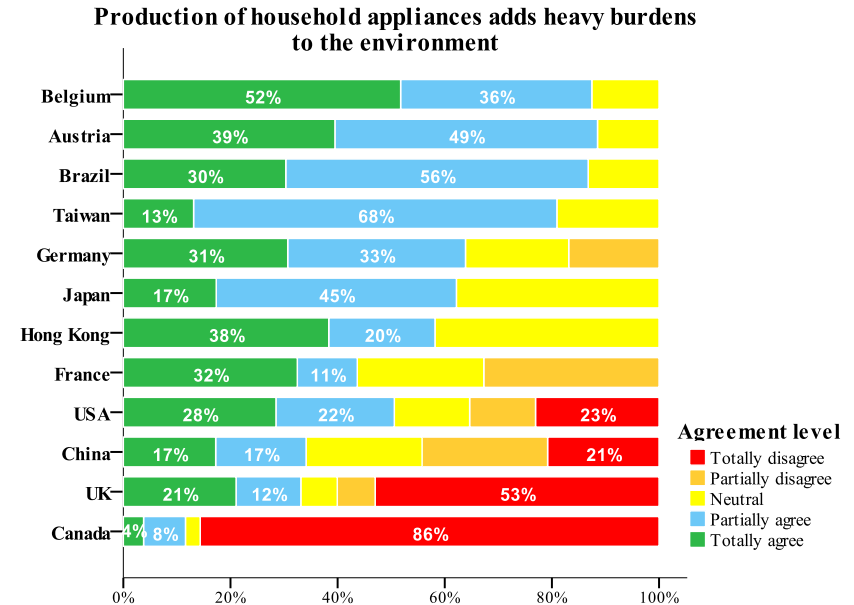
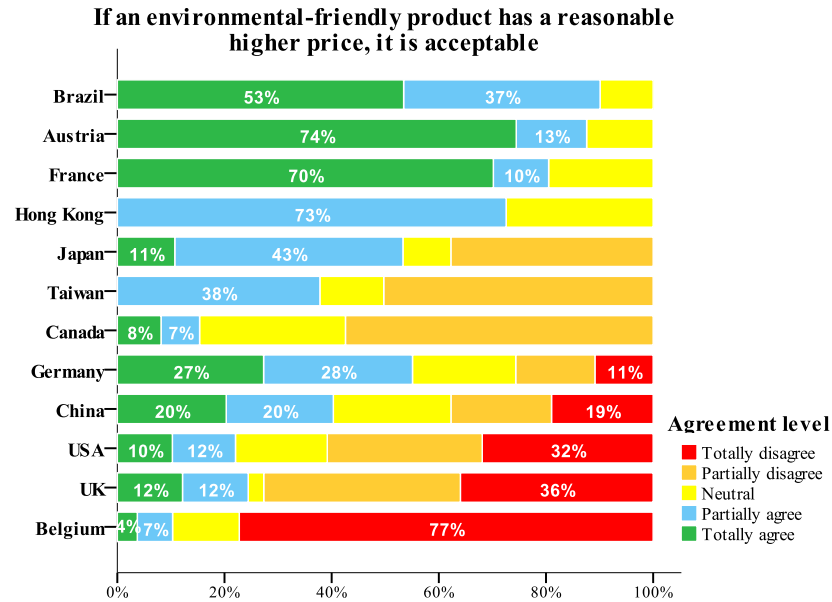
Component Transformation Matrix

Component	1	2	3	4
1	.765	-.481	-.360	.232
2	.589	.786	.185	-.028
3	.065	-.215	.792	.567
4	-.251	.324	-.457	.790

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

**Appendix 18** General awareness on production and consumption – respondents from 12 countries/districts

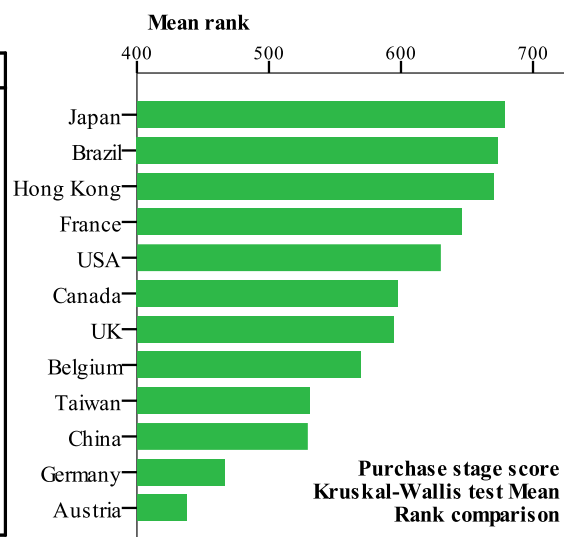




**Appendix 19** Kruskal-Wallis Test mean rank comparison of SCIndex sectional scores

**Ranks**

	Country/District	N	Mean Rank
Purchase_stage_score	Austria	13	437.73
	Belgium	6	569.00
	Brazil	17	673.50
	Canada	5	597.70
	China	754	529.43
	France	8	646.00
	Germany	140	466.16
	Hong Kong	6	670.00
	Japan	13	678.42
	Taiwan	8	530.50
	UK	20	594.33
	USA	79	630.20
	Total	1069	



**Test Statistics<sup>b,c</sup>**

	Purchase_stage_score	
Chi-Square	25.436	
df	11	
Asymp. Sig.	.008	
Monte Carlo Sig. Sig.	.005 <sup>a</sup>	
99% Confidence Interval	Lower Bound	.003
	Upper Bound	.006

**Test Statistics<sup>b,c</sup>**

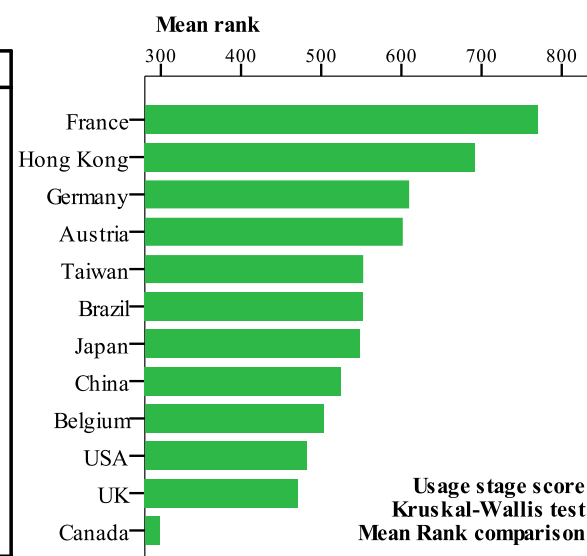
	Usage_stage_score	
Chi-Square	22.167	
df	11	
Asymp. Sig.	.023	
Monte Carlo Sig. Sig.	.021 <sup>a</sup>	
99% Confidence Interval	Lower Bound	.017
	Upper Bound	.024

- a. Based on 10000 sampled tables with starting seed 2000000.
- b. Kruskal Wallis Test
- c. Grouping Variable: Country/District

- a. Based on 10000 sampled tables with starting seed 624387341.
- b. Kruskal Wallis Test
- c. Grouping Variable: Country/District

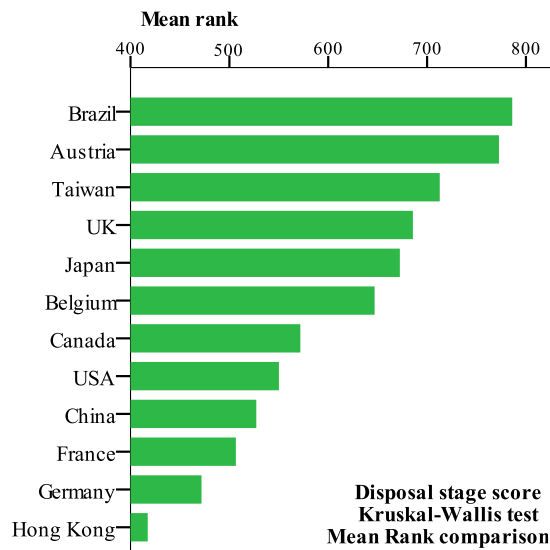
**Ranks**

	Country/District	N	Mean Rank
Usage_stage_score	Austria	13	601.73
	Belgium	6	502.83
	Brazil	17	551.91
	Canada	5	298.40
	China	754	524.59
	France	8	769.88
	Germany	140	609.68
	Hong Kong	6	691.58
	Japan	13	547.88
	Taiwan	8	552.38
	UK	20	471.23
	USA	79	481.42
	Total	1069	



Ranks

	CountryDistrict	N	Mean Rank
End-of-life_stage_score	Austria	13	772.69
	Belgium	6	646.92
	Brazil	17	786.15
	Canada	5	571.80
	China	754	527.24
	France	8	506.56
	Germany	140	471.80
	Hong Kong	6	417.42
	Japan	13	672.46
	Taiwan	8	712.81
	UK	20	685.65
	USA	79	550.11
	Total	1069	



Test Statistics<sup>b,c</sup>

	End-of-life_stage_score	
Chi-Square	37.373	
df	11	
Asymp. Sig.	.000	
Monte Carlo Sig. Sig.	.000 <sup>a</sup>	
99% Confidence Interval	Lower Bound	.000
	Upper Bound	.000

a. Based on 10000 sampled tables with starting seed 957002199.

b. Kruskal Wallis Test

c. Grouping Variable: CountryDistrict

Test Statistics<sup>b,c</sup>

	General_awareness_score	
Chi-Square	74.893	
df	11	
Asymp. Sig.	.000	
Monte Carlo Sig. Sig.	.000 <sup>a</sup>	
99% Confidence Interval	Lower Bound	.000
	Upper Bound	.000

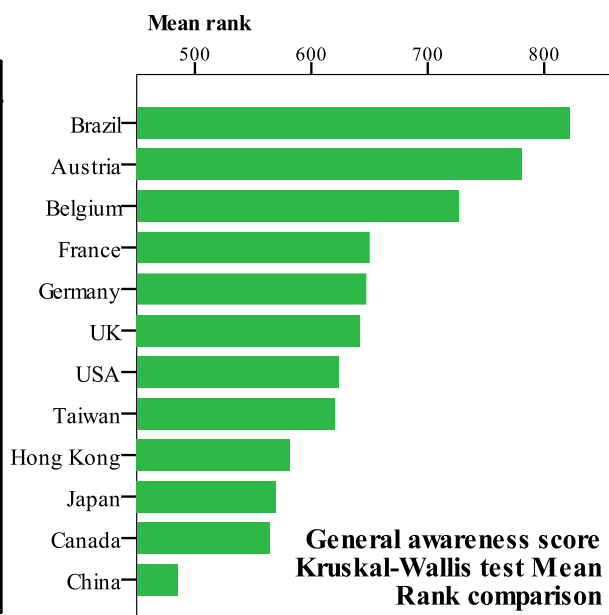
a. Based on 10000 sampled tables with starting seed 743671174.

b. Kruskal Wallis Test

c. Grouping Variable: CountryDistrict

Ranks

	CountryDistrict	N	Mean Rank
General_awareness_score	Austria	13	780.88
	Belgium	6	726.33
	Brazil	17	821.62
	Canada	5	563.90
	China	753	485.21
	France	8	650.13
	Germany	140	647.21
	Hong Kong	6	581.67
	Japan	13	569.62
	Taiwan	8	620.06
	UK	20	641.98
	USA	78	623.21
	Total	1067	



**Appendix 20** Post hoc tests for Kruskal-Wallis test – Mann-Whitney tests (Bonferroni correction)

Ranks				Ranks				Ranks						
Country/District	N	Mean Rank	Sum of Ranks	Country/District	N	Mean Rank	Sum of Ranks	Country/District	N	Mean Rank	Sum of Ranks			
Purchase_stage_score	Brazil	17	480.85	8174.50	Purchase_stage_score	Austria	13	11.04	143.50	Purchase_stage_score	Germany	140	96.28	13478.50
	China	754	383.86	289431.50		Brazil	17	18.91	321.50		USA	79	134.32	10611.50
	Total	771				Total	30				Total	219		

**Test Statistics<sup>b</sup>**

			Purchase_stage_score
Mann-Whitney U			4796.500
Wilcoxon W			289431.500
Z			-1.776
Asymp. Sig. (2-tailed)			.076
Monte Carlo Sig. (2-tailed)	Sig.		.076 <sup>a</sup>
	99% Confidence Interval	Lower Bound	.070
		Upper Bound	.083
Monte Carlo Sig. (1-tailed)	Sig.		.038 <sup>a</sup>
	99% Confidence Interval	Lower Bound	.033
		Upper Bound	.043

a. Based on 10000 sampled tables with starting seed 299883525.  
 b. Grouping Variable: CountryDistrict

**Test Statistics<sup>b</sup>**

		Purchase_stage_score
Mann-Whitney U		52.500
Wilcoxon W		143.500
Z		-2.428
Asymp. Sig. (2-tailed)		.015
Exact Sig. [2*(1-tailed Sig.)]		.014 <sup>a</sup>

a. Not corrected for ties.  
 b. Grouping Variable: CountryDistrict

**Test Statistics<sup>b</sup>**

			Purchase_stage_score
Mann-Whitney U			3608.500
Wilcoxon W			13478.500
Z			-4.267
Asymp. Sig. (2-tailed)			.000
Monte Carlo Sig. (2-tailed)	Sig.		.000 <sup>a</sup>
	99% Confidence Interval	Lower Bound	.000
		Upper Bound	.000
Monte Carlo Sig. (1-tailed)	Sig.		.000 <sup>a</sup>
	99% Confidence Interval	Lower Bound	.000
		Upper Bound	.000

a. Based on 10000 sampled tables with starting seed 1314643744.  
 b. Grouping Variable: CountryDistrict

Ranks				Ranks				Ranks						
Country/District	N	Mean Rank	Sum of Ranks	Country/District	N	Mean Rank	Sum of Ranks	Country/District	N	Mean Rank	Sum of Ranks			
Usage_stage_score	China	754	436.32	328987.50	Usage_stage_score	Canada	5	3.80	19.00	Usage_stage_score	Germany	140	119.51	16731.00
	Germany	140	507.70	71077.50		France	8	9.00	72.00		USA	79	93.15	7359.00
	Total	894				Total	13				Total	219		

**Test Statistics<sup>b</sup>**

			Usage_stage_score
Mann-Whitney U			44352.500
Wilcoxon W			328987.500
Z			-3.004
Asymp. Sig. (2-tailed)			.003
Monte Carlo Sig. (2-tailed)	Sig.		.003 <sup>a</sup>
	99% Confidence Interval	Lower Bound	.001
		Upper Bound	.004
Monte Carlo Sig. (1-tailed)	Sig.		.001 <sup>a</sup>
	99% Confidence Interval	Lower Bound	.000
		Upper Bound	.002

a. Based on 10000 sampled tables with starting seed 334431365.  
 b. Grouping Variable: CountryDistrict

**Test Statistics<sup>b</sup>**

		Usage_stage_score
Mann-Whitney U		4.000
Wilcoxon W		19.000
Z		-2.345
Asymp. Sig. (2-tailed)		.019
Exact Sig. [2*(1-tailed Sig.)]		.019 <sup>a</sup>

a. Not corrected for ties.  
 b. Grouping Variable: CountryDistrict

**Test Statistics<sup>b</sup>**

			Usage_stage_score
Mann-Whitney U			4199.000
Wilcoxon W			7359.000
Z			-2.956
Asymp. Sig. (2-tailed)			.003
Monte Carlo Sig. (2-tailed)	Sig.		.003 <sup>a</sup>
	99% Confidence Interval	Lower Bound	.002
		Upper Bound	.005
Monte Carlo Sig. (1-tailed)	Sig.		.002 <sup>a</sup>
	99% Confidence Interval	Lower Bound	.001
		Upper Bound	.003

a. Based on 10000 sampled tables with starting seed 743671174.  
 b. Grouping Variable: CountryDistrict

Ranks					Ranks					Ranks				
Country/District	N	Mean Rank	Sum of Ranks		Country/District	N	Mean Rank	Sum of Ranks		Country/District	N	Mean Rank	Sum of Ranks	
End-of-life_stage_score	Austria	13	563.69	7328.00	End-of-life_stage_score	Austria	13	116.81	1518.50	End-of-life_stage_score	Germany	140	104.95	14692.50
	China	754	380.90	287200.00		Germany	140	73.30	10262.50		USA	79	118.96	9397.50
	Total	767				Total	153				Total	219		

Test Statistics <sup>b</sup>					Test Statistics <sup>b</sup>					Test Statistics <sup>b</sup>				
	End-of-life stage score					End-of-life stage score					End-of-life stage score			
Mann-Whitney U	2565.000	Mann-Whitney U	392.500	Mann-Whitney U	4822.500									
Wilcoxon W	287200.000	Wilcoxon W	10262.500	Wilcoxon W	14692.500									
Z	-2.955	Z	-3.390	Z	-1.572									
Asymp. Sig. (2-tailed)	.003	Asymp. Sig. (2-tailed)	.001	Asymp. Sig. (2-tailed)	.116									
Monte Carlo Sig. (2-tailed)	Sig. .003 <sup>a</sup>	Monte Carlo Sig. (2-tailed)	Sig. .000 <sup>a</sup>	Monte Carlo Sig. (2-tailed)	Sig. .118 <sup>a</sup>									
	99% Confidence Interval	Lower Bound	.001	99% Confidence Interval	Lower Bound	.109								
		Upper Bound	.004		Upper Bound	.126								
Monte Carlo Sig. (1-tailed)	Sig. .001 <sup>a</sup>	Monte Carlo Sig. (1-tailed)	Sig. .000 <sup>a</sup>	Monte Carlo Sig. (1-tailed)	Sig. .060 <sup>a</sup>									
	99% Confidence Interval	Lower Bound	.000	99% Confidence Interval	Lower Bound	.054								
		Upper Bound	.002		Upper Bound	.066								

a. Based on 10000 sampled tables with starting seed 2000000.

b. Grouping Variable: Country/District

a. Based on 10000 sampled tables with starting seed 1314643744.

b. Grouping Variable: Country/District

a. Based on 10000 sampled tables with starting seed 1502173562.

b. Grouping Variable: Country/District

Ranks				
Country/District	N	Mean Rank	Sum of Ranks	
End-of-life_stage_score	Germany	140	74.56	10438.50
	Japan	13	103.27	1342.50
	Total	153		

Ranks				
Country/District	N	Mean Rank	Sum of Ranks	
End-of-life_stage_score	Germany	140	77.08	10791.50
	UK	20	104.43	2088.50
	Total	160		

Test Statistics <sup>b</sup>				
	End-of-life stage score			
Mann-Whitney U	568.500			
Wilcoxon W	10438.500			
Z	-2.237			
Asymp. Sig. (2-tailed)	.025			
Monte Carlo Sig. (2-tailed)	Sig. .027 <sup>a</sup>			
	99% Confidence Interval	Lower Bound	.023	
		Upper Bound	.031	
Monte Carlo Sig. (1-tailed)	Sig. .014 <sup>a</sup>			
	99% Confidence Interval	Lower Bound	.011	
		Upper Bound	.017	

a. Based on 10000 sampled tables with starting seed 334431365.

b. Grouping Variable: Country/District

Test Statistics <sup>b</sup>				
	End-of-life stage score			
Mann-Whitney U	921.500			
Wilcoxon W	10791.500			
Z	-2.471			
Asymp. Sig. (2-tailed)	.013			
Monte Carlo Sig. (2-tailed)	Sig. .014 <sup>a</sup>			
	99% Confidence Interval	Lower Bound	.011	
		Upper Bound	.017	
Monte Carlo Sig. (1-tailed)	Sig. .006 <sup>a</sup>			
	99% Confidence Interval	Lower Bound	.004	
		Upper Bound	.008	

a. Based on 10000 sampled tables with starting seed 624387341.

b. Grouping Variable: Country/District

Ranks					Ranks					Ranks				
Country/District	N	Mean Rank	Sum of Ranks		Country/District	N	Mean Rank	Sum of Ranks		Country/District	N	Mean Rank	Sum of Ranks	
General_awareness_score	China	753	425.47	320381.00	General_awareness_score	Brazil	17	15.59	265.00	General_awareness_score	Austria	13	17.42	226.50
	Germany	140	562.79	78790.00		Taiwan	8	7.50	60.00		Japan	13	9.58	124.50
	Total	893				Total	25				Total	26		

**Test Statistics<sup>b</sup>**

	General_awareness_score
Mann-Whitney U	36500.000
Wilcoxon W	320381.000
Z	-5.806
Asymp. Sig. (2-tailed)	.000
Monte Carlo Sig. (2-tailed) Sig.	.000 <sup>a</sup>
99% Confidence Interval Lower Bound	.000
Upper Bound	.000
Monte Carlo Sig. (1-tailed) Sig.	.000 <sup>a</sup>
99% Confidence Interval Lower Bound	.000
Upper Bound	.000

**Test Statistics<sup>b</sup>**

	General_awareness_score
Mann-Whitney U	24.000
Wilcoxon W	60.000
Z	-2.585
Asymp. Sig. (2-tailed)	.010
Exact Sig. [2*(1-tailed Sig.)]	.009 <sup>a</sup>

**Test Statistics<sup>b</sup>**

	General_awareness_score
Mann-Whitney U	33.500
Wilcoxon W	124.500
Z	-2.647
Asymp. Sig. (2-tailed)	.008
Exact Sig. [2*(1-tailed Sig.)]	.007 <sup>a</sup>

a. Based on 10000 sampled tables with starting seed 957002199.  
 b. Grouping Variable: CountryDistrict

a. Not corrected for ties.  
 b. Grouping Variable: CountryDistrict

a. Not corrected for ties.  
 b. Grouping Variable: CountryDistrict

Ranks					Ranks					Ranks				
Country/District	N	Mean Rank	Sum of Ranks		Country/District	N	Mean Rank	Sum of Ranks		Country/District	N	Mean Rank	Sum of Ranks	
SCIndex_total_score	Brazil	17	563.50	9579.50	SCIndex_total_score	Brazil	17	61.88	1052.00	SCIndex_total_score	Germany	140	75.26	10536.50
	China	753	381.48	287255.50		USA	78	44.97	3508.00		Japan	13	95.73	1244.50
	Total	770				Total	95				Total	153		

**Test Statistics<sup>b</sup>**

	SCIndex_total_score
Mann-Whitney U	3374.500
Wilcoxon W	287255.500
Z	-3.337
Asymp. Sig. (2-tailed)	.001
Monte Carlo Sig. (2-tailed) Sig.	.000 <sup>a</sup>
99% Confidence Interval Lower Bound	.000
Upper Bound	.001
Monte Carlo Sig. (1-tailed) Sig.	.000 <sup>a</sup>
99% Confidence Interval Lower Bound	.000
Upper Bound	.001

**Test Statistics<sup>b</sup>**

	SCIndex_total_score
Mann-Whitney U	427.000
Wilcoxon W	3508.000
Z	-2.291
Asymp. Sig. (2-tailed)	.022
Monte Carlo Sig. (2-tailed) Sig.	.022 <sup>a</sup>
99% Confidence Interval Lower Bound	.018
Upper Bound	.025
Monte Carlo Sig. (1-tailed) Sig.	.011 <sup>a</sup>
99% Confidence Interval Lower Bound	.008
Upper Bound	.014

**Test Statistics<sup>b</sup>**

	SCIndex_total_score
Mann-Whitney U	666.500
Wilcoxon W	10536.500
Z	-1.593
Asymp. Sig. (2-tailed)	.111
Monte Carlo Sig. (2-tailed) Sig.	.115 <sup>a</sup>
99% Confidence Interval Lower Bound	.106
Upper Bound	.123
Monte Carlo Sig. (1-tailed) Sig.	.057 <sup>a</sup>
99% Confidence Interval Lower Bound	.051
Upper Bound	.063

a. Based on 10000 sampled tables with starting seed 1241531719.  
 b. Grouping Variable: CountryDistrict

a. Based on 10000 sampled tables with starting seed 329836257.  
 b. Grouping Variable: CountryDistrict

a. Based on 10000 sampled tables with starting seed 1993510611.  
 b. Grouping Variable: CountryDistrict

**Appendix 21** Household ICT appliances SCIndex total score – ANOVA and plots

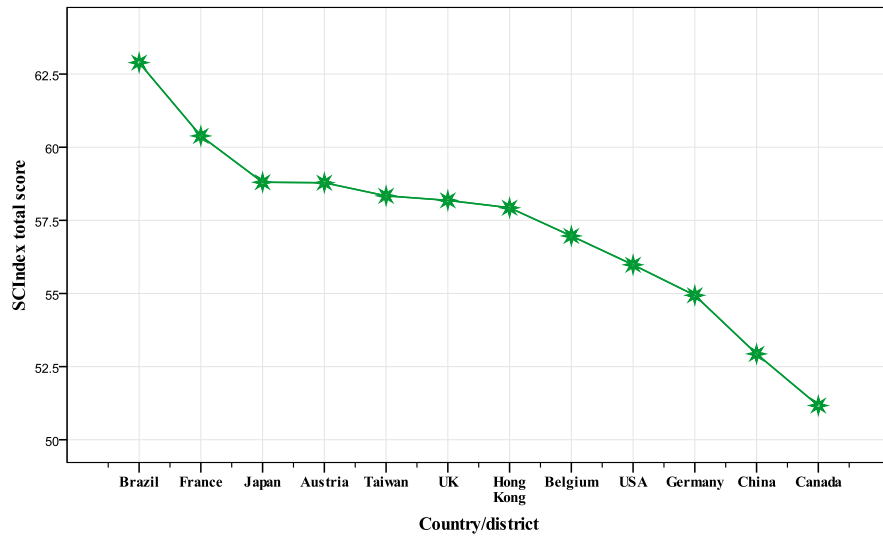
**Descriptives**

SCIndex total score	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
					Austria	13		
Belgium	6	56.97	8.743	3.569	47.79	66.14	46	72
Brazil	17	62.89	10.129	2.457	57.68	68.10	45	81
Canada	5	51.17	13.353	5.972	34.59	67.75	39	67
China	753	52.93	11.688	.426	52.10	53.77	15	81
France	8	60.39	7.306	2.583	54.28	66.49	48	74
Germany	140	54.94	8.598	.727	53.50	56.37	34	81
Hong Kong	6	57.93	10.226	4.175	47.20	68.66	48	76
Japan	13	58.80	9.180	2.546	53.25	64.35	44	69
Taiwan	8	58.34	6.292	2.224	53.08	63.60	46	67
UK	20	58.18	11.549	2.582	52.78	63.59	32	83
USA	78	55.98	10.657	1.207	53.58	58.38	26	83
Total	1067	53.96	11.223	.344	53.28	54.63	15	83

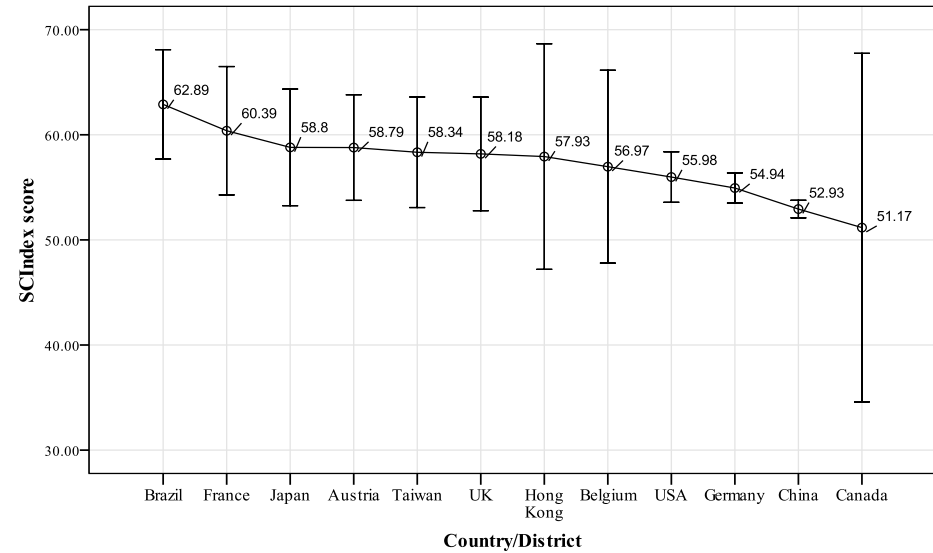
**Multiple Comparisons - Post hoc tests for ANOVA**

SCIndex_total_score Games-Howell		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) Country/District	(J) Country/District				Lower Bound	Upper Bound
China	Austria				-5.852	2.345
	Belgium	-4.032	3.594	.977	-22.41	14.35
	Brazil	-9.957*	2.493	.032	-19.31	-.60
	Canada	1.764	5.987	1.000	-32.78	36.31
	France	-7.451	2.618	.314	-19.16	4.25
	Germany	-2.003	.842	.425	-4.78	.78
	Hong Kong	-4.996	4.196	.967	-26.52	16.53
	Japan	-5.868	2.582	.534	-16.01	4.28
	Taiwan	-5.403	2.265	.498	-15.47	4.67
	UK	-5.249	2.617	.686	-14.87	4.37
	USA	-3.046	1.280	.429	-7.33	1.24

**Household ICT appliances Sustainable Consumer Index total score - means plots**



**Household ICT appliances SCIndex total score - means with 95% Confidence Interval**



**Appendix 22 Household ICT appliances SCIndex sectional score – ANOVA**

**Descriptives**

Purchase stage score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Austria	13	16.8398	4.14011	1.14826	14.3379	19.3416	11.85	26.25
Belgium	6	18.1333	5.01973	2.04930	12.8655	23.4012	10.50	23.75
Brazil	17	19.8499	2.71787	.65918	18.4525	21.2473	15.20	24.00
Canada	5	18.7900	4.00350	1.79042	13.8190	23.7610	13.05	22.60
China	754	17.2984	5.44053	.19813	16.9095	17.6874	1.00	27.00
France	8	19.5229	2.68330	.94869	17.2796	21.7662	16.25	24.75
Germany	140	17.1305	3.42755	.28968	16.5577	17.7032	7.45	25.80
Hong Kong	6	19.6638	1.05165	.42933	18.5602	20.7675	18.40	21.08
Japan	13	19.6333	4.81947	1.33668	16.7209	22.5457	10.40	25.20
Taiwan	8	18.0875	2.20061	.77803	16.2477	19.9273	14.95	21.50
UK	20	18.8880	3.09362	.69175	17.4402	20.3359	13.92	24.83
USA	79	19.3100	3.72448	.41904	18.4757	20.1442	7.70	27.25
Total	1069	17.5657	4.99468	.15276	17.2660	17.8655	1.00	27.25

**Tests of Normality**

Country/District	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Purchase_stage_score						
Austria	.148	13	.200*	.927	13	.308
Belgium	.188	6	.200*	.947	6	.719
Brazil	.130	17	.200*	.952	17	.488
Canada	.216	5	.200*	.919	5	.522
China	.079	754	.000	.947	754	.000
France	.199	8	.200*	.923	8	.455
Germany	.044	140	.200*	.992	140	.635
Hong Kong	.189	6	.200*	.944	6	.693
Japan	.259	13	.017	.846	13	.025
Taiwan	.130	8	.200*	.971	8	.909
UK	.092	20	.200*	.976	20	.873
USA	.064	79	.200*	.986	79	.555

a. Lilliefors Significance Correction

\*. This is a lower bound of the true significance.

**Test of Homogeneity of Variance**

		Levene Statistic	df1	df2	Sig.
Purchase_stage_score	Based on Mean	6.519	11	1057	.000
	Based on Median	5.340	11	1057	.000
	Based on Median and with adjusted df	5.340	11	937.120	.000
	Based on trimmed mean	6.092	11	1057	.000

**Descriptives**

Usage stage score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Austria	13	16.9846	5.29998	1.46995	13.7819	20.1874	6.50	23.40
Belgium	6	16.1667	3.87436	1.58170	12.1008	20.2326	10.40	21.90
Brazil	17	17.0118	3.95473	.95916	14.9784	19.0451	11.00	26.00
Canada	5	11.6800	6.45655	2.88746	3.6631	19.6969	4.50	19.70
China	754	16.2549	4.28981	.15623	15.9482	16.5616	4.20	26.00
France	8	19.6125	4.38290	1.54959	15.9483	23.2767	12.50	24.00
Germany	140	17.6139	3.95735	.33446	16.9526	18.2752	9.00	27.50
Hong Kong	6	18.4333	3.01441	1.23063	15.2699	21.5968	14.30	21.90
Japan	13	16.8231	3.22468	.89437	14.8744	18.7717	11.90	22.00
Taiwan	8	16.9375	3.37128	1.19193	14.1190	19.7560	13.50	22.80
UK	20	15.9700	3.85119	.86115	14.1676	17.7724	8.30	26.00
USA	79	15.8127	4.68714	.52734	14.7628	16.8625	2.40	25.50
Total	1069	16.4433	4.29793	.13145	16.1853	16.7012	2.40	27.50

**Tests of Normality**

Country/District	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Usage_stage_score						
Austria	.187	13	.200*	.921	13	.262
Belgium	.199	6	.200*	.975	6	.927
Brazil	.160	17	.200*	.928	17	.205
Canada	.272	5	.200*	.904	5	.430
China	.055	754	.000	.987	754	.000
France	.276	8	.073	.820	8	.047
Germany	.045	140	.200*	.989	140	.370
Hong Kong	.168	6	.200*	.938	6	.642
Japan	.121	13	.200*	.955	13	.678
Taiwan	.200	8	.200*	.902	8	.300
UK	.149	20	.200*	.944	20	.287
USA	.071	79	.200*	.987	79	.613

a. Lilliefors Significance Correction

\*. This is a lower bound of the true significance.

**Test of Homogeneity of Variance**

		Levene Statistic	df1	df2	Sig.
Usage_stage_score	Based on Mean	1.098	11	1057	.359
	Based on Median	.936	11	1057	.504
	Based on Median and with adjusted df	.936	11	999.521	.504
	Based on trimmed mean	1.098	11	1057	.359

Descriptives

Disposal stage score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Austria	13	16.6154	2.19045	.60752	15.2917	17.9391	12.50	20.00
Belgium	6	14.6667	5.93015	2.42097	8.4434	20.8900	4.00	22.00
Brazil	17	17.3824	6.96762	1.68990	13.7999	20.9648	.50	27.50
Canada	5	14.4000	2.38223	1.06536	11.4421	17.3579	10.50	16.50
China	754	13.0683	5.16896	.18824	12.6988	13.4378	.00	25.00
France	8	13.6875	3.76959	1.33275	10.5360	16.8390	8.50	19.50
Germany	140	12.6929	4.82559	.40784	11.8865	13.4992	.00	23.00
Hong Kong	6	12.5833	7.78085	3.17652	4.4178	20.7488	1.50	25.50
Japan	13	15.2692	4.63957	1.28679	12.4656	18.0729	5.00	22.50
Taiwan	8	16.0000	4.00892	1.41737	12.6485	19.3515	8.00	22.00
UK	20	15.9500	6.62908	1.48231	12.8475	19.0525	2.00	25.00
USA	79	13.5127	5.98769	.67367	12.1715	14.8538	.00	24.50
Total	1069	13.2834	5.26321	.16098	12.9676	13.5993	.00	27.50

Descriptives

General awareness score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Austria	13	8.3462	1.37515	.38140	7.5152	9.1771	5.00	10.00
Belgium	6	8.0000	1.30384	.53229	6.6317	9.3683	6.50	10.00
Brazil	17	8.6471	1.42264	.34504	7.9156	9.3785	5.50	10.00
Canada	5	6.3000	3.34664	1.49666	2.1446	10.4554	.50	8.50
China	753	6.3181	2.42468	.08836	6.1446	6.4915	-2.50	10.00
France	8	7.5625	1.69953	.60087	6.1417	8.9833	5.00	10.00
Germany	140	7.5000	1.70061	.14373	7.2158	7.7842	.00	10.00
Hong Kong	6	7.2500	1.80970	.73881	5.3508	9.1492	5.50	9.50
Japan	13	7.0769	1.23905	.34365	6.3282	7.8257	5.00	10.00
Taiwan	8	7.3125	.70394	.24888	6.7240	7.9010	6.50	8.50
UK	20	7.3750	2.47022	.55236	6.2189	8.5311	.00	10.00
USA	78	7.1731	2.43996	.27627	6.6230	7.7232	-2.00	10.00
Total	1067	6.6579	2.35492	.07209	6.5165	6.7994	-2.50	10.00

Tests of Normality

Country/District	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
End-of-life_stage_score						
Austria	.108	13	.200*	.981	13	.985
Belgium	.256	6	.200*	.877	6	.254
Brazil	.182	17	.136	.911	17	.106
Canada	.233	5	.200*	.880	5	.311
China	.159	754	.000	.900	754	.000
France	.173	8	.200*	.962	8	.829
Germany	.131	140	.000	.938	140	.000
Hong Kong	.228	6	.200*	.930	6	.584
Japan	.198	13	.174	.922	13	.270
Taiwan	.229	8	.200*	.917	8	.406
UK	.171	20	.126	.941	20	.248
USA	.109	79	.021	.958	79	.012

a. Lilliefors Significance Correction

\*. This is a lower bound of the true significance.

Tests of Normality

Country/District	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
General_awareness_score						
Austria	.192	13	.200*	.870	13	.052
Belgium	.167	6	.200*	.960	6	.817
Brazil	.224	17	.024	.810	17	.003
Canada	.324	5	.094	.751	5	.030
China	.143	753	.000	.936	753	.000
France	.138	8	.200*	.968	8	.879
Germany	.084	140	.016	.938	140	.000
Hong Kong	.255	6	.200*	.810	6	.073
Japan	.217	13	.095	.907	13	.169
Taiwan	.171	8	.200*	.934	8	.557
UK	.176	20	.107	.859	20	.007
USA	.135	78	.001	.841	78	.000

a. Lilliefors Significance Correction

\*. This is a lower bound of the true significance.

Test of Homogeneity of Variance

	Levene Statistic	df1	df2	Sig.
End-of-life_stage_score				
Based on Mean	2.141	11	1057	.016
Based on Median	1.504	11	1057	.124
Based on Median and with adjusted df	1.504	11	1010.605	.124
Based on trimmed mean	2.021	11	1057	.024

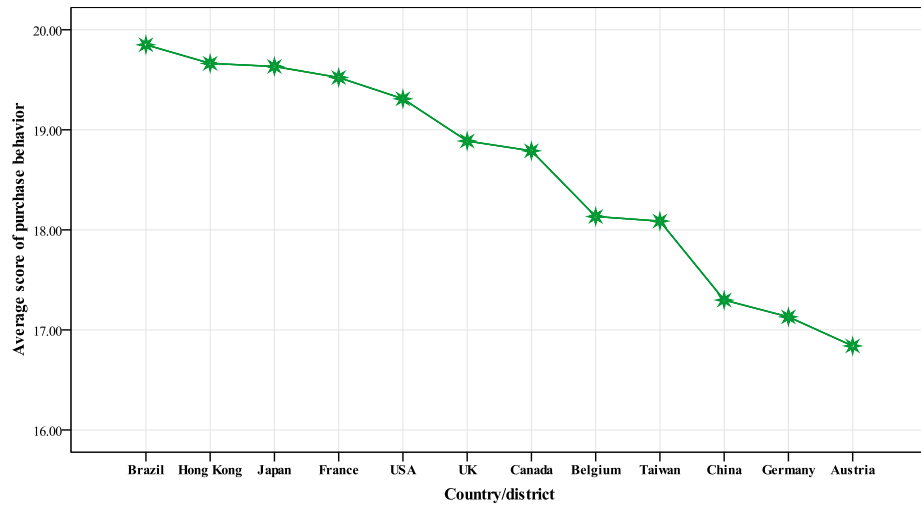
Test of Homogeneity of Variance

	Levene Statistic	df1	df2	Sig.
General_awareness_score				
Based on Mean	3.163	11	1055	.000
Based on Median	2.936	11	1055	.001
Based on Median and with adjusted df	2.936	11	963.978	.001
Based on trimmed mean	2.932	11	1055	.001

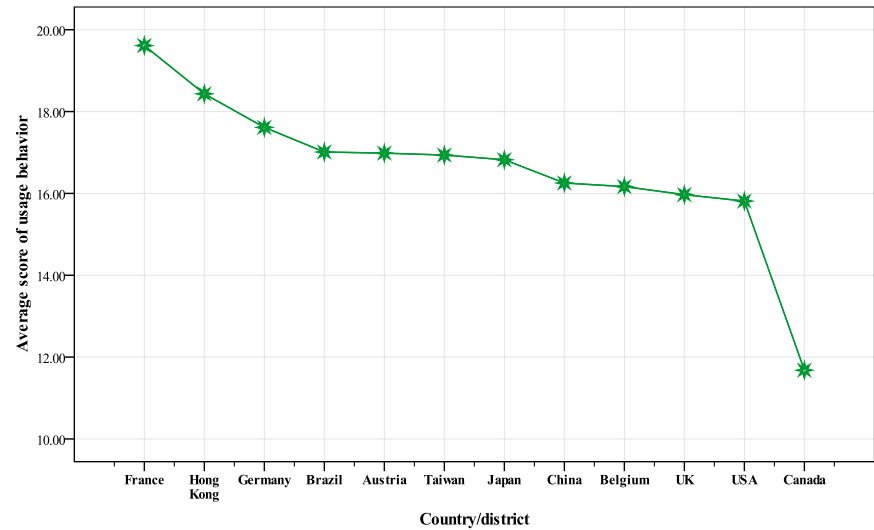


**Appendix 23** SCIndex sectional scores plot of sample means and 95% confidence interval – 12 countries/districts

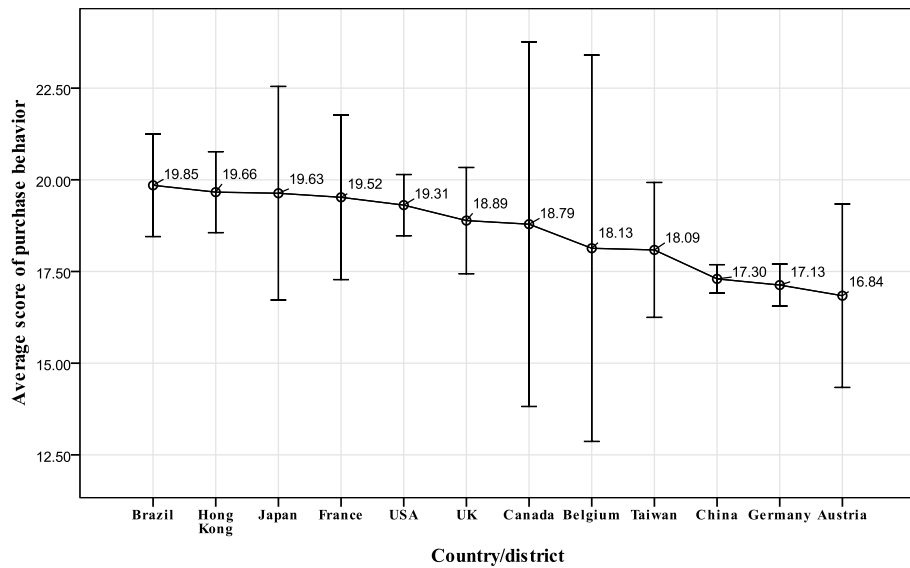
**Household ICT appliances SCIndex - sectional score on purchase stage**



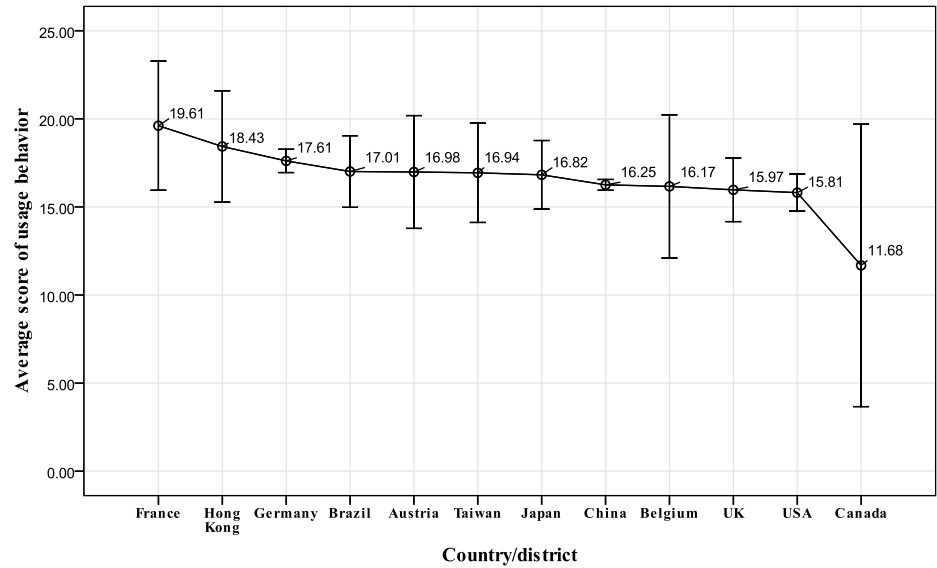
**Household ICT appliances SCIndex - sectional score on usage stage**



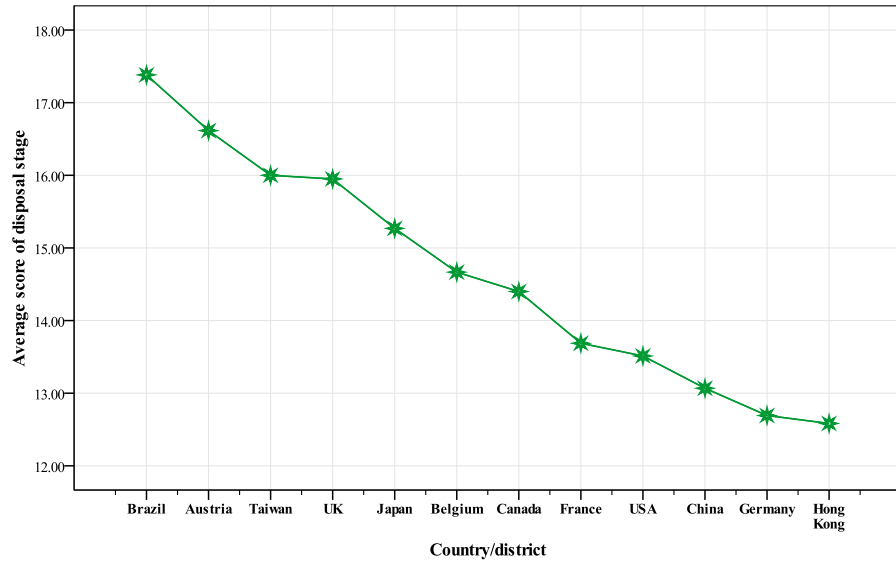
**Household ICT appliances Sustainable Consumption Index sectional score on purchase stage - mean with 95% Confidence Interval**



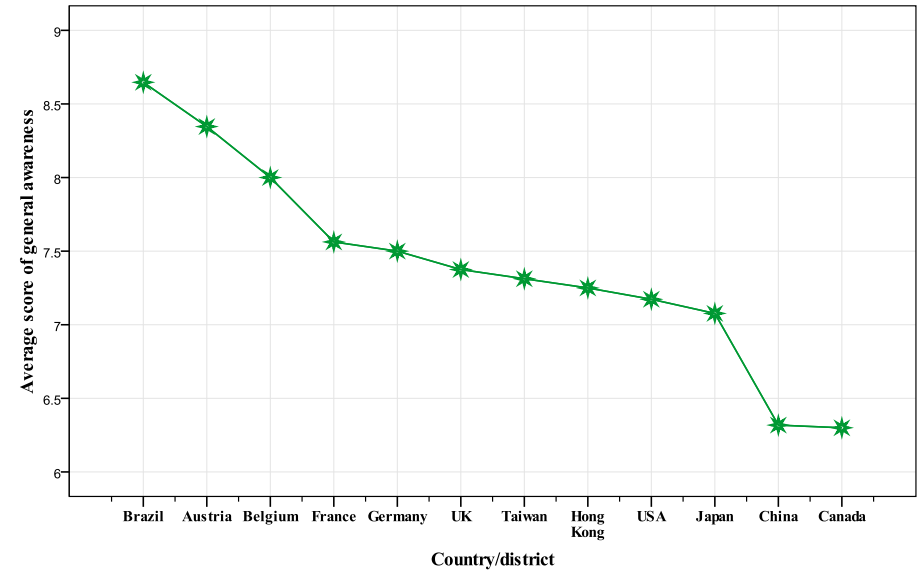
**Household ICT appliances Sustainable Consumption Index sectional score on usage stage - mean with 95% Confidence Interval**



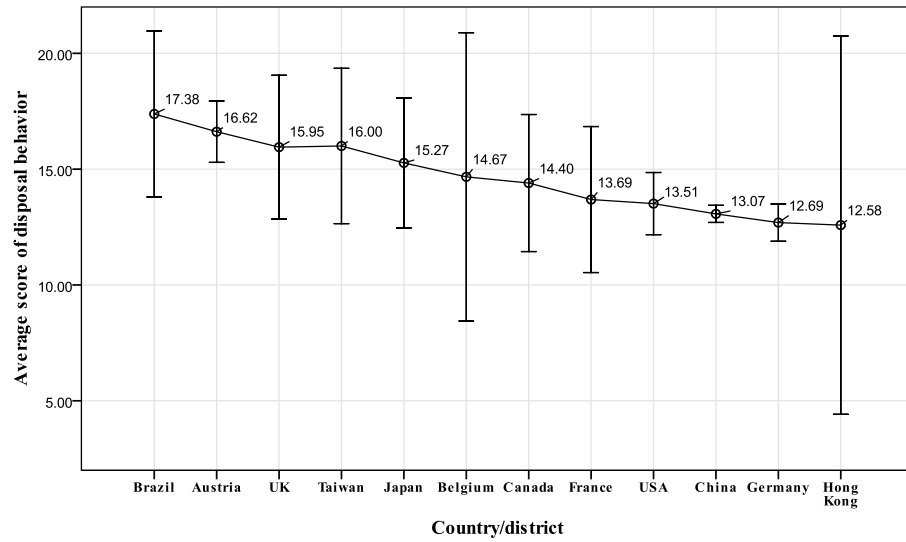
Household ICT appliances SCIndex - sectional score on end-of-life stage



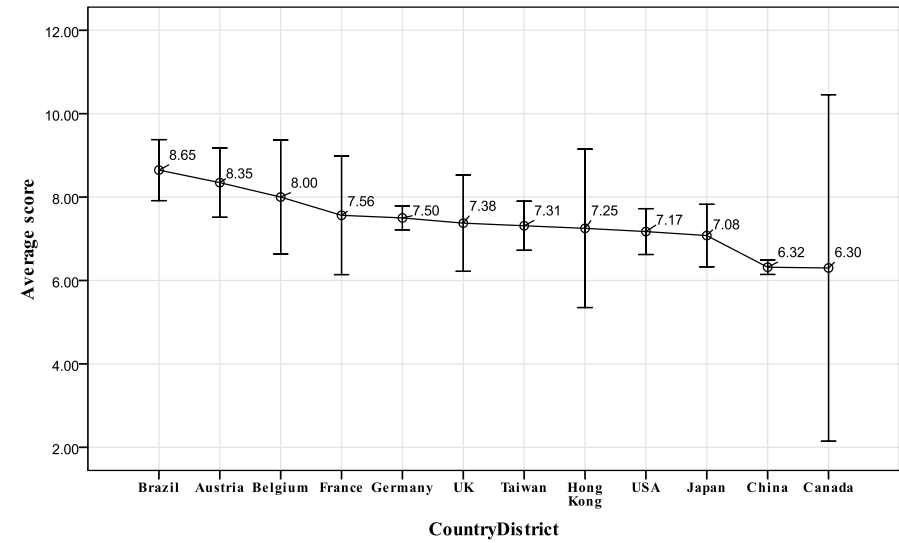
Household ICT appliances SCIndex - sectional score of general awareness



Household ICT appliances Sustainable Consumption Index sectional score on end-of-life stage - mean with 95% Confidence Interval



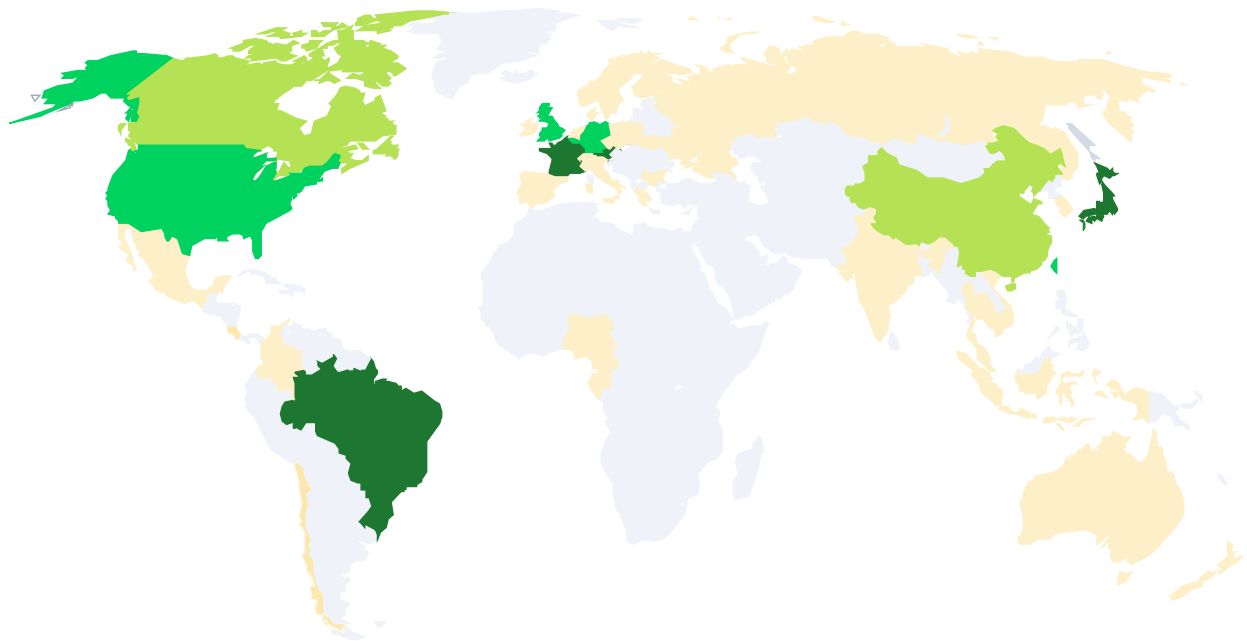
Household ICT appliances Sustainable Consumption Index sectional score general awareness - mean with 95% Confidence Interval



Appendix 24 Household ICT appliances SCIndex score map

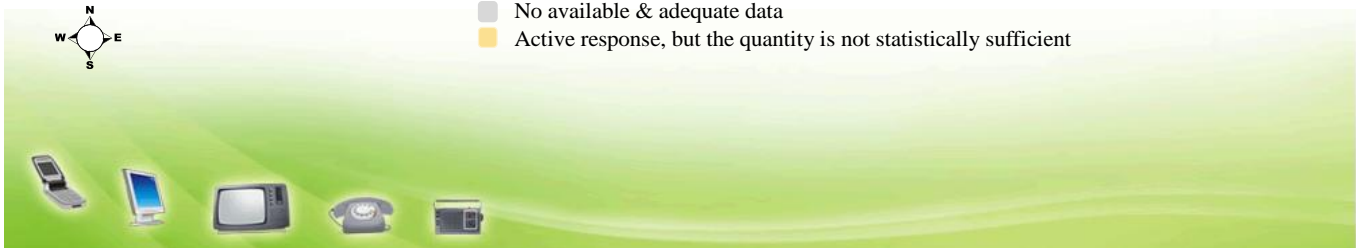


Result of SCIndex Global Anonymous Survey  
Sustainable Consumer Index of Household Information and Communication Technology (ICT) Appliances



**SCIndex Score**  
 ■ 58.6–63.0, more sustainable  
 ■ 54.6–58.5, medium level  
 ■ 50.0–54.5, less sustainable

■ No available & adequate data  
 ■ Active response, but the quantity is not statistically sufficient



**Appendix 25** Reasons to buy a new mobile phone or computer for private use with gender and age – case of China

**Reasons to buy a new one\*Gender Crosstabulation**

			Gender		Total
			female	male	
Reasons to buy a new mobile phone or computer for private use <sup>a</sup>	I never had one	Count	80	83	163
		% within Gender	30.4%	27.7%	
	The old one is outdated	Count	76	112	188
		% within Gender	28.9%	37.3%	
	The old one is too noisy	Count	7	17	24
		% within Gender	2.7%	5.7%	
	The old one consumes too much electricity	Count	12	22	34
		% within Gender	4.6%	7.3%	
	Battery of the old appliance is aging	Count	36	40	76
		% within Gender	13.7%	13.3%	
	The old one is broken	Count	116	124	240
		% within Gender	44.1%	41.3%	
	It's affordable to replace	Count	83	95	178
		% within Gender	31.6%	31.7%	
	Quality is much better	Count	58	71	129
		% within Gender	22.1%	23.7%	
	Modern image	Count	56	51	107
		% within Gender	21.3%	17.0%	
	New function is cool	Count	73	77	150
		% within Gender	27.8%	25.7%	
	It's a symbol of social status	Count	10	24	34
		% within Gender	3.8%	8.0%	
	Gift to friends or relatives	Count	12	21	33
		% within Gender	4.6%	7.0%	
	Better leisure and entertainment	Count	47	71	118
		% within Gender	17.9%	23.7%	
	The new one is environmental friendly product	Count	15	34	49
		% within Gender	5.7%	11.3%	
	I'm urged by promotion activities, like trade-in	Count	10	18	28
		% within Gender	3.8%	6.0%	
	For the convenient e-learning or e-shopping	Count	79	83	162
		% within Gender	30.0%	27.7%	
	Timely and efficient to communicate and contact	Count	108	121	229
		% within Gender	41.1%	40.3%	
	It largely benefits my life, work and study	Count	140	143	283
		% within Gender	53.2%	47.7%	
<b>Total</b>		Count	263	300	563

Percentages and totals are based on respondents.

a. Dichotomy group tabulated at value 1.

**\$r6\*Age Crosstabulation**

			Age							Total	
			<18	18-24	25-35	36-45	46-55	56-65	>65		
Reasons to replace <sup>a</sup>	I never had one	Count	25	40	56	27	15	6	2	171	
		% within Age	55.6%	36.7%	24.3%	19.6%	27.8%	30.0%	66.7%		
	The old one is outdated	Count	10	35	82	43	22	8	1	201	
		% within Age	22.2%	32.1%	35.7%	31.2%	40.7%	40.0%	33.3%		
	The old one is too noisy	Count	2	4	10	4	3	2	1	26	
		% within Age	4.4%	3.7%	4.3%	2.9%	5.6%	10.0%	33.3%		
	The old one consumes too much electricity	Count	0	7	20	6	5	1	0	39	
		% within Age	.0%	6.4%	8.7%	4.3%	9.3%	5.0%	.0%		
	Battery of the old appliance is aging	Count	4	10	37	26	5	4	0	86	
		% within Age	8.9%	9.2%	16.1%	18.8%	9.3%	20.0%	.0%		
	The old one is broken	Count	12	48	101	68	20	5	0	254	
		% within Age	26.7%	44.0%	43.9%	49.3%	37.0%	25.0%	.0%		
	It's affordable to replace	Count	15	30	74	41	14	8	2	184	
		% within Age	33.3%	27.5%	32.2%	29.7%	25.9%	40.0%	66.7%		
	Quality is much better	Count	7	16	60	30	11	10	1	135	
		% within Age	15.6%	14.7%	26.1%	21.7%	20.4%	50.0%	33.3%		
	Modern image	Count	5	20	45	27	8	5	1	111	
		% within Age	11.1%	18.3%	19.6%	19.6%	14.8%	25.0%	33.3%		
	New function is cool	Count	9	24	57	46	11	9	1	157	
		% within Age	20.0%	22.0%	24.8%	33.3%	20.4%	45.0%	33.3%		
	It's a symbol of social status	Count	1	8	15	10	6	2	1	43	
		% within Age	2.2%	7.3%	6.5%	7.2%	11.1%	10.0%	33.3%		
	Gift to friends or relatives	Count	0	7	13	10	3	1	1	35	
		% within Age	.0%	6.4%	5.7%	7.2%	5.6%	5.0%	33.3%		
	Better leisure and entertainment	Count	17	25	45	24	8	9	1	129	
		% within Age	37.8%	22.9%	19.6%	17.4%	14.8%	45.0%	33.3%		
	The new one is environmental friendly product	Count	4	8	14	15	4	6	1	52	
		% within Age	8.9%	7.3%	6.1%	10.9%	7.4%	30.0%	33.3%		
	I'm urged by promotion activities, like trade-in	Count	1	4	13	8	3	0	0	29	
		% within Age	2.2%	3.7%	5.7%	5.8%	5.6%	.0%	.0%		
	For the convenient e-learning or e-shopping	Count	15	30	72	39	10	7	1	174	
		% within Age	33.3%	27.5%	31.3%	28.3%	18.5%	35.0%	33.3%		
	Timely and efficient to communicate and contact	Count	19	36	96	55	23	10	2	241	
		% within Age	42.2%	33.0%	41.7%	39.9%	42.6%	50.0%	66.7%		
	It largely benefits my life, work and study	Count	25	42	115	75	28	14	1	300	
		% within Age	55.6%	38.5%	50.0%	54.3%	51.9%	70.0%	33.3%		
<b>Total</b>			Count	45	109	230	138	54	20	3	599

Percentages and totals are based on respondents.

a. Dichotomy group tabulated at value 1.

**Appendix 26** Factor analysis of the agreements to purchase statements – China

**KMO and Bartlett's Test**

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.626
Bartlett's Test of Sphericity	Approx. Chi-Square	776.607
	df	15
	Sig.	.000

**Total Variance Explained**

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.191	36.513	36.513	2.191	36.513	36.513	1.629	27.150	27.150
2	1.049	17.485	53.998	1.049	17.485	53.998	1.604	26.733	53.882
3	1.015	16.910	70.907	1.015	16.910	70.907	1.021	17.025	70.907
4	.922	15.373	86.280						
5	.477	7.952	94.232						
6	.346	5.768	100.000						

Extraction Method: Principal Component Analysis.

**Component Matrix<sup>a</sup>**

	Component		
	1	2	3
Advertisements and promotions motivate me to buy their products	.601	.575	
Fast emerging new products urges me to purchase continuously to catch up with the trends	.744		
The happiness and satisfaction of my life increases with gaining new products		.469	.475
After getting new products, the actual usability of it is as high as I expected			.868
I prefer to spend my leisure time on shopping	.770		
I always need to buy more, because my own possessions aren't sufficient	.794		

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

**Rotated Component Matrix<sup>a</sup>**

	Component		
	1	2	3
Advertisements and promotions motivate me to buy their products		.843	
Fast emerging new products urges me to purchase continuously to catch up with the trends		.785	
The happiness and satisfaction of my life increases with gaining new products	-.595		
After getting new products, the actual usability of it is as high as I expected			.947
I prefer to spend my leisure time on shopping	.780		
I always need to buy more, because my own possessions aren't sufficient	.767		

Extraction Method: Principal Component Analysis.  
Rotation Method: Varimax with Kaiser Normalization.

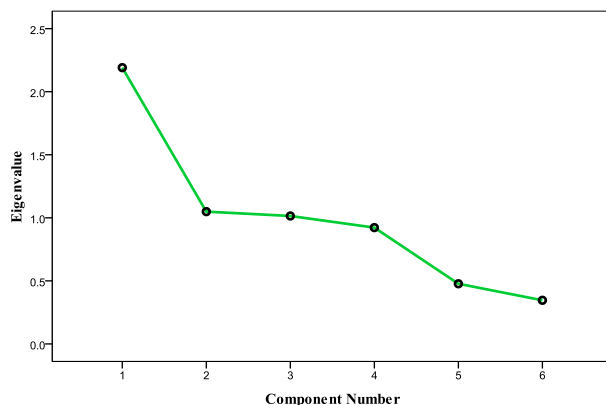
a. Rotation converged in 6 iterations.

**Component Transformation Matrix**

Component	1	2	3
1	.714	.698	.051
2	-.647	.686	-.333
3	-.268	.205	.941

Extraction Method: Principal Component Analysis.  
Rotation Method: Varimax with Kaiser Normalization.

**Scree Plot**



**Appendix 27** Factor analysis of respondents' behavior after using computers – China

**KMO and Bartlett's Test**

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.532
Bartlett's Test of Sphericity	Approx. Chi-Square	580.704
	df	10
	Sig.	.000

**Total Variance Explained**

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.823	36.456	36.456	1.823	36.456	36.456	1.793	35.854	35.854
2	1.139	22.782	59.238	1.139	22.782	59.238	1.099	21.973	57.827
3	1.010	20.201	79.439	1.010	20.201	79.439	1.081	21.613	79.439
4	.724	14.488	93.928						
5	.304	6.072	100.000						

Extraction Method: Principal Component Analysis.

**Component Matrix<sup>a</sup>**

	Component		
	1	2	3
After using the computer, I leave it on until next time	.873		
After using the computer, I set it to stand-by mode		-.754	.464
After using the computer, I leave it in automatic stand-by	.899		
After using the computer, I immediately shut it down	-.486		.694
I unplug it, after turning off		.749	.495

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

**Rotated Component Matrix<sup>a</sup>**

	Component		
	1	2	3
After using the computer, I leave it on until next time	.899		
After using the computer, I set it to stand-by mode			.855
After using the computer, I leave it in automatic stand-by	.910		
After using the computer, I immediately shut it down		.534	.556
I unplug it, after turning off		.875	

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

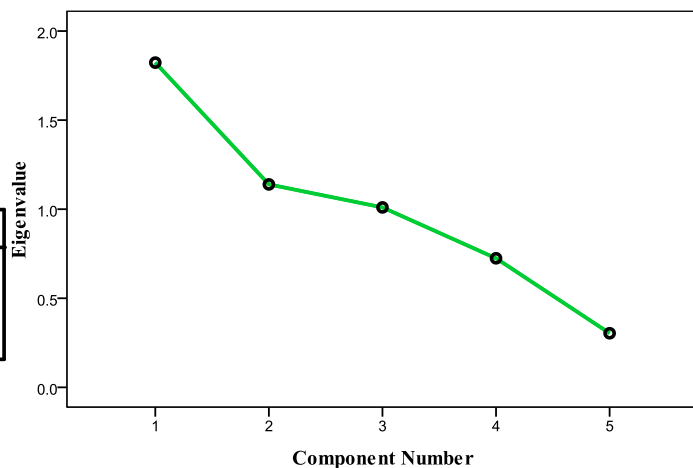
**Component Transformation Matrix**

Component	1	2	3
1	.981	-.182	-.070
2	.077	.691	-.718
3	.179	.699	.692

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

**Scree Plot**



**Appendix 28** Factor analysis of respondents' disposal behavior of ICT appliances – China

**KMO and Bartlett's Test**

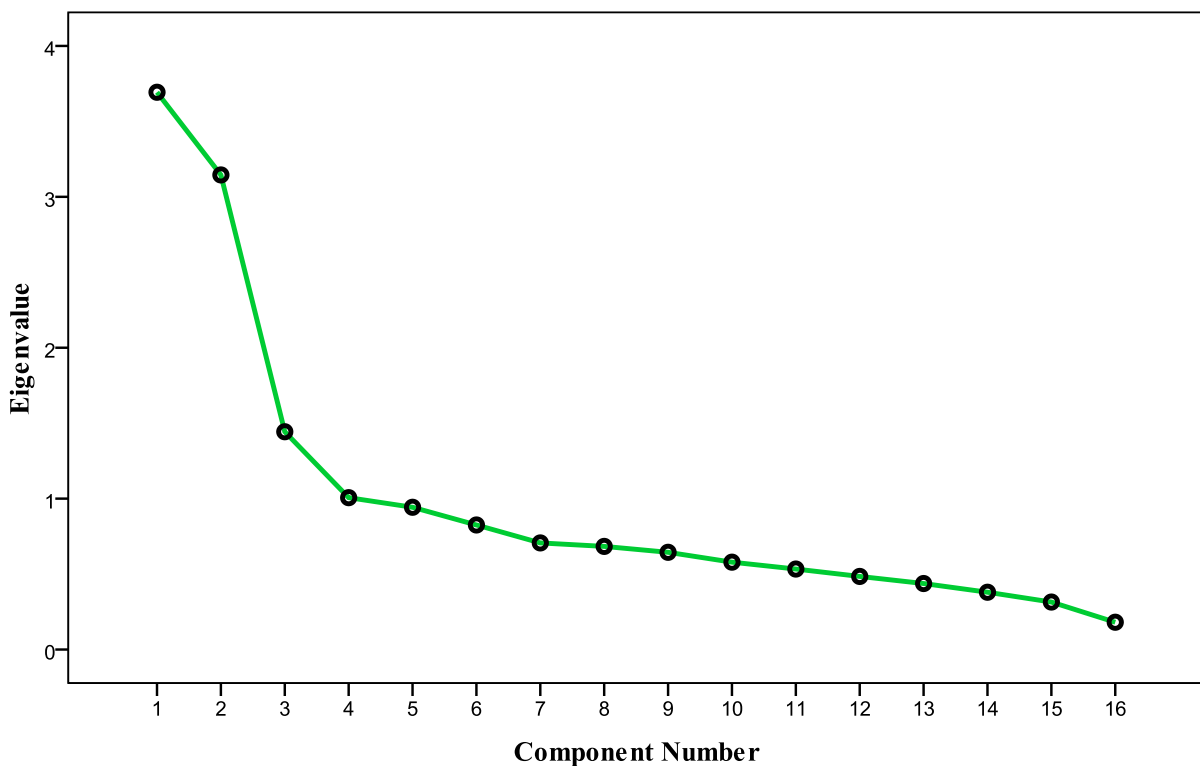
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.805
Bartlett's Test of Sphericity	Approx. Chi-Square	3848.527
	df	120
	Sig.	.000

**Total Variance Explained**

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.693	23.081	23.081	3.693	23.081	23.081	3.250	20.313	20.313
2	3.145	19.657	42.738	3.145	19.657	42.738	2.630	16.438	36.751
3	1.443	9.020	51.758	1.443	9.020	51.758	2.026	12.661	49.412
4	1.006	6.290	58.049	1.006	6.290	58.049	1.382	8.636	58.049
5	.943	5.892	63.941						
6	.825	5.159	69.100						
7	.707	4.416	73.516						
8	.683	4.272	77.788						
9	.644	4.027	81.815						
10	.579	3.619	85.433						
11	.533	3.334	88.767						
12	.484	3.028	91.795						
13	.437	2.734	94.529						
14	.380	2.373	96.902						
15	.315	1.967	98.869						
16	.181	1.131	100.000						

Extraction Method: Principal Component Analysis.

**Scree Plot**



**Component Matrix<sup>a</sup>**

	Component			
	1	2	3	4
If it broke down, I prefer to repair it first, rather than to immediately replace	-.451		.470	
For the mobile phone or laptop computer, I replace battery to extend the life time	-.514			
I prefer to reuse the still functional components				
I donate it to non-profit organization		.732		
I discard it with the garbage	.730			
I throw it on the road side	.715	.502		
I take it to a recycling or collection center		.574		
I prefer to simply store it, rather to invest time and energy to bring it to collection center	.562	.467		
I store it until I have more pieces to bring them to collection center together		.564		
I resell it on-line or at a second-hand store			.620	
As long as the collector pays, regardless of the price, I sell it to him to clear up	.501			
I give it to relatives or friends			.571	
I am well informed of national/local requirement of how to discard appliances		.626		
I care about where the appliance will end up after collection		.574		
I have no time to think much about used appliances	.625			
I'm free to dispose of my things any way I want	.517			

Extraction Method: Principal Component Analysis.

a. 4 components extracted.

**Rotated Component Matrix<sup>a</sup>**

	Component			
	1	2	3	4
If it broke down, I prefer to repair it first, rather than to immediately replace			.547	
For the mobile phone or laptop computer, I replace battery to extend the life time			.532	
I prefer to reuse the still functional components		.567		
I donate it to non-profit organization		.720		
I discard it with the garbage	.772			
I throw it on the road side	.819			
I take it to a recycling or collection center			.569	
I prefer to simply store it, rather to invest time and energy to bring it to collection center	.790			
I store it until I have more pieces to bring them to collection center together			.672	
I resell it on-line or at a second-hand store				.764
As long as the collector pays, regardless of the price, I sell it to him to clear up	.713			
I give it to relatives or friends				.722
I am well informed of national/local requirement of how to discard appliances		.800		
I care about where the appliance will end up after collection		.786		
I have no time to think much about used appliances	.695			
I'm free to dispose of my things any way I want			-.558	

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

**Component Transformation Matrix**

Component	1	2	3	4
1	.744	-.378	-.514	.195
2	.592	.756	.262	-.100
3	.118	-.203	.608	.758
4	-.286	.495	-.545	.614

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.



## Appendix 29 Multiple regression of SCIndex total score with predictors – China

ANOVA<sup>a</sup>

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	33571.801	1	33571.801	364.570	.000 <sup>a</sup>
	Residual	69156.563	751	92.086		
	Total	102728.364	752			
2	Regression	47106.518	2	23553.259	317.590	.000 <sup>b</sup>
	Residual	55621.846	750	74.162		
	Total	102728.364	752			
3	Regression	59799.715	3	19933.238	347.786	.000 <sup>c</sup>
	Residual	42928.649	749	57.315		
	Total	102728.364	752			
4	Regression	64413.740	4	16103.435	314.380	.000 <sup>d</sup>
	Residual	38314.624	748	51.223		
	Total	102728.364	752			
5	Regression	70540.670	5	14108.134	327.416	.000 <sup>e</sup>
	Residual	32187.694	747	43.089		
	Total	102728.364	752			
6	Regression	72456.077	6	12076.013	297.589	.000 <sup>f</sup>
	Residual	30272.288	746	40.579		
	Total	102728.364	752			

a. Predictors: (Constant), Casual disposal

b. Predictors: (Constant), Casual disposal, Reuse & awareness

c. Predictors: (Constant), Casual disposal, Reuse & awareness, Frequency to replace desktop computer

d. Predictors: (Constant), Casual disposal, Reuse & awareness, Frequency to replaced desktop computer, Responsible disposal

e. Predictors: (Constant), Casual disposal, Reuse & awareness, Frequency to replace desktop computer, Responsible disposal, Stimuli oriented

f. Predictors: (Constant), Casual disposal, Reuse & awareness, Frequency to replace desktop computer, Responsible disposal, Stimuli oriented, Simply leave

g. Dependent Variable: SCIndex\_total\_score

Coefficients<sup>a</sup>

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	52.948	.350		151.407	.000	52.261	53.634		
	Casual disposal	-6.687	.350	-0.57	-19.094	.000	-7.374	-5.999	1.000	1.000
2	(Constant)	52.952	.314		168.729	.000	52.336	53.568		
	Casual disposal	-6.694	.314	-.572	-21.299	.000	-7.311	-6.077	1.000	1.000
	Reuse & awareness	4.242	.314	.363	13.509	.000	3.625	4.858	1.000	1.000
3	(Constant)	61.146	.616		99.292	.000	59.937	62.355		
	Casual disposal	-5.940	.281	-.508	-21.147	.000	-6.492	-5.389	.967	1.034
	Reuse & awareness	4.368	.276	.374	15.817	.000	3.826	4.910	.999	1.001
	Frequency to replace desktop computer	-4.226	.284	-.358	-14.882	.000	-4.784	-3.669	.967	1.035
4	(Constant)	61.254	.582		105.196	.000	60.111	62.397		
	Casual disposal	-5.917	.266	-.506	-22.282	.000	-6.439	-5.396	.967	1.034
	Reuse & awareness	4.363	.261	.373	16.711	.000	3.850	4.875	.999	1.001
	Frequency to replace desktop computer	-4.286	.269	-.363	-15.961	.000	-4.814	-3.759	.966	1.035
	Responsible disposal	2.486	.262	.212	9.491	.000	1.972	3.000	.999	1.001
5	(Constant)	60.272	.540		111.541	.000	59.212	61.333		
	Casual disposal	-5.256	.250	-.449	-21.041	.000	-5.746	-4.766	.920	1.087
	Reuse & awareness	4.799	.242	.411	19.814	.000	4.324	5.275	.976	1.024
	Frequency to replace desktop computer	-3.777	.250	-.320	-15.111	.000	-4.268	-3.287	.938	1.066
	Responsible disposal	2.987	.244	.255	12.247	.000	2.508	3.466	.970	1.031
	Stimuli oriented	-3.075	.258	-.263	-11.924	.000	-3.581	-2.568	.865	1.156
6	(Constant)	59.506	.536		110.991	.000	58.453	60.558		
	Casual disposal	-4.717	.255	-.403	-18.512	.000	-5.217	-4.217	.832	1.201
	Reuse & awareness	4.845	.235	.415	20.604	.000	4.384	5.307	.975	1.025
	Frequency to replace desktop computer	-3.382	.249	-.286	-13.567	.000	-3.872	-2.893	.888	1.126
	Responsible disposal	2.913	.237	.248	12.296	.000	2.448	3.378	.968	1.033
	Stimuli oriented	-2.733	.255	-.233	-10.713	.000	-3.234	-2.232	.832	1.202
	Simply leave	-1.824	.266	-.156	-6.870	.000	-2.346	-1.303	.764	1.308

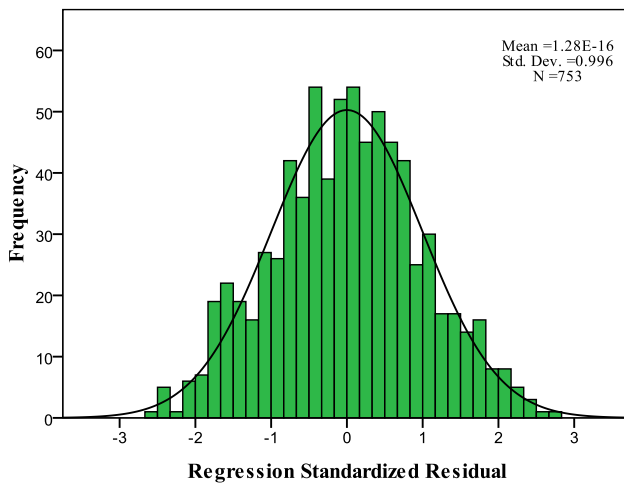
a. Dependent Variable: SCIndex\_total\_score

Model Summary<sup>d</sup>

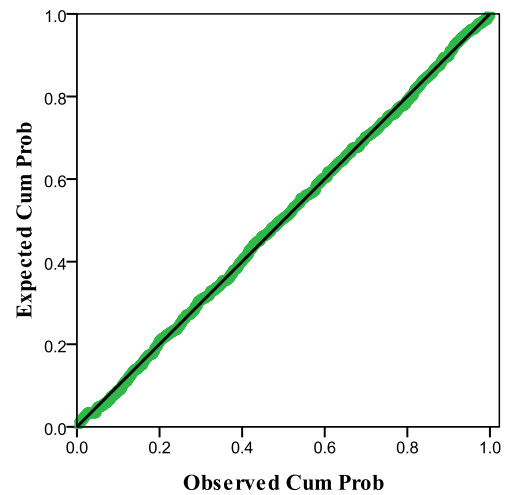
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.572 <sup>a</sup>	.327	.326	9.59614	.327	364.570	1	751	.000	1.578
2	.677 <sup>b</sup>	.459	.457	8.61176	.132	182.501	1	750	.000	
3	.763 <sup>c</sup>	.582	.580	7.57064	.124	221.465	1	749	.000	
4	.792 <sup>d</sup>	.627	.625	7.15701	.045	90.078	1	748	.000	
5	.829 <sup>e</sup>	.687	.685	6.56424	.060	142.191	1	747	.000	
6	.840 <sup>f</sup>	.705	.703	6.37020	.019	47.201	1	746	.000	

- a. Predictors: (Constant), Casual disposal
- b. Predictors: (Constant), Casual disposal, Reuse & awareness
- c. Predictors: (Constant), Casual disposal, Reuse & awareness, Frequency to replace desktop computer
- d. Predictors: (Constant), Casual disposal, Reuse & awareness, Frequency to replace desktop computer, Lifetime extension & Responsible disposal
- e. Predictors: (Constant), Casual disposal, Reuse & awareness, Frequency to replace desktop computer, Lifetime extension & Responsible disposal, Stimuli oriented
- f. Predictors: (Constant), Casual disposal, Reuse & awareness, Frequency to replace desktop computer, Lifetime extension & Responsible disposal, Stimuli oriented, Simply leave
- g. Dependent Variable: SCIndex\_total\_score

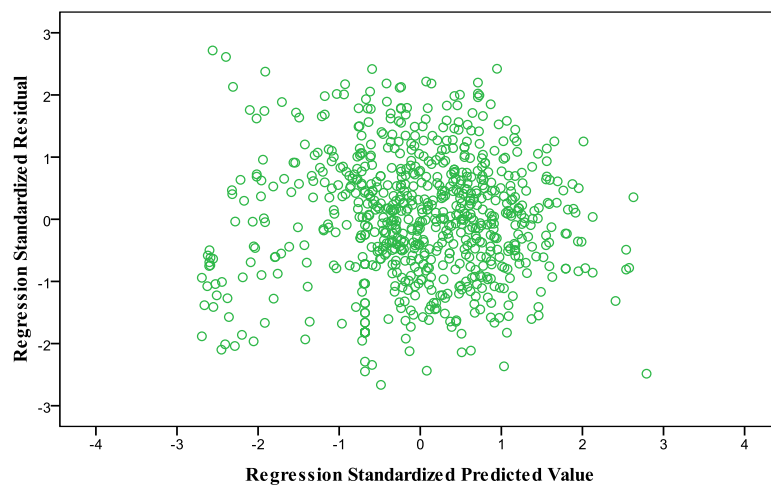
Histogram to test normality of residuals  
Dependent Variable: SCIndex\_total\_score



Normal P-P Plot of Regression Standardized Residual  
Dependent Variable: SCIndex\_total\_score



Scatterplot to test assumption of homoscedasticity  
Dependent Variable: SCIndex\_total\_score



### Appendix 30 Respondents' willingness to buy the laptop with various profiles

#### Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Gender * Willingness to buy the given laptop	995	88.8%	125	11.2%	1120	100.0%

#### Gender \* Willingness to buy the given laptop Crosstabulation

% within Gender

		Willingness to buy the given laptop					Total
		Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any computer	No, I don't need any laptop	
Gender	female	16.5%	24.7%	36.4%	6.7%	15.6%	100.0%
	male	18.7%	22.8%	40.8%	4.3%	13.3%	100.0%
Total		17.7%	23.7%	38.8%	5.4%	14.4%	100.0%

#### Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Profession * Willingness to buy the given laptop	1083	96.7%	37	3.3%	1120	100.0%

#### Profession \* Willingness to buy the given laptop Crosstabulation

% within Profession

		Willingness to buy the given laptop					Total
		Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any computer	No, I don't need any laptop	
Profession	Student	15.5%	25.9%	39.7%	6.7%	12.1%	100.0%
	Educational work	18.0%	24.6%	40.1%	4.8%	12.6%	100.0%
	Scientific researcher	24.3%	30.0%	31.4%	5.7%	8.6%	100.0%
	Medical affairs staff	18.5%	16.7%	37.0%	5.6%	22.2%	100.0%
	Government official	15.4%	15.4%	47.3%	3.3%	18.7%	100.0%
	Company employee / "white-collar employee"	22.8%	23.4%	38.6%	5.7%	9.5%	100.0%
	Factory worker / "blue-collar worker"	22.4%	8.2%	38.8%	6.1%	24.5%	100.0%
	Service sector (restaurant, supermarket, etc.)	8.3%	33.3%	25.0%	11.1%	22.2%	100.0%
	Finance and insurance business	17.6%	17.6%	41.2%	5.9%	17.6%	100.0%
	Farmer	7.3%	26.8%	39.0%	12.2%	14.6%	100.0%
	Others	16.8%	25.5%	41.0%	4.3%	12.4%	100.0%
Total		17.6%	23.5%	39.2%	5.8%	13.8%	100.0%

#### Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Education * Willingness to buy the given laptop	1075	96.0%	45	4.0%	1120	100.0%

#### Education \* Willingness to buy the given laptop Crosstabulation

% within Education

		Willingness to buy the given laptop					Total
		Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any computer	No, I don't need any laptop	
Education	primary or less school (middle or high)	16.7%	16.7%	50.0%	16.7%		100.0%
	undergraduate	10.0%	19.6%	42.5%	10.3%	17.6%	100.0%
	graduate	17.4%	23.2%	42.0%	3.8%	13.6%	100.0%
	higher	26.0%	27.1%	32.6%	3.5%	10.9%	100.0%
Total		21.4%	28.6%	31.0%	7.1%	11.9%	100.0%
		17.7%	23.5%	39.1%	5.9%	13.9%	100.0%

## Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Age * Willingness to buy the given laptop	1069	95.4%	51	4.6%	1120	100.0%

## Age \* Willingness to buy the given laptop Crosstabulation

% within Age

		Willingness to buy the given laptop				Total	
		Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any computer		No, I don't need any laptop
Age	<18	9.0%	23.1%	34.6%	16.7%	16.7%	100.0%
	18-24	13.1%	27.3%	45.5%	6.1%	8.1%	100.0%
	25-35	19.5%	26.4%	36.7%	4.2%	13.2%	100.0%
	36-45	21.5%	18.2%	36.4%	4.8%	19.1%	100.0%
	46-55	17.0%	18.1%	45.7%	6.4%	12.8%	100.0%
	56-65	23.1%	15.4%	40.4%	3.8%	17.3%	100.0%
	>65	7.7%	30.8%	30.8%	15.4%	15.4%	100.0%
Total		17.8%	23.5%	39.0%	5.9%	13.8%	100.0%

## Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Salary * Willingness to buy the given laptop	1022	91.3%	98	8.8%	1120	100.0%

## Salary \* Willingness to buy the given laptop Crosstabulation

% within Salary

		Willingness to buy the given laptop				Total	
		Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any computer		No, I don't need any laptop
Salary	0-1000	14.4%	24.1%	37.5%	9.1%	15.0%	100.0%
	1000-3000	14.2%	21.8%	39.5%	6.1%	18.4%	100.0%
	3000-5000	16.1%	17.9%	45.5%	4.5%	16.1%	100.0%
	5000-10000	22.7%	22.7%	43.2%		11.4%	100.0%
	10000-15000	29.8%	24.6%	36.8%	3.5%	5.3%	100.0%
	15000-20000	20.6%	17.6%	44.1%		17.6%	100.0%
	20000-30000	34.0%	28.0%	28.0%	4.0%	6.0%	100.0%
	30000-50000	20.0%	24.4%	35.6%	6.7%	13.3%	100.0%
	>50000	27.3%	32.7%	25.5%	5.5%	9.1%	100.0%
Total		18.2%	23.2%	38.4%	5.9%	14.4%	100.0%

## Ownership \* Willingness to buy the given laptop Crosstabulation

% within Ownership

		Willingness to buy the given laptop				Total	
		Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any computer		No, I don't need any laptop
Ownership	renting	23.2%	27.3%	37.4%	3.7%	8.4%	100.0%
	owning	16.6%	21.4%	37.8%	7.0%	17.2%	100.0%
	others	14.2%	25.1%	44.3%	5.5%	10.9%	100.0%
Total		18.0%	23.7%	38.8%	5.8%	13.7%	100.0%

## Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Ownership * Willingness to buy the given laptop	1054	94.1%	66	5.9%	1120	100.0%

## Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Number of people * Willingness to buy the given laptop	1067	95.3%	53	4.7%	1120	100.0%

## Number of people \* Willingness to buy the given laptop Crosstabulation

% within NoP

		Willingness to buy the given laptop					Total
		Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any computer	No, I don't need any laptop	
Number of people in your household	1	21.1%	18.7%	49.6%	2.4%	8.1%	100.0%
	2	20.9%	28.0%	33.6%	4.7%	12.8%	100.0%
	3	19.0%	26.2%	36.1%	4.8%	13.9%	100.0%
	4	16.7%	23.6%	40.4%	3.0%	16.3%	100.0%
	5	13.9%	13.9%	35.6%	17.8%	18.8%	100.0%
	>5	8.2%	22.7%	48.5%	8.2%	12.4%	100.0%
Total		17.7%	23.7%	39.1%	5.7%	13.8%	100.0%

## Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Country/district * Willingness to buy the given laptop	1055	98.7%	14	1.3%	1069	100.0%

## Country/district \* Willingness to buy the given laptop Crosstabulation

% within CountryDistrict

		Willingness to buy the given laptop					Total
		Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any computer	No, I don't need any laptop	
Country/district	Austria	30.8%	23.1%	46.2%			100.0%
	Belgium	66.7%		16.7%	16.7%		100.0%
	Brazil	31.3%	25.0%	25.0%	6.3%	12.5%	100.0%
	Canada	40.0%	20.0%	20.0%		20.0%	100.0%
	China	13.8%	20.5%	43.5%	6.7%	15.4%	100.0%
	France	25.0%	37.5%	37.5%			100.0%
	Germany	23.9%	28.3%	34.8%	.7%	12.3%	100.0%
	Hong Kong	33.3%	50.0%		16.7%		100.0%
	Japan	7.7%	23.1%	46.2%	15.4%	7.7%	100.0%
	Taiwan	12.5%	50.0%	37.5%			100.0%
	UK	35.0%	25.0%	20.0%	5.0%	15.0%	100.0%
	USA	22.1%	29.9%	26.0%	6.5%	15.6%	100.0%
Total		17.2%	22.8%	39.8%	5.9%	14.3%	100.0%

### Appendix 31 Chi-square test of willingness to buy the assumed laptop

Education \* Willingness to buy the given laptop Crosstabulation - for chi-square test

			Willingness to buy the given laptop				Total
			Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any laptop	
Education	school (middle or high)	Count	30	59	128	53	270
		% within Education	11.1%	21.9%	47.4%	19.6%	100.0%
	undergraduate	Count	74	99	179	58	410
		% within Education	18.0%	24.1%	43.7%	14.1%	100.0%
	graduate	Count	67	70	84	28	249
		% within Education	26.9%	28.1%	33.7%	11.2%	100.0%
	higher	Count	18	24	26	10	78
		% within Education	23.1%	30.8%	33.3%	12.8%	100.0%
Total		Count	189	252	417	149	1007
		% within Education	18.8%	25.0%	41.4%	14.8%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	35.623 <sup>a</sup>	9	.000
Likelihood Ratio	35.945	9	.000
Linear-by-Linear Association	24.069	1	.000
N of Valid Cases	1007		

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.188	.000
	Cramer's V	.109	.000
	Contingency Coefficient	.185	.000
N of Valid Cases		1007	

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.54.

Age \* Willingness to buy the given laptop Crosstabulation - for chi-square test

			Willingness to buy the given laptop				Total
			Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any laptop	
Age	<18	Count	7	18	27	13	65
		% within Age	10.8%	27.7%	41.5%	20.0%	100.0%
	18-24	Count	26	54	90	16	186
		% within Age	14.0%	29.0%	48.4%	8.6%	100.0%
	25-35	Count	83	112	156	56	407
		% within Age	20.4%	27.5%	38.3%	13.8%	100.0%
	36-45	Count	45	38	76	40	199
		% within Age	22.6%	19.1%	38.2%	20.1%	100.0%
	46-55	Count	16	17	43	12	88
		% within Age	18.2%	19.3%	48.9%	13.6%	100.0%
Total		Count	177	239	392	137	945
		% within Age	18.7%	25.3%	41.5%	14.5%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	28.009 <sup>a</sup>	12	.006
Likelihood Ratio	28.857	12	.004
Linear-by-Linear Association	.043	1	.836
N of Valid Cases	945		

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.172	.006
	Cramer's V	.099	.006
	Contingency Coefficient	.170	.006
N of Valid Cases		945	

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.42.

Ownership \* Willingness to buy the given laptop Crosstabulation

			Willingness to buy the given laptop					Total
			Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any computer	No, I don't need any laptop	
Ownership	renting	Count	69	81	111	11	25	297
		% within Ownership	23.2%	27.3%	37.4%	3.7%	8.4%	100.0%
	owning	Count	95	123	217	40	99	574
		% within Ownership	16.6%	21.4%	37.8%	7.0%	17.2%	100.0%
	others	Count	26	46	81	10	20	183
		% within Ownership	14.2%	25.1%	44.3%	5.5%	10.9%	100.0%
Total		Count	190	250	409	61	144	1054
		% within Ownership	18.0%	23.7%	38.8%	5.8%	13.7%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	27.380 <sup>a</sup>	8	.001
Likelihood Ratio	27.906	8	.000
Linear-by-Linear Association	9.076	1	.003
N of Valid Cases	1054		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.59.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.161	.001
	Cramer's V	.114	.001
	Contingency Coefficient	.159	.001
N of Valid Cases		1054	

Salary \* Willingness to buy the given laptop Crosstabulation - for chi-square test

		Willingness to buy the given laptop				Total	
		Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any laptop		
Salary	0-1000	Count	46	77	120	48	291
		% within Salary	15.8%	26.5%	41.2%	16.5%	100.0%
	1000-3000	Count	37	57	103	48	245
		% within Salary	15.1%	23.3%	42.0%	19.6%	100.0%
	3000-5000	Count	18	20	51	18	107
		% within Salary	16.8%	18.7%	47.7%	16.8%	100.0%
	5000-10000	Count	20	20	38	10	88
		% within Salary	22.7%	22.7%	43.2%	11.4%	100.0%
	10000-15000	Count	17	14	21	3	55
		% within Salary	30.9%	25.5%	38.2%	5.5%	100.0%
	15000-20000	Count	7	6	15	6	34
		% within Salary	20.6%	17.6%	44.1%	17.6%	100.0%
	20000-30000	Count	17	14	14	3	48
		% within Salary	35.4%	29.2%	29.2%	6.3%	100.0%
	30000-50000	Count	9	11	16	6	42
		% within Salary	21.4%	26.2%	38.1%	14.3%	100.0%
	>50000	Count	15	18	14	5	52
		% within Salary	28.8%	34.6%	26.9%	9.6%	100.0%
Total	Count	186	237	392	147	962	
	% within Salary	19.3%	24.6%	40.7%	15.3%	100.0%	

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	40.649 <sup>a</sup>	24	.018
Likelihood Ratio	41.032	24	.017
Linear-by-Linear Association	17.276	1	.000
N of Valid Cases	962		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.20.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.206	.018
	Cramer's V	.119	.018
	Contingency Coefficient	.201	.018
N of Valid Cases		962	

NoP \* Willingness to buy the given laptop Crosstabulation - for chi-square test

		Willingness to buy the given laptop				Total		
		Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any computer			
NoP	1	Count	26	23	61	3	10	123
		% within NoP	21.1%	18.7%	49.6%	2.4%	8.1%	100.0%
	2	Count	44	59	71	10	27	211
		% within NoP	20.9%	28.0%	33.6%	4.7%	12.8%	100.0%
	3	Count	63	87	120	16	46	332
		% within NoP	19.0%	26.2%	36.1%	4.8%	13.9%	100.0%
	4	Count	34	48	82	6	33	203
		% within NoP	16.7%	23.6%	40.4%	3.0%	16.3%	100.0%
	5	Count	14	14	36	18	19	101
		% within NoP	13.9%	13.9%	35.6%	17.8%	18.8%	100.0%
	>5	Count	8	22	47	8	12	97
		% within NoP	8.2%	22.7%	48.5%	8.2%	12.4%	100.0%
Total	Count	189	253	417	61	147	1067	
	% within NoP	17.7%	23.7%	39.1%	5.7%	13.8%	100.0%	

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	63.196 <sup>a</sup>	20	.000
Likelihood Ratio	56.768	20	.000
Linear-by-Linear Association	14.560	1	.000
N of Valid Cases	1067		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.55.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.243	.000
	Cramer's V	.122	.000
	Contingency Coefficient	.236	.000
N of Valid Cases		1067	

## Appendix 32 Multinomial logistic regression models of willingness to buy the laptop

Multinomial Logistic Regression - Case Processing Summary

		N	Marginal Percentage
Willingness to buy the given laptop	Yes, I will	176	17.3%
	Yes, I'll probably buy it. But I still have concerns	243	23.9%
	No, I have concerns	406	39.9%
	No, I don't need any computer	59	5.8%
	No, I don't need any laptop	134	13.2%
Number of people	1	116	11.4%
	2	200	19.6%
	3	314	30.8%
	4	198	19.4%
	5	97	9.5%
	>5	93	9.1%
Have you ever used any second-hand household electronic appliance?	no	634	62.3%
	yes	384	37.7%
Valid		1018	100.0%
Missing		102	
Total		1120	
Subpopulation		12	

Model Fitting Information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	351.848			
Final	205.970	145.878	24	.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	25.617	20	.179
Deviance	25.991	20	.166

Step Summary

Model	Action	Effect(s)	Model Fitting Criteria	Effect Selection Tests		
			-2 Log Likelihood	Chi-Square <sup>a</sup>	df	Sig.
0	Entered	Intercept	351.848	.		
1	Entered	Have ever used	264.453	87.395	4	.000
2	Entered	Number of people	205.970	58.483	20	.000

Pseudo R-Square

Cox and Snell	.134
Nagelkerke	.141
McFadden	.050

Stepwise Method: Forward Entry

a. The chi-square for entry is based on the likelihood ratio test.

Likelihood Ratio Tests

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	205.970 <sup>a</sup>	.000	0	.
Number of people	264.453	58.483	20	.000
Have you every used	287.279	81.309	4	.000

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Classification

Observed	Predicted					Percent Correct
	Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any computer	No, I don't need any laptop	
Yes, I will	0	79	97	0	0	.0%
Yes, I'll probably buy it. But I still have concerns	0	105	138	0	0	43.2%
No, I have concerns	0	85	321	0	0	79.1%
No, I don't need any computer	0	14	45	0	0	.0%
No, I don't need any laptop	0	27	107	0	0	.0%
Overall Percentage	.0%	30.5%	69.5%	.0%	.0%	41.8%



Multinomial Logistic Regression -Parameter Estimates

Willingness to buy the given laptop <sup>a</sup>		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
Yes, I will	Intercept	-1.105	.455	5.903	1	.015			
	[NoP=1] <sup>c</sup>	.949	.507	3.506	1	.061	2.584	.957	6.978
	[NoP=2]	1.340	.486	7.596	1	.006	3.819	1.473	9.905
	[NoP=3]	1.313	.470	7.812	1	.005	3.718	1.480	9.337
	[NoP=4]	1.002	.489	4.198	1	.040	2.723	1.044	7.101
	[NoP=5]	.955	.557	2.939	1	.086	2.598	.872	7.737
	[NoP=6]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[r121=0] <sup>d</sup>	-1.389	.193	51.815	1	.000	.249	.171	.364
[r121=1]	0 <sup>b</sup>	.	.	0	.	.	.	.	
Yes, I'll probably buy it. But I still have concerns	Intercept	.071	.290	.060	1	.806			
	[NoP=1] <sup>c</sup>	-.410	.370	1.229	1	.268	.664	.322	1.370
	[NoP=2]	.440	.325	1.842	1	.175	1.553	.822	2.934
	[NoP=3]	.320	.305	1.105	1	.293	1.378	.758	2.504
	[NoP=4]	.054	.327	.027	1	.869	1.055	.556	2.003
	[NoP=5]	-.272	.423	.414	1	.520	.762	.333	1.745
	[NoP=6]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[r121=0] <sup>d</sup>	-1.153	.174	43.860	1	.000	.316	.224	.444
[r121=1]	0 <sup>b</sup>	.	.	0	.	.	.	.	
No, I don't need any computer	Intercept	-1.378	.445	9.597	1	.002			
	[NoP=1] <sup>c</sup>	-1.718	.816	4.435	1	.035	.179	.036	.888
	[NoP=2]	-.220	.515	.183	1	.669	.803	.293	2.201
	[NoP=3]	-.337	.472	.508	1	.476	.714	.283	1.802
	[NoP=4]	-.918	.572	2.574	1	.109	.399	.130	1.226
	[NoP=5]	1.045	.481	4.716	1	.030	2.843	1.107	7.298
	[NoP=6]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[r121=0] <sup>d</sup>	-.463	.309	2.243	1	.134	.629	.343	1.154
[r121=1]	0 <sup>b</sup>	.	.	0	.	.	.	.	
No, I don't need any laptop	Intercept	-1.261	.372	11.495	1	.001			
	[NoP=1] <sup>c</sup>	-.700	.498	1.978	1	.160	.497	.187	1.317
	[NoP=2]	.301	.404	.555	1	.456	1.351	.612	2.982
	[NoP=3]	.272	.372	.533	1	.465	1.312	.633	2.721
	[NoP=4]	.344	.388	.790	1	.374	1.411	.660	3.016
	[NoP=5]	.630	.435	2.102	1	.147	1.878	.801	4.402
	[NoP=6]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[r121=0] <sup>d</sup>	-.077	.230	.113	1	.736	.925	.590	1.452
[r121=1]	0 <sup>b</sup>	.	.	0	.	.	.	.	

a. The reference category is: No, I have concerns.

b. This parameter is set to zero because it is redundant.

c.'NoP' = Number of people at your residence. 6=">5" (persons)

d.'r121' = Have you ever used the second-hand household electronic appliances? 0="No", 1="Yes"

**Multinomial Logistic Regression - Case Processing Summary**

		N	Marginal Percentage
Willingness to buy the given laptop	Yes, I will	173	17.7%
	Yes, I'll probably buy it. But I still have concerns	230	23.5%
	No, I have concerns	382	39.1%
	No, I don't need any computer	58	5.9%
	No, I don't need any laptop	134	13.7%
Salary	0-1000	307	31.4%
	1000-3000	248	25.4%
	3000-5000	107	11.0%
	5000-10000	82	8.4%
	10000-15000	55	5.6%
	15000-20000	34	3.5%
	20000-30000	47	4.8%
	30000-50000	43	4.4%
	>50000	54	5.5%
	Have you ever used any second-hand household electronic appliance?	no	604
yes		373	38.2%
Valid		977	100.0%
Missing		143	
Total		1120	
Subpopulation		18	

**Step Summary**

Model	Action	Effect(s)	Model Fitting Criteria		Effect Selection Tests	
			-2 Log Likelihood	Chi-Square <sup>a</sup>	df	Sig.
0	Entered	Intercept	398.049	.		
1	Entered	Have ever used	311.601	86.449	4	.000
2	Entered	Salary	257.879	53.721	32	.009

**Pseudo R-Square**

Cox and Snell	.134
Nagelkerke	.141
McFadden	.049

Stepwise Method: Forward Entry

a. The chi-square for entry is based on the likelihood ratio test.

**Model Fitting Information**

Model	Model Fitting Criteria		Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.	
Intercept Only	398.049				
Final	257.879	140.170	36	.000	

**Goodness-of-Fit**

	Chi-Square	df	Sig.
Pearson	37.909	32	.218
Deviance	40.820	32	.136

**Likelihood Ratio Tests**

Effect	Model Fitting Criteria		Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.	
Intercept	257.879 <sup>a</sup>	.000	0	.	
Have ever used	334.707	76.828	4	.000	
Salary	311.601	53.721	32	.009	

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

**Classification**

Observed	Predicted					Percent Correct
	Yes, I will	Yes, I'll probably buy it. But I still have concerns	No, I have concerns	No, I don't need any computer	No, I don't need any laptop	
Yes, I will	24	56	93	0	0	13.9%
Yes, I'll probably buy it. But I still have concerns	19	77	134	0	0	33.5%
No, I have concerns	11	64	307	0	0	80.4%
No, I don't need any computer	2	15	41	0	0	.0%
No, I don't need any laptop	5	26	103	0	0	.0%
Overall Percentage	6.2%	24.4%	69.4%	.0%	.0%	41.8%

Multinomial Logistic Regression -Parameter Estimates

		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
<b>Willingness to buy the given laptop<sup>a</sup></b>									
Yes, I will	Intercept	1.901	.585	1.05E1	1	.001			
	[r121=0] <sup>c</sup>	-1.313	.256	2.63E1	1	.000	.269	.163	.444
	[r121=1]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[Salary=1]	-1.078	.612	3.106	1	.078	.340	.103	1.128
	[Salary=2]	-1.300	.617	4.438	1	.035	.272	.081	.913
	[Salary=3]	-1.136	.667	2.900	1	.089	.321	.087	1.187
	[Salary=4]	-.645	.707	.833	1	.361	.524	.131	2.097
	[Salary=5]	.990	.945	1.098	1	.295	2.691	.422	17.147
	[Salary=6]	-.999	.805	1.539	1	.215	.368	.076	1.785
	[Salary=7]	.300	.860	.122	1	.727	1.350	.250	7.281
[Salary=8]	-1.023	.783	1.709	1	.191	.360	.078	1.667	
[Salary=9]	0 <sup>b</sup>	.	.	0	.	.	.	.	
Yes, I'll probably buy it. But I still have concerns	Intercept	2.011	.573	1.23E1	1	.000			
	[r121=0] <sup>c</sup>	-1.084	.241	2.01E1	1	.000	.338	.211	.543
	[r121=1]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[Salary=1]	-.751	.592	1.610	1	.204	.472	.148	1.505
	[Salary=2]	-1.024	.596	2.951	1	.086	.359	.112	1.155
	[Salary=3]	-1.303	.653	3.983	1	.046	.272	.076	.977
	[Salary=4]	-.723	.692	1.092	1	.296	.485	.125	1.884
	[Salary=5]	.584	.943	.384	1	.535	1.794	.283	11.386
	[Salary=6]	-1.364	.809	2.843	1	.092	.256	.052	1.248
	[Salary=7]	.105	.850	.015	1	.902	1.110	.210	5.876
[Salary=8]	-1.084	.765	2.007	1	.157	.338	.076	1.515	
[Salary=9]	0 <sup>b</sup>	.	.	0	.	.	.	.	
No, I have concerns	Intercept	1.207	.584	4.272	1	.039			
	[r121=0] <sup>c</sup>	.074	.233	.102	1	.749	1.077	.683	1.699
	[r121=1]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[Salary=1]	-.297	.595	.248	1	.618	.743	.231	2.388
	[Salary=2]	-.387	.597	.420	1	.517	.679	.211	2.189
	[Salary=3]	-.243	.631	.148	1	.700	.784	.228	2.702
	[Salary=4]	.159	.678	.055	1	.815	1.172	.310	4.426
	[Salary=5]	1.041	.934	1.242	1	.265	2.832	.454	17.662
	[Salary=6]	-.345	.745	.215	1	.643	.708	.164	3.052
	[Salary=7]	.283	.852	.110	1	.740	1.327	.250	7.055
[Salary=8]	-.330	.745	.196	1	.658	.719	.167	3.097	
[Salary=9]	0 <sup>b</sup>	.	.	0	.	.	.	.	
No, I don't need any computer	Intercept	-.085	.787	.012	1	.914			
	[r121=0] <sup>c</sup>	-.364	.349	1.088	1	.297	.695	.351	1.377
	[r121=1]	0 <sup>b</sup>	.	.	0	.	.	.	.
	[Salary=1]	-.060	.804	.006	1	.941	.942	.195	4.551
	[Salary=2]	-.681	.823	.683	1	.408	.506	.101	2.543
	[Salary=3]	-1.153	.945	1.487	1	.223	.316	.050	2.014
	[Salary=4]	-20.400	.000	.	1	.	1.381E-9	1.38E-9	1.38E-9
	[Salary=5]	.334	1.260	.070	1	.791	1.396	.118	16.487
	[Salary=6]	-20.847	.000	.	1	.	8.83E-10	8.8E-10	8.8E-10
	[Salary=7]	-.095	1.191	.006	1	.936	.909	.088	9.386
[Salary=8]	-.437	1.042	.176	1	.675	.646	.084	4.979	
[Salary=9]	0 <sup>b</sup>	.	.	0	.	.	.	.	

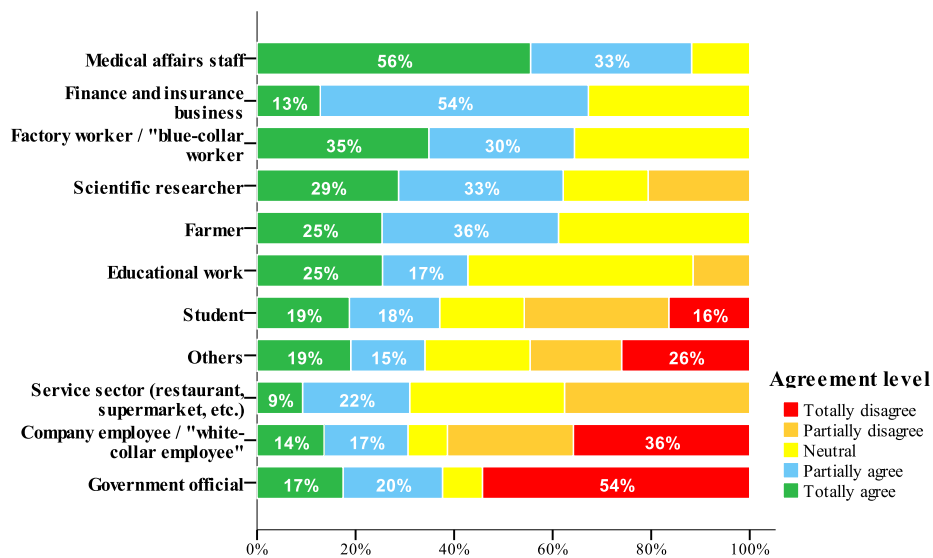
a. The reference category is: No, I don't need any laptop.

b. This parameter is set to zero because it is redundant.

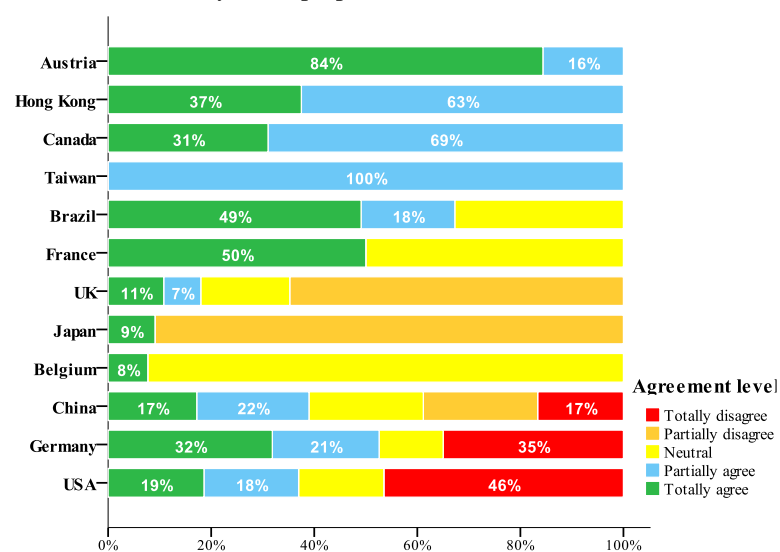
c.'r121' = Have you ever used the second-hand household electronic appliances? 0="No", 1="Yes"

### Appendix 33 Reasons to buy the assumed laptop

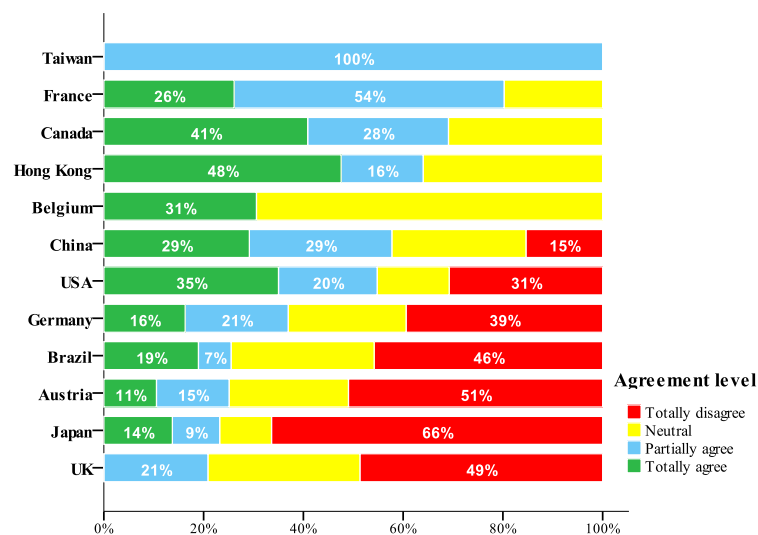
**I'd love to buy this laptop, because it is portable**



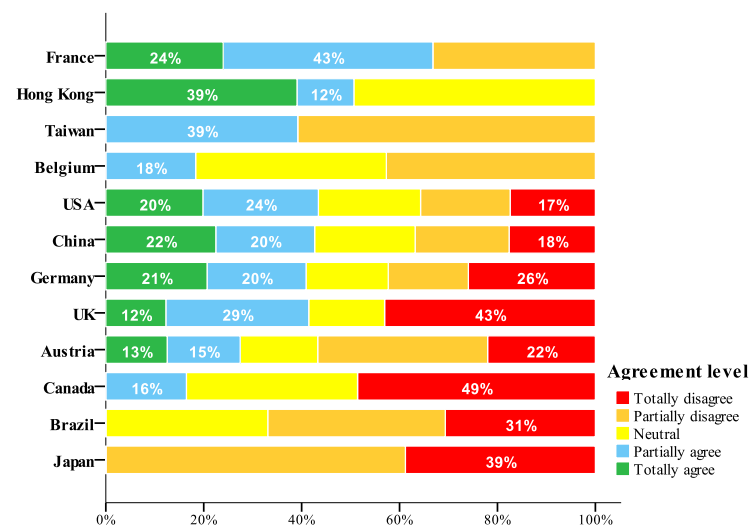
**I'd love to buy this laptop, because it is economical**



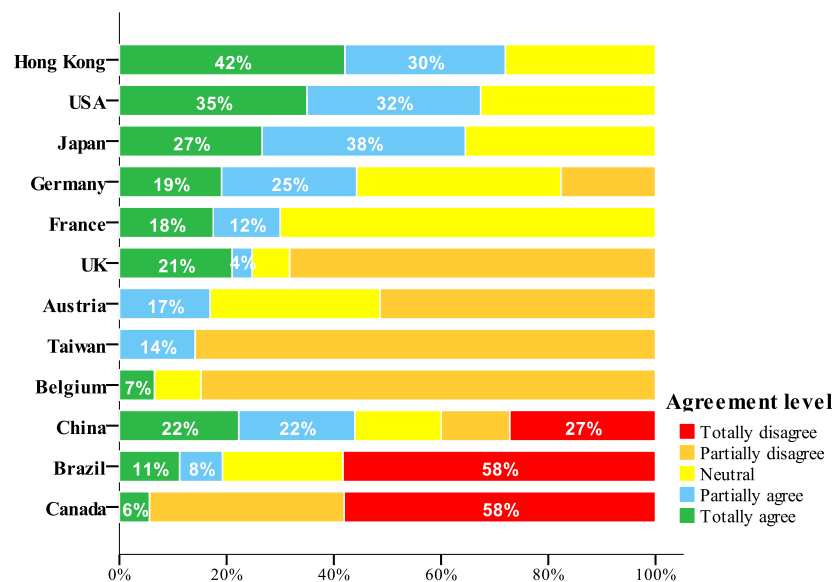
**I'd love to buy this laptop, because it is good for short-term use**



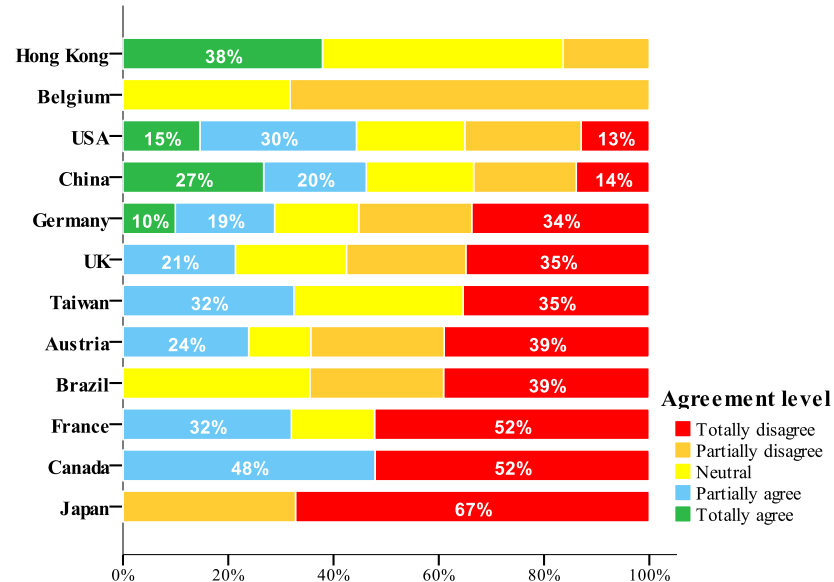
**I'd love to buy this laptop, because it is good as a back-up**



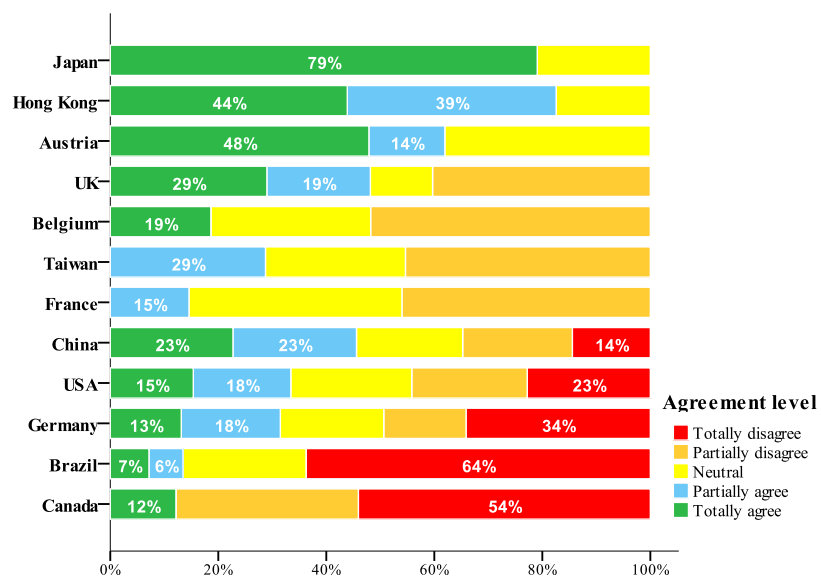
**I'd love to buy this laptop, because it is quality certified**



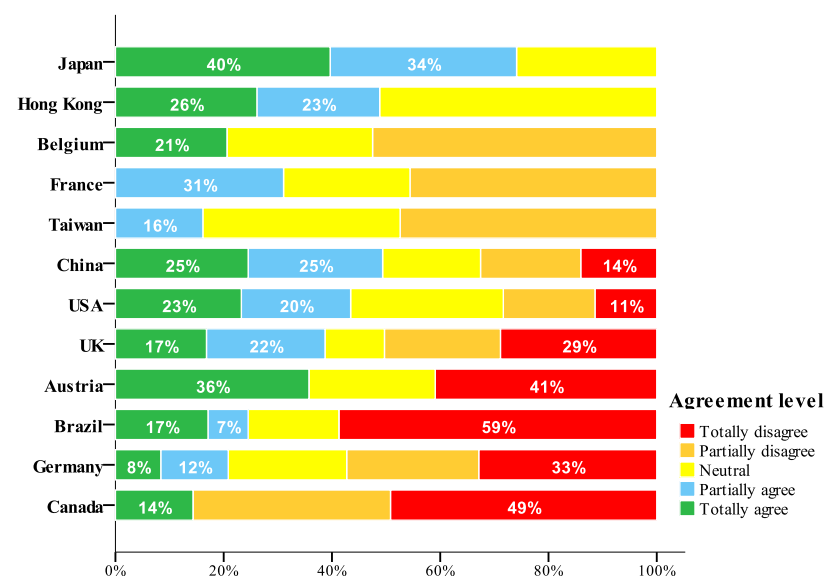
**I'd love to buy this laptop, because it can be as a gift for my friends or relatives**



**I'd love to buy this laptop, because it is benefit to the environment**



**I'd love to buy this laptop, because it is benefit to the society**



**Appendix 34** Concerns about buying the assumed laptop in the case of have ever/never used any second-hand electronic appliances

