Aalto University
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Conceptualizing and Measuring Green IT Readiness in Finnish Companies. Application Area: Electronic Invoice

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ABSTRACT

IT has a dual role in the current climate change actions. Its emissions, 2 % of the annual global CO_2e, equal to the much critiqued aviation industry. On the other hand, it can be used to reduce emissions in other sectors. The new area of study, Green IT, focuses on these abilities.

The purposes of this research are twofold. Firstly, the goal is to determine Finnish businesses Green IT Readiness -levels. It means companies' maturity in integrating environmental viewpoint to IT related activities throughout its lifecycle. The G -Readiness framework is also used to test the role of eco-sustainability in adoption of e-invoicing. The second part of the research is about IT's enabling role in reducing carbon footprint of invoicing as invoices are turned from paper to electronic format.

According to the research, the respondent companies' G -Readiness seems to be mediocre. The framework with four measures (Attitude, Paperless Office, Management and Virtualization) was studied through a survey and tested using Partial Least Squares analysis (PLS). The study concludes that G -Readiness is currently being characterized as an attitude rather than a set of planned and coordinated tasks. Interestingly, the study indicates that environmental considerations do not explain adoption of e-invoicing.

The case study on carbon footprint of invoices indicates that an e-invoice is four times more environmentally friendly than a paper invoice. The most reductions arise from increased productivity of IT enabled work, which is measured by office worker's carbon footprint. Use of paper products and traditional mail delivery were also found to have noticeable impact, while technology and the use of it generated only a fraction of the footprint. The footprint of an office worker had not been accounted for in the previous research. Thus this finding produced totally new information to the field.

The findings raise an important point about the link between eco-sustainability and productivity. Adoption of e-invoicing increases productivity and reduces emissions, but businesses have not truly accounted for this link. This indicates that many IT enabled process improvements could easily be accounted for in sustainability reporting. To reach the highest possible reductions in emissions, companies should integrate the eco-sustainability and productivity link to value chain thinking rather than focus on single processes alone.

Keywords: Green IT, Green IT Readiness, e-invoice, carbon footprint, eco-sustainability

TIIVISTELMÄ

IT:llä on kaksoisrooli ilmastonmuutoksen vastaisissa toimissa. Sen päästöt, 2% vuotuisista maailmanlaajuisista päästöistä, ovat samaa luokkaa paljon parjatun ilmailun kanssa. Omien päästöjen pienentämisen lisäksi IT:tä voidaan käyttää päästösäästöjen saavuttamiseksi muilla sektoireilla. Vihreä IT on uusi tutkimusalue, joka keskittyy näihin IT:n ominaisuuksiin.

Tämä tutkielma tarkastelee vihreää IT:tä kahdesta näkökulmasta. Ensimmäinen tavoite on kartoittaa suomalaisten yritysten Green IT Readiness -taso, joka kertoo yrityksien kyvystä sisällyttää ympäristönäkökulma IT:n hallintaan koko elinkaaren ajalle. Samalla tutkitaan myös ympäristönäkökulman roolia verkkolaskun käyttöönotossa. Tutkimuksen toisessa vaiheessa keskitytään IT:n mahdollistavaan rooliin taloushallinnossa. Tapaustutkimuksessa vertaillaan paperilaskun ja verkkolaskun hiilijalanjälkiä.

Tulokset osoittavat, että vastanneiden yritysten G -Readiness on keskinkertaisella tasolla. Neljä ulottuvuutta (asenne, paperiton toimisto, johtaminen ja virtualisointi) käsittävää mallia tutkittiin kyselyn avulla ja testattiin käyttämällä osittaisen pienimmän neliösumman mentelmää PLS:ää. Käytännössä G -Readiness on positiivinen tahtotila suunniteltujen ja koordinoitujen toimien sijaan. Tutkimus osoitti myös, ettei ympäristönäkökulmalla ole ollut vaikutusta verkkolaskun käyttöönotossa.

Laskujen hiilijalanjälkiin keskittyneessä tapaustutkimuksessa havaittiin verkkolaskun olevan neljä kertaa ympäristöystävällisempi toimintatapa, kuin paperilasku. Eniten päästösäästöä syntyi työn tuottavuuden kasvusta, jota mittaa toimistotyöntekijän hiilijalanjälki. Lisäksi ympäristöystävällisyyteen vaikuttavat muun muassa tulostuspaperi, kirjekuori ja jakelu kun taas teknologian vaikutus oli vähäinen. Toimistotyöntekijän osuutta laskujen hiilijalanjäljissä ei oltu laskettu aikaisemmin.

Ympäristötehokkuuden ja tuottavuuden välillä oleva yhteys on erittäin tärkeä yrityksen näkökulmasta. Verkkolaskun käyttöönotto kasvattaa tehokkuutta ja se on myös ympäristöystävällinen vaihtoehto, mutta yritykset eivät ole hyödyntäneet tätä yhteyttä tehokkaasti. Liiketoimintojen kehityksessä tulisi huomioida prosessien ja yksittäisten toimijoiden lisäksi muut arvoketjun osat. Suurimmat päästösäästöt voidaan saavuttaa samoin integroimalla ympäristötehokkuus arvoketjuihin yksittäisten prosessien sijaan.

Avainsanat: Vihreä IT, Valmius hyödyntää vihreää IT:tä, verkkolasku, hiilijalanjälki, ympäristötehokkuus

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1 INTRODUCTION

Corporate social and environmental responsibility is gaining attention in businesses around the world. Along with public institutions and non-governmental organizations, NGO:s, businesses are redesigning their processes and reaching for business opportunities arising from a problem called climate change. Climate change means "increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level" (IPCC, 2007, p. 30). It is often quantified through green house gas emissions. In 2002 the global annual emissions were 40 $GtCO_2e$[1] and are expected to rise to approximately 53 $GtCO_2e$ per year by 2020. If no corrective action is taken, the rise may cost "at least 5 % of global gross domestic product (GDP) each year" (The Climate Group, 2008, p. 12). If corrective action is taken, the loss can be limited to about 1 % of global GDP per year (The Climate Group, 2008). Thus there are both environmental and financial reasons to take action. From business, and especially IT, point of view, this means business opportunities at the new, expanding green market.

The alarming figures and high costs of climate change are driving governments and businesses towards mitigating this risk. Governmental bodies change legislation to motivate people and businesses to act in an environmental friendly way. From business point of view, there are two alternate ways to react; reactive and proactive. Reactive businesses basically follow and act upon legislation whereas proactive businesses seek to exploit green business opportunities and change ways of working even before it is required by law.

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[1] The commonly used carbon dioxide equivalent, CO_2e, is used to compare greenhouse gases based on their global warming potential, GWP. The tons of gas are multiplied by the GWP factor to transfer the figure to CO_2e. This helps to get an overall idea of the amount of emissions. (European Environment Agency, 2007)

program, which has for instance worked on electronic invoicing and fully integrated accounting. (Aalto University School of Economics, 2010) The program is one of the thematic groups of Aalto Service Factory, which coordinates service related activities in the university and promotes cooperation between industries and academia. (Aalto University Service Factory, 2010)

1.1 Background

As with many business improvements, IT is one of the key enablers of low carbon economy as well. Hence the term Green IT, which implies use of IT to control and redesign low carbon activities. It can be used for control as well as redesign of green operations.

That is why IT has a dual role in slowing down climate change. It means that IT sector must control its own emissions and develop and offer solutions that help control emissions in other sectors. The emissions caused by IT are about 2 % of the global emissions, which is about the same as the emissions of the aviation industry (Gartner, 2007). While eliminating inefficiencies within the industry is important, the greater savings will be realized when IT is used as an enabler of more energy efficient and environmentally sound actions.

The savings in emissions are not only good for the environment but also create financial savings. IT's 2 % of current yearly emissions, $MtCO_2e$, are said to not be sustainable (Gartner, 2007). In other words, IT departments could carry out their function with less equipment and energy used without compromising the functionality of the service. As the use of IT intensifies globally, these emissions are expected to be raised to about 6 % per year by 2020 (The Climate Group, 2008, p. 17).

The overall potential of IT in fighting climate change is a significant and attractive to businesses. It is estimated that ICT can reduce emissions by 7.8 GtCO2e by 2020, which is five times more than its own carbon footprint. In monetary terms it means savings of 600 billion Euros as less electricity and fuel are needed. (The Climate Group, 2008, p. 29) So, once IT itself is greener, the effects on other industries can be developed and implemented at a larger scale. Thus studying the business insight and strategies behind green initiatives helps to understand how well companies are preparing for future. The above figures quantify the significant market potential, which further indicates the importance of understanding this aspect.

1.2 Motivation

Knowing the importance of environmental issues and the potential of IT in advancing ecological sustainability, it is sensible to investigate the current state of Green IT. The topic is current and still somewhat lacking in research. The business research on Green IT has produced extensive reports already few years ago while the academia has now started to fill the research gap.

To tackle the issue at company level, it is sensible to determine the IT professionals' understanding of Green IT. At the start of this thesis work, no formal Green IT studies had been published in Finland, but some articles indicate the topic is not yet grounded in Finnish companies. Thus determining a company's maturity in integrating environmental viewpoint to IT related activities, i.e. Green IT Readiness, would provide important insight to the current state of Green IT in Finland. The readiness data can also be used to study whether businesses have considered environmental benefits when implementing electronic invoicing. Since Green IT is expected to have both financial and environmental benefits, the results of the study should be interesting to both businesses and academia.

After determining the above mentioned Green IT Readiness level in Finnish companies, several action plans to advance it should be created. Therefore exploring such opportunities is worthwhile, as it allows elaborating possible action plans. Electronic invoicing is a form of dematerialization, and dematerialization is said to reduce environmental impacts. According to one estimation, if 10 million customers in Europe would shift to electronic invoicing in their phone bills alone, they would save 10 943 tons of CO_2. 90 million customers would save nearly 100 000 tons of CO_2 (Pamlin & Szomolanyl, 2006). Finnish businesses are advanced in electronic invoicing, e-invoicing. However, accurate facts about the environmental benefits of e-invoicing are needed to disseminate the information to a larger audience and enhance actual G-Readiness in terms of e-invoicing. Thus it is motivating to study ecological sustainability of invoices and produce such information as an example of ways to determine and report Green IT activities.

1.3 Research problem

The goals of this research are twofold. Firstly, the main part of the study is about looking into Green IT Readiness, G-Readiness, from empirical perspective and examining the relationship between such readiness and electronic invoicing. G-Readiness means studying businesses' capability to include the environmental aspect into purchasing, using and disposing IT. In the secondary part of the thesis a case study is carried out to determine can 'green' be placed on the benefits list of electronic invoicing.

Hence the research questions are:

1. What is the level of Green IT Readiness in Finnish companies?
    a. How can the readiness be measured and explained?
    b. Does the readiness level explain adoption of electronic invoices?

2. What is the carbon footprint of paper-based invoicing and electronic invoicing?

1.4 Scope of the research

The main study on green IT readiness is based on the research by Molla, Cooper & Pittayachawan (2009). The goal is to replicate the study to determine G-Readiness and study if environmental issues explain adoption of electronic invoicing. The model is of holistic type and includes both IT and non-IT issues, which accommodates for a wide perspective on green IT. All in all the study provides with a solid framework and well defined scope.

In addition, case study about carbon footprint of traditional and electronic invoices is conducted. Scope wise it means studying the movements and related carbon dioxide emissions of one paper and one electronic invoice within the reach of the case company in question.

1.5 Structure

This thesis is structured as follows. First a literature study clarifying the fundamentals of corporate responsibility and sustainability and research on Green IT is covered. The political agenda is discussed shortly as it is a significant driver in the green economy.

Secondly the research methods for the G-Readiness survey and case study on invoice carbon footprint are discussed. Then the data collection and analysis are presented. Finally the findings and conclusions are presented from both theoretical and managerial perspectives.

1.6 List of definitions

- *Carbon footprint*: The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product." (Wiedmann, 2008)

- *Carbon dioxide equivalent CO_2e*: “A metric measure used to compare the missions from various greenhouse gases based upon their global warming potential (GWP)” (European Environment Agency, 2007)
- *Sustainable development*: “Development that provides economic, social and environmental benefits in the long term having regard to the needs of living and future generations. Defined by the World Commission on Environment and Development in 1987 as: development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (European Environment Agency, 2007)

- *Ecological sustainability (eco*-sustainability): “the ability of one or more entities, either individually or collectively, to exist and thrive (either unchanged or in evolved forms) for lengthy timeframes, in such a manner that the existence and flourishing of other collectivities of entities is permitted at related levels and in related systems” (Starik & Rands, 1995)

- Information technology (IT): IT refers to the physical IT infrastructure and the human and managerial IT infrastructures. (Molla, Cooper, & Pittayachawan, 2009) In this form IT includes ICT and the terms can be used interchangeably.

- *Green IT*: Green IT is a systematic application of environmental sustainability criteria to the design, production, sourcing, use and disposal of the IT technical infrastructure as well as within the human and managerial components of the IT infrastructure in order to reduce IT, business process and supply chain related emissions and waste and improve energy efficiency.” (Molla, Cooper, & Pittayachawan, 2009, p. 4)

- *Electronic invoice*: An electronic invoice is a structured, XML –based open standard message, such as Finvoice or TEAPPSXML. (Penttinen, 2008)

2 LITERATURE REVIEW ON CORPORATE RESPONSIBILITY AND DEVELOPMENT OF RESEARCH FRAMEWORK

This section will introduce the different dimensions of corporate responsibility and establish the link between sustainability and IT. Once we have put a green stamp on IT, the green IT readiness framework used in this research is introduced.

2.1 Literature review

This section introduces various concepts of corporate responsibility. Then a connection to environmental politics is established. Finally business motivations for environmental sustainability are discussed.

2.1.1 Corporate responsibility and related concepts

While companies, as they are expected, take more responsibility about the surrounding environment and community it exists in, the terms used about this responsibility vary quite a lot. Some definitions emphasize social and others environmental responsibility. The most often used terms that apply to this study are explained below.

Sustainable development and corporate social responsibility (CSR), or corporate responsibility (CR), surrounds around three aspects, social, environmental and economic dimensions (Figure 1). These three form the so called triple bottom line. Activities, or development is said to be sustainable when it leaves the future generations at least as much resources to be used as the current generations got in first place. It can be said a firm's activities are sustainable, or that a business practices corporate responsibility, when the above definition of sustainability is met. (Lovio & Kuisma, 2004) As per this definition, responsible business activities are sustainable. However, it can be assumed that business activities, which are considered or called responsible, are not always sustainable per se. This is because it may be difficult to prove sustainability.

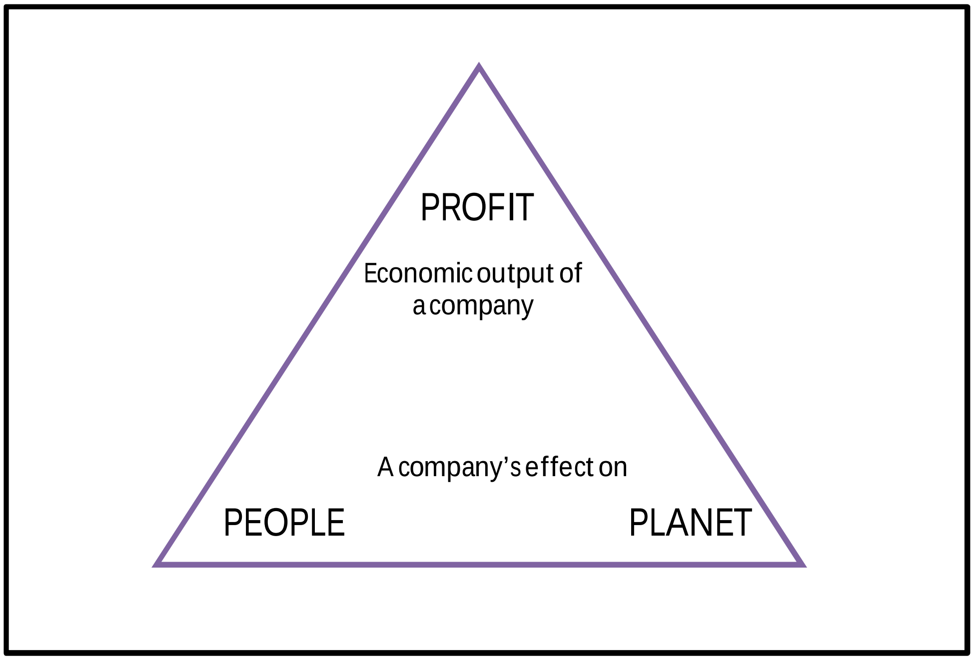


Figure 1: Three dimensions of corporate social responsibility, applied from Lovio & Kuisma, 2004

For a company to be responsible, its triple bottom line has to be balanced. This means that a success in environmental and economic dimensions with the cost of social performance, for example, is not considered responsible. Thus the three components should be studied separately. Yet the concepts are intertwined, the cause and effect relationships being both positive and negative. Finding the balance is difficult for businesses because the environmental and social dimensions cannot be discussed in purely economic terms. To be responsible, companies would need to accept this constraint. Thus firms should seek an acceptable level of performance in the three aspects, i.e. acceptable triple bottom line. (Lovio & Kuisma, 2004)

To highlight the relationship between business activities and natural resources, a concept of ecological sustainability, or eco-sustainability, is introduced. As per definition, eco-sustainability means "the ability of one or more entities, either individually or collectively, to exist and thrive (either unchanged or in evolved forms) for lengthy timeframes, in such a manner that the existence and flourishing of other collectivities of entities is permitted at related levels and in related systems" (Starik & Rands, 1995). This concept is important in CR because almost all businesses exploit natural resources. Regarding CR, eco-sustainability has three concerns, eco-efficiency, eco-equity and eco-effectiveness (Dyllic & Hockerts, 2002).

The blocks of eco-sustainability are not necessarily hierarchical levels but dimensions that reach to different directions. Eco-efficiency is about being capable of offering goods and services at competitive prices while constantly reducing their ecological impacts (DeSimone & Popoff, 1997). Eco-equity adds the responsibility and rights issue to the concept. It means both peoples' equal rights to the environment and resources surrounding them and the responsibility businesses have for the future generations (Dyllic & Hockerts, 2002; Gladwin, Kennelley, & Krause, 2005). Lastly, eco-effectiveness demands people and businesses to look at the origins of the environmental problems and re-engineer the system to stop the problems (Chen, Boudreau, & Watson, 2008).

IT can enhance and enable the above mentioned blocks of eco-sustainability. Use of IT to automate processes creates eco-efficiency and use of IT to inform stakeholders about green issues advances eco-equity. These together lead to eco-effective practices, which are adopted as mimetic and coercive or normative pressures affect decision making. It means companies keep up with competitors and automate processes to increase productivity, and that increased awareness creates a culture of eco-sustainability. The logic is further illustrated in Figure 2.

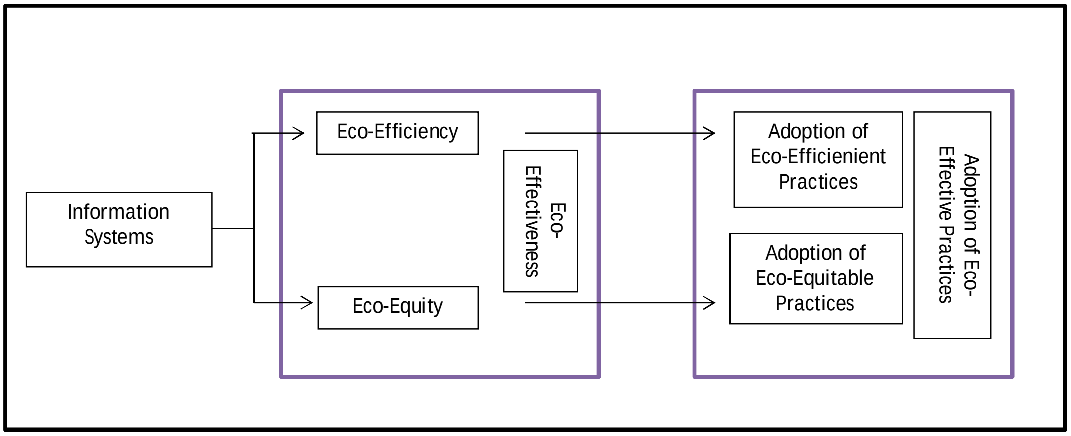


Figure 2: Eco-sustainability and Information Systems, applied from Chen, Boudreau & Watson, 2008

CR articles are gaining ground in published academic research. A study by Egri and Ralston (2008) determined to what extent corporate responsibility was discussed in leading international management and business studies between 1998 and 2007. This research assumed corporate responsibility to cover four topics: ethics, corporate social responsibility, environmental responsibility and governance. The study excluded responsibility focused journals such as Journal of Business Ethics or the Journal of Business Strategy and Environment. The results showed that 6,9 % (or 321 of 4671) of all articles focused on corporate responsibility, and 19 % of those concentrated on environmental issues. Most of the studies were empirical, and a significant portion of the articles was written on case studies. Altogether the articles were characterized by geography; the research was mostly conducted in developed countries. (Egri & Ralston, 2008)

2.1.2 Environmental politics

One of the drivers behind the green industry is legislation. While Finland controls its legislation itself, the EU initiatives are to be implemented as well. The EU has taken an active role in identifying ways to mitigate climate change and setting targets to do so. Finland in its part will drive towards meeting these targets.

According to the estimations by the European Commission, achieving a low carbon economy would cost about “0,5 % of world GDP between 2013 and 2030” (European Commission, 2007, p. 7) and that by 2020 this action would have reduced the global GDP growth by 0,14 % per year only. Additional benefits that were not quantified in the EC research cumulate from lower emissions, improved health conditions and more secure supply of energy. (European Commission, 2007) The GeSI figures that were discussed earlier in the introduction are a bit higher. It may be concluded that the scope and ways of mitigating climate change behind these studies differ from each other. However, it can be said that mitigating climate change will be financially better option than not doing so.

To mitigate the climate change, EU is targeting to cut emissions by at least 20 % by 2020 compared to the situation in 1990 (European Commission, 2007, p. 9). There are several components to it. For example, it is important that the energy consumption is to be cut by 20% from the current business as usual consumption. The use of renewable energy sources must be increased. The aim is to produce 20 % of the energy needed in 2020 in this way. To understand the level of change, the share of renewable was only 7 % in 2007. (European Commission, 2007, p. 10)

To facilitate the change, EU needs an effective toolbox. IT is a significant part of the plan. A report by EU experts say IT enables 50-125 % of the cut and changes needed to reach the goal of 20 % less green house gas emissions by 2020. (DG Information Society and Media Advisory Group, 2008) This further confirms the importance of studying green IT now.

2.1.3 Why do companies go green?

The role of companies in societies is changing; they are responsible not only for stockholders only but for other stakeholders as well. The global issues, climate change being one of those, obviously require businesses alike to act. As a matter of fact, it is seen that businesses of any size and in any industry should view environmental actions as a part of their way of working if they want to succeed (Esty & Winston, 2009) While the governments and non-governmental organizations, NGO:s, do their share, the market economy is argued to hold the biggest power to actually change the course of issues like climate change (Hart, 1997).

In general, it is said that there are two factors behind the motivations to go green. First of all, the scarcity of natural resources demands better solutions. Second, the stakeholders' environmental awareness, and thus demand for greener solutions, is increasing. It is noticeable that these two factors are intertwined. (Esty & Winston, 2009) Since we currently exceed the Earth's capacity to restore by about 30 %, and are expected to need the resources of two Earths by 2030 unless we change the way we live (WWF, 2008, p. 1), it is clear that environmentally friendly products and services are in high demand.

2.1.3.1 Motivations behind environmental responsibility

There are three types of motivations for companies to go green. Green solutions can be categorized for example as risk management, seeking business opportunities and so called goodwill and responsibility to the society and environment. (E.g. Bansal & Roth, 2000 and Esty & Winston, 2009) These forces are not separate, but can be mixed (Bansal & Roth, 2000). It means a company can do for example risk management and philanthropy, or look at the all three forms. In addition, it would be preferable to find a balance between these different activities (Hart, 1997). The three types of motivations with related IT examples are presented in Table 1 below.

Table 1: Motivations behind environmental responsibility

Type of motivation	Description	Effect	IT example
Environmental risk management	Aligning business activities with current and forthcoming rules and regulations (Esty & Winston, 2009)	Reduce operational and financial risks (Esty & Winston, 2009)	Energy efficient data center operations help cut emissions and energy bill
Upside benefits	Innovations and business opportunities that "improve long-term profitability" (Bansal & Roth, 2000, p. 724)	•Potential higher revenues, lower costs •Attract investors •Intangible benefits: brand loyalty and employee satisfaction (Esty & Winston, 2009)	•Use of IT to develop new renewable energy solutions •Active participation in developing environmentally friendly regulatory environment for electronics; example Nokia (Kautto & Kärnä, 2006)
Environmental stewardship	"Doing the right thing" (Esty & Winston, 2009)	Putting effort to environmental responsibility especially in regard to a firm's core business benefits both stockholders and stakeholders (Esty & Winston, 2009)	Green IT and financial benefits are often aligned (See Appendix X for references)

Hart (1997) discusses several alternatives on how to deal with the fact that the Earth's capacity is not sufficient for growing the way we live now. His first two solutions for becoming more sustainable are reducing the population or consuming a lot less than what we do now. However, these are not feasible or justifiable solutions because firstly, a significant reduction in world population is highly unlikely to happen and a rather inhumane suggestion. Reducing consumption drastically is not feasible either because just stabilizing or slowing down population growth would require the upgrading living conditions of a significant portion of the population, hence consumption would increase instead of decreasing. Decreasing consumption would mean more poverty, which does not enhance the quality of life. Thus he argues that the best way to deal with sustainability problems is that businesses take stand and seek to grow through better technologies that allow people to be smarter consumers.

Hart's strategy to sustainable technologies includes three stages: pollution prevention, product stewardship and clean technology. The first step at the lowest level is called pollution prevention. It means that businesses should make a "shift from pollution control to pollution prevention" (Hart, 1997, p. 71). It means the use of environmental management systems, EMS:s, such as ISO 14001 to help avoid polluting in manufacturing. The second stage is called product stewardship, which in this case means integrating environmental viewpoint into the full life cycle of a product. Design for environment is a concept that describes this stage. Clean technology is the third stage where companies are proactive rather than reactive. It means investigating and investing in future technologies. (Hart, 1995 & 1997)

Reaching and executing these stages can be done in several ways. A firm may have had to reach preliminary steps beforehand or other processes maybe needed to be in place at the same time. Thus two alternate ways can be identified. Path dependence indicates the three strategies follow one another. Embeddedness, in contrast, calls for simultaneous development of the three stages. (Hart, 1995)

In order for companies to be successful today and in future, they need to find a proper balance between these stages. If a company focuses only on pollution prevention and product stewardship, i.e. focuses on today's problems only, the future may be unsure. If a company's environmental toolbox comprises of a sustainability vision and ambitions regarding clean technology alone, it may be missing the resources to execute its environmental strategy. There should also be a balance between a focus on process improvements and technology development and visions about product stewardship. The latter alone may lead to the so called greenwash if the processes behind green end-products still cause significant harm. (Hart, 1997) It means that producing a greener product to replace an old one may not be wise if the production process is not green. Another example would be a situation where it is better for the environment to use the current products until the end of their life and replace only then, instead of replacing a product by a greener one in the middle of the life cycle.

2.1.3.2 Business benefits of environmental responsibility

Instead of arguing whether or not environmental responsibility pays off, it is better to concentrate on understanding how different types of activities benefit companies and stakeholders. To give a comparative example, an innovative Green IT solution and the act of donating money to local environmental organization require different type of efforts from the company. Surely the goals behind these acts are different, and thus are the potential paybacks. Somewhere between these two would be the pollution prevention activities, which guarantee paybacks but also include less potential than the innovative new technologies.

The payback from pollution prevention can already be seen in the bottom line, while other, more intangible benefits may be more difficult to quantify. While the biggest polluters may benefit the most, there still are opportunities for the cleaner companies too. Companies, especially those who have significant environmental effects or well known brands, must consider the cost of not going green. Environmental trouble often leads to lots of negative publicity, which surely does affect the firm performance. At the same time the upside benefits would be out of reach. (Esty & Winston, 2009)

Regarding pollution prevention, it takes about two years before the effects show in the bottom line. According to a study from 1988-1989, when the biggest polluters still had not started extensive environmental programs, return on sales, ROS, and return on assets, ROA, improved after about a year, indicating improvement in operating efficiency. Return on equity, ROE, improved only after about two years. The lag can be explained by the facts that ROE, in addition to operating efficiency, also represents financial structure of the firm, and that a better environmental reputation can lower the cost of capital to the firm. These results are the average of several industries at the end of 1980s, so it may be assumed that today’s cleaner companies may not witness such drastic changes as a result of pollution prevention. (Hart & Ahuja, 1996)

When estimating the benefits of today’s companies’, linking the level of business integration to the potential benefits gives a rough guideline on the possible returns. As said earlier, different types of activities give different yields. Halme and Laurila (2009) classify corporate responsibility activities into three categories. Philanthropy is an additional activity that does not relate to the firm’s core business. Integration means improving the social or environmental performance of current business for example through certifications. Innovation means developing new, sustainable products and services at the core of the business. The logic is that the higher the level of integration, the greater the potential benefits are. The clear and distinctive categories provide companies with a tool that illustrates the implications of different responsibility activities to businesses in particular. The framework is further illustrated in Figure 3.

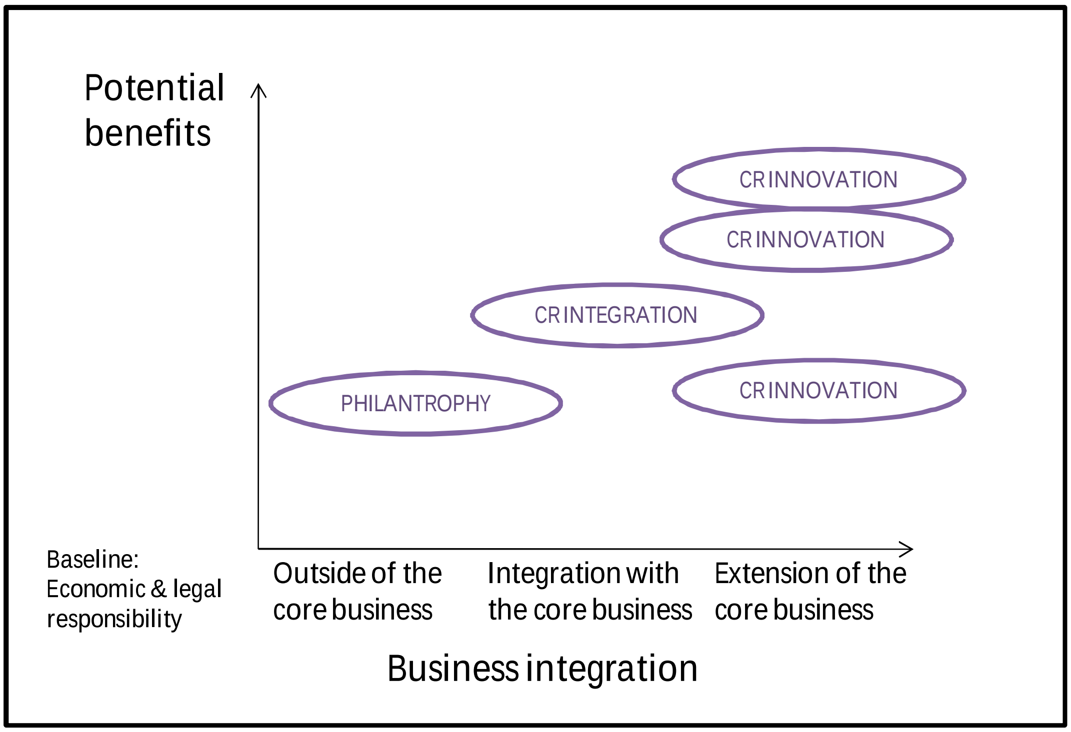


Figure 3: Business integration and potential benefits of corporate responsibility, applied from Halme & Laurila, 2009

Linking the level of business integration to Hart's argument about different environmental stages of sustainable technology strategies, a company may practice all several types of activities. However, the most integral and special type of offering entails the biggest competitive advantage and thus greatest potential. Referring to the sustainability argument, integration and innovation yield true sustainability. Thus it would be sensible for today's companies to ensure their current and future operations include both CR integration and innovation type of activities.

2.2 Green IT

The research on environmental aspects, or eco-sustainability, of information systems indicates that IT has a dual role in moving towards a low carbon economy. IT can in this relation be classified as *bad* or *good*. The former refers to the careless use of IT leading to higher than necessary emissions from IT and the latter to the good effects IT can have on overall emissions. Putting Green IT into practice, businesses can *control and reduce* the emissions of IT and *enable* the same in other sectors. The following sections illustrate the case through introduction of Green IT definitions, market and the Green IT Readiness concept used in this thesis.

2.2.1 Definitions of Green IT

The concepts of green or sustainable IT or ICT is not yet clearly established, so there are several definitions for it. Initially green IT referred mainly to the energy efficiency of data centers and other equipment. From thereon, more holistic approaches have been adopted to include environmental effects at a wider scale. While the earliest definitions have used IT or ICT, there is also a call for green information systems, IS, which is entailed to be even more holistic approach. However, it still seems that Green IT, ICT and IS definitions are not distinct neither in academic writing nor in business practice. The following paragraphs illustrate some examples.

Green IT or ICT can be defined through its life cycle. Environmentally sustainable ICT can be defined as “the design, production, operation and disposal of ICT and ICT-enabled products and services in a manner that is not harmful and may be positively beneficial to the environment during the course of its whole-of-life” (Elliot, 2007, p. 107). This view takes into account the fact that the equipment should become less harmful to the environment and that the technology can also be used to do something that creates greater benefit in other industries.

A holistic but yet quite detailed view to Green IT is taken in the original work of Molla et al (2009). According to them Green IT is “a systematic application of environmental sustainability criteria to the design, production, sourcing, use and disposal of the IT technical infrastructure as well as within the human and managerial components of the IT infrastructure in order to reduce IT, business process and supply chain related emissions and waste and improve energy efficiency." (Molla, Cooper, & Pittayachawan, 2009, p. 4) This view accounts for both technology and the human use of it, of which latter is excluded from Green IT in narrower definitions. Thus this definition actually approaches the definition of Green IS. This definition is used in this research.

Information systems is a broader context than IT and in search of synergies and greater benefits, the green discussion is in part shifting to Green IS instead of Green IT. Watson, Boudreau and Chen (2010) define IS as "an integrated and cooperating set of people, processes, software, and information technologies to support individual, organizational, or societal goals“ (Watson, Boudreau, & Chen, 2010, p. 24). Melville in turn defines "IS for environmental sustainability as IS-enabled organizational practices and processes that improve environmental and economic performance" (Melville, 2010, pp. 1-2). Melville refers to sustainability as it is, use of resources without compromising the future generations' ability to meet their needs. However, it does not necessarily show in the definition. This is because one can assume from the definition that some level of improvement is enough even if it does not meet the requirements of sustainable development. While these definitions discuss IS, these are not significantly broader than Molla et al's definition. This highlights the issue that the reader should pay attention to the different definitions or the terms used.

2.2.2 Green IT Research

Environmental business research is conducted and presented in academic journals as well as commercial research and consulting businesses. There are studies in general journals and journals that concentrate on environmental or sustainable topics alone. Currently there is no journal concentrating only on sustainability of information systems in particular.

Commercial research organizations, joint industry associations and non-profit organizations have produced several Green IT reports during the past years. Gartner is a technology research organization and Global eSustainability Initiative, GeSI, is a technology industry initiative that became an NGO in 2008. These both have produced Green IT reports that are widely quoted in media and research. In addition, companies like Accenture and Forrester Research and NGO:s such as WWF continuously contribute to the research by looking into specific areas of improvement in IT sector.

Green IT is a new topic in information systems science. The researchers are now adopting the topic on the research agenda, which can be seen as an initiation of the discussion in the journals and emerging conference tracks in international conferences. The main journals in the area of information systems science have been slow in publishing green IT research. In a recent study, only one article on green IT was published in information systems journals up to 2007. (Melville, 2010) A further survey from 2008 to 2010 in the same journals (Appendix 1) produced total of four hits in MIS Quarterly and MIS Quarterly Executive. In addition, MIS Quarterly has announced a special issue in Green IT in 2011.

The emergence of the topic can be seen better in information systems conferences than in the articles. This is a logical observation because new topics are introduced in conferences, from where the studies move to be published in academic journals. The earliest conference tracks on Green IT come from 2007, while in 2010 all major IS conferences have a Green IT/IS track.

The research papers published in conferences indicate that the Green IT research is gaining momentum. The early research themes such as concept definitions and research agenda formulation are strongly present and complemented with studies on the managerial attitudes and reasons behind using Green IT. The effects in the supply chain are studied as well. In addition, there are practical applications, for example environmental decision support systems. The tracks, themes and references are further introduced in Appendix 2.

2.2.3 IT's dual role in reducing emissions

This section discusses both sides of the dual role IT has in sustainability practices. IT emissions, the bad, are covered first, following by the market opportunities, the good. Then electronic invoice is discussed as an example of a Green IT solution.

2.2.3.1 Emissions associated with IT

In order to understand the magnitude of the environmental harm that IT causes, it makes sense to study the emissions. This is illustrated here using the research from GeSI report Smart 2020. GeSI report discusses the greenhouse gas emissions of ICT, which in their research includes PCs, telecom networks and devices, printers and data centers. The emissions are calculated in tons of carbon dioxide equivalent CO_2e. (The Climate Group, 2008)

ICT carbon footprint is expected to be doubled by 2020, meaning around 6 % increase in global annual CO_2 emissions. It is worth noting that most of the carbon footprint comes from the use of the equipment, so reducing the emissions during that time can help the environment most. (The Climate Group, 2008) The situation is further illustrated in Figure 4.

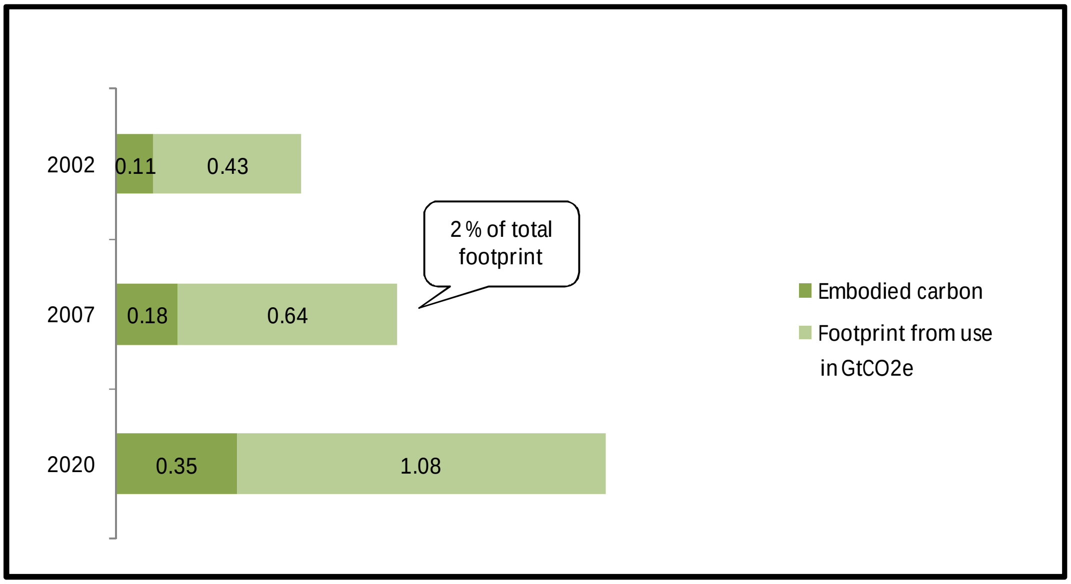


Figure 4: The global ICT footprint, applied from the Climate Group, 2008

New data centers are set up at a fast pace, making those the fastest growing component of ICT carbon footprint. The demand is driven by high and increasing need for storage. Currently the average utilization rates are somewhat poor, 6 % for servers and 56 % for facilities. Thus the energy consumption may increase because of a larger number of poorly utilized servers. The issue could be mitigated by a better design that would up the consumption and reduce the number of servers needed. Most of the use related emissions come from the need for power and cooling, as Figure 5 below indicates (The Climate Group, 2008).

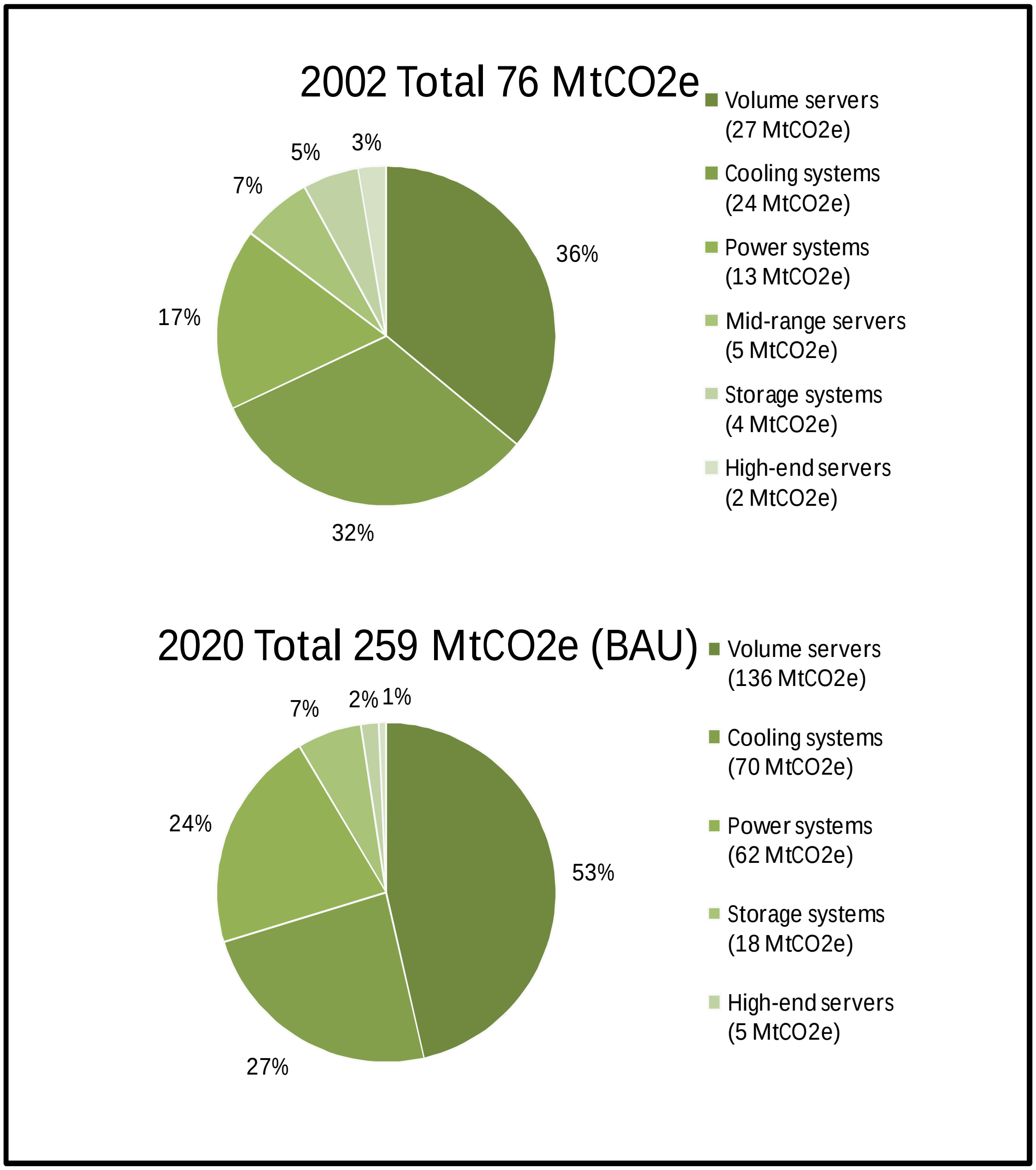


Figure 5: Data center footprint, applied from the Climate Group, 2008

The data center emissions are expected to grow by 7 % each year if no action is taken against it. These emissions can be reduced through better technologies and better use of technologies. Power and cooling requirements can be lowered through more environmentally friendly technologies and better design of the data centers in terms of layout. Virtualization can lower the figures because less physical servers would be needed. Cloud computing includes concepts such as software as a service, SaaS, or paying for storage per demand. As said, better storage leads to lesser emissions. Smart cooling and temperature management is estimated to lower the emissions by 18 % and virtualization by 27 %. The savings scenarios are further illustrated in Figure 6 below. (The Climate Group, 2008)

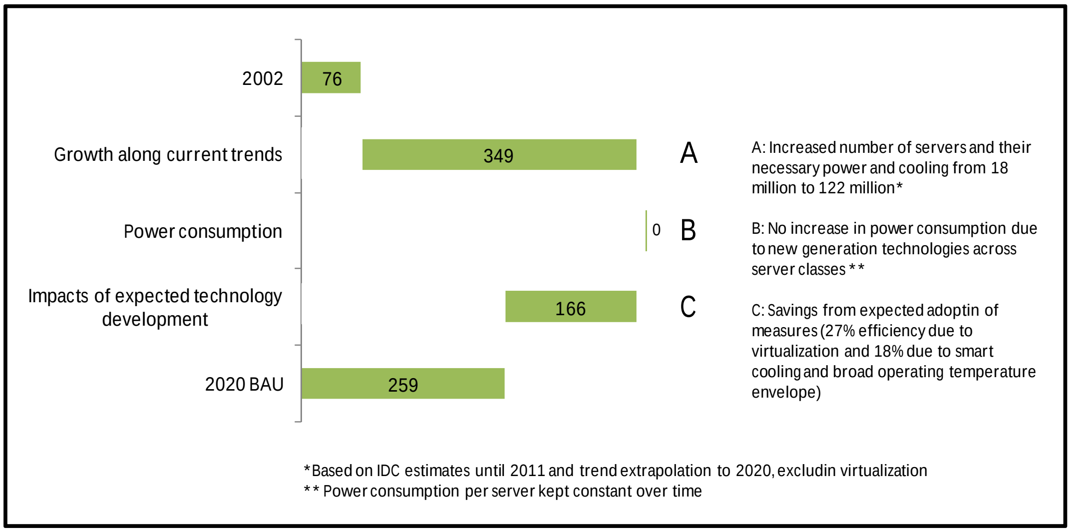


Figure 6: The global data center footprint, applied from the Climate Group, 2008

Dematerialization has potential to lower emissions but it is challenging, as it requires a cultural shift. It means that people need to adopt new ways of working and living. In technical sense dematerialization, for example electronic invoicing can be seen as an opportunity to pick low hanging fruit when developing corporate environmental responsibility. Since automating accounting related processes, including electronic invoicing, are (slowly?) becoming a standard, the companies doing so already can include that activity in the list of responsibility activities. Being able to root environmental values into corporate culture will further be beneficial to the company anyhow. (The Climate Group, 2008)

2.2.3.2 Green IT market

In addition to the advancements in the technology, IT can reduce emissions in other sectors too. This represents the second and larger part of the dual role explained at the beginning of section three. There are some challenges related to development, implementation and adoption of the new solutions, but still the market is expected to grow significantly.

The market for Green IT is rapidly expanding and expected to hit almost USD 5 billion by 2013. A significant portion of that is located in Europe, as Figure 7 below illustrates. This estimation is based on an overall definition of green IT services as "consulting services that help enterprise IT organizations reduce their companies' environmental impact by assessing, planning, and implementing initiatives that make the procurement, operation, and disposal of IT assets more environmentally responsible." (Mines, 2008, p. 2)

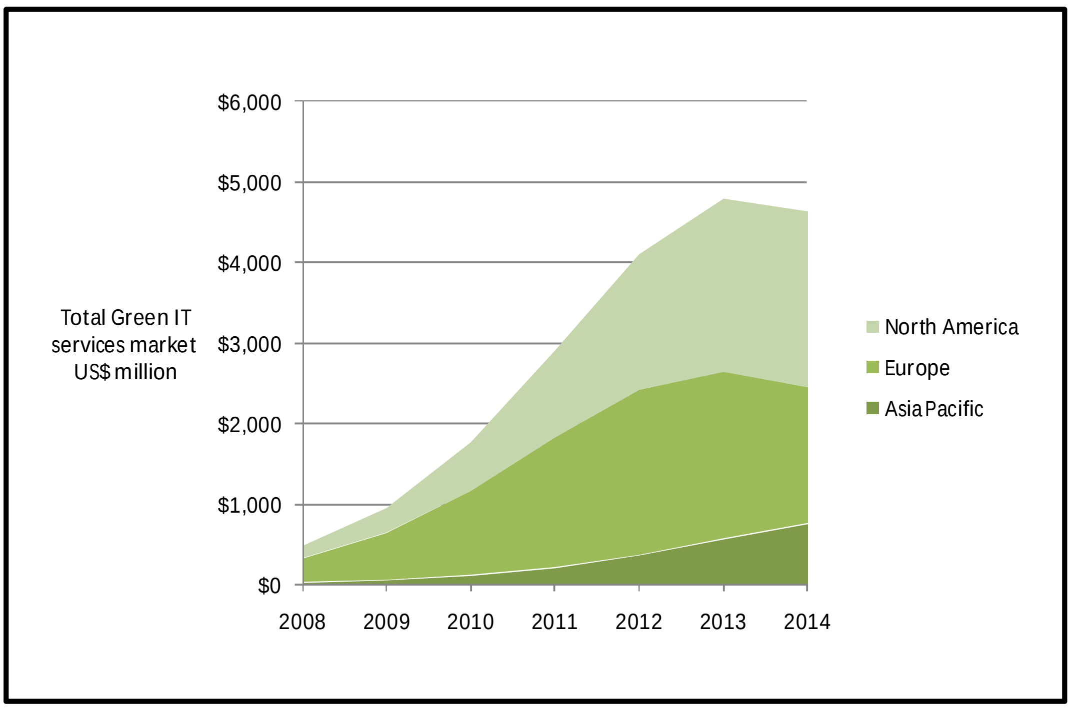


Figure 7: Global IT Services market outlook, applied from Mines, 2008

While the carbon footprint of IT has to be reduced, the larger gains will come from the use of IT to lower emissions in other sectors. The sectors where ICT can potentially have the biggest impact are smart logistics, smart buildings, smart grid and smart motors and industry processes. The carbon footprint can potentially be reduced by almost 8 GtCO2e in this area, five times more than ICT's own carbon footprint. (The Climate Group, 2008, p. 27) The cross sectoral opportunities are illustrated in Figure 8 below.

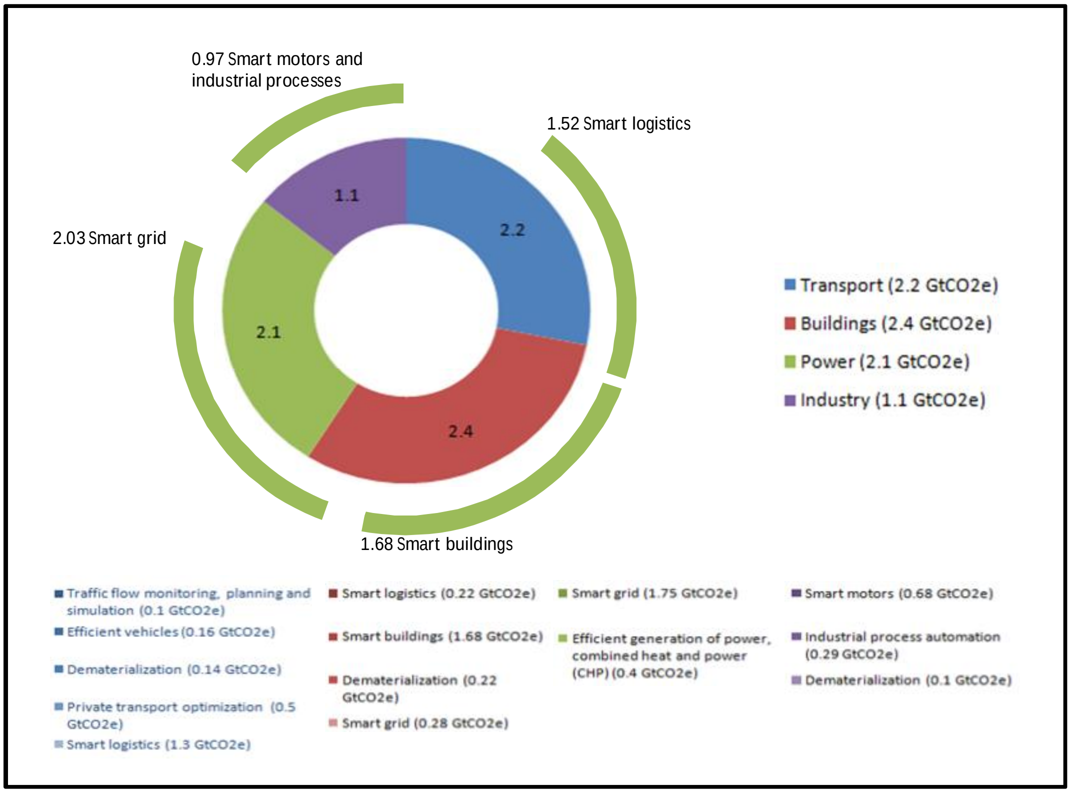


Figure 8: ICT: the enabling effect, applied from the Climate Group, 2008

The G-Readiness study conducted in this thesis includes elements from the four areas illustrated above. There are several points of contact. Dematerialization is a topic in several areas. Transportation arises in teleconferencing instead of business travel and electronic invoices instead of paper invoices. Energy efficiency in buildings is studied especially through data centers and smart energy supply is covered through renewable sources of energy and utilization of heat generated by IT equipment for heating. (The Climate Group, 2008) These issues are discussed in detail in section 4.1, which covers the survey details.

GeSI identified several factors that hinder ICT's ability to reach better environmental efficiencies, including knowledge, innovation and cooperation challenges. First of all businesses do not often know what the carbon footprints of their products and services are and what are the consequences. The issue is intensified by the fact that incentives are often misaligned. It for example means that the person making purchasing decisions may only be responsible for computing power or other characteristic of the equipment to be bought but not have to pay the energy bill. (The Climate Group, 2008)

Even if the awareness of Green ICT products and services was increased, there may be market barriers that slow down adoption of the new solutions. And while the businesses raise their awareness, informing consumers is still difficult. There are standards that are developed and applied currently, but the implementation has to happen at a larger scale. (The Climate Group, 2008)

Examples of these standards that are in use today are RoHS, WEEE and the Energy Star. RoHS is the Restriction of the use of certain Hazardous Substances in Electrical and Electronic Equipment. It limits the use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ether (PBDE), of which the last two ones are flame retardants. The restriction concerns products that entered the market after July 2006. WEEE, the Waste Electrical and Electronic Equipment, requires producers to take care of recycling and/or reuse of their products at the end of life and cover the costs as well. While the RoHS has to be followed exactly in the EU countries, the WEEE is a minimum directive, meaning the member countries can tighten the requirements if they will. (Teknologiateollisuus, 2010) ENERGY STAR in turn is a label that is voluntary and it helps consumers identify products that meet a certain level of energy efficiency. The label was started in the United States and from 2001 onwards EU has used the label as well. It is in use only for the office equipment in the EU. (European Commission, 2009)

Lastly, in order for the cross-industry benefits to realize, companies have to engage in partnerships and true collaboration. Such attempts are still few but GeSI firmly states that low carbon economy cannot be reached without such collaboration throughout value chains. (The Climate Group, 2008)

For a product or service to be successful, it must be good and green. Green alone is not sufficient and such offerings can be labeled as greenwash. It means the offering may seemingly be environmentally friendly but not necessarily fulfill the actual function at a satisfactory level, or the production process may be more harmful to the environment than that of a green product should be. Put shortly, there are three factors to be kept in mind when developing green products and services. First of all, the offering has to satisfy existing green needs. Secondly, other requirements, such as quality, by the customer must be met as well. Thirdly, a feasibility study should indicate that financially the green solution is doable. If the costs are too high compared to potential payback, then the solution is not worth it. (Esty & Winston, 2009)

2.2.3.3 E-invoice as a Green IT solution

Electronic invoice, which is gaining popularity in Finland and other countries, is also a sound IT solution from environmental point of view. It is known to increase productivity and enable better service, and environmental benefits can be assumed due to dematerialization.

A structured e-invoice means an XML-based message, which has potential to reduce the carbon footprint of an invoice significantly. The invoices are transmitted via XML-based open standards. Finvoice and TEAPPSXML are examples of such standards in

Finland. A PDF invoice is not considered an electronic invoice in this study. The benefit of standardized message over for example PDF invoices is that it allows full automation. In addition, the consolidator model, or many-to-many model, used in Finland, requires setting up the system for electronic invoicing only once whereas seller-direct and buyer-direct models require the integration to be done for each case separately. (Penttinen, 2008) While most Finnish SMEs using electronic invoice actually use a PDF invoice, which they perceive to be a good enough solution (Suomen Yrittäjät, 2008), it is important to clarify the full benefits of electronic financial processes come from more sophisticated solutions.

An electronic invoice is a Green IT component as it is a form of dematerialization. Dematerialization is said to have some problems since the potential is substantial but realization depends more on individual users than for example a decision to use less emitting motors in a factory, providing lower costs and better environment. However, a sophisticated electronic invoice can significantly reduce unnecessary processing. In addition, the newest form of integration is use of ISO standardized accounting references that can be inserted already on the invoice, and thus further linking the invoice to accounting. Process efficiency, speed and fewer errors are listed as benefits of both of these activities. (Penttinen, 2008& 2009) Thus it could be argued that the case for e-invoicing is stronger than that of an appeal on people to stop printing unnecessary e-mails for example. Its environmental benefits can be accounted for in the form of carbon footprint.

Carbon footprint is a popular measure of environmental effects of goods, services, people, cities and other numerous objectives. It can be used to estimate the environmental effects of a finished good, a process or a life cycle of the object. The main benefits of carbon footprint are that it is easy to interpret and compare, without being too loose or simple to be meaningful. (Natural Interest, 2010)

Carbon footprints are often calculated in carbon dioxide equivalent, CO_2e, which indicates that the six greenhouse gases, GHGs, can be accounted for. The GHGs are carbon dioxide CO_2, methane CH_4, nitrous oxide N_2O, hydrofluorocarbons HFCs, perfluorocarbons PFCs and sulphur hexafluoride SF_6 (United Nations, 1998). Several protocols are available for use to ensure accuracy and comparability of carbon footprints. Examples of these are the GHG protocol, ISO 14064-I standard (The Greenhouse Gas Protocol, 2010) and Carbon Trust standard, of which the first and last are used in this study through Natural Interest (Natural Interest, 2010).

2.2.4 Green IT in Finland

Green IT is an emerging topic also in Finland. There have been Green IT articles and some seminars for a few years, but in 2010 the topic has gotten more ground. The understanding of Green IT seems to be at a low level, and people usually associate the term with data center efficiency.

Recent articles promote Green IT as a way to cut cost and slow down climate change. New technology in data centers can even halve the electric bill of the equipment used at a data center. Most Finnish businesses do not know how big effect for example efficiently organized heating and cooling can have on data center energy bill and environment. This is because heating and cooling, for example are not organized efficiently (Kotilainen, 2008). Electricity costs can rise noticeably, for example the electricity bill per server can easily reach the cost of the server itself in a little over three years of time. Thus the starting point is to understand what Green IT could be and then start making changes that benefit the environment and the budget. In addition, greening improves the firm image to outsiders as well as staff. (Kotilainen, 2010)

Tekes, the Finnish Funding Agency for Technology and Innovation, is a publicly funded organization that finances R&D activities and innovation. The funding does not cover only technology but service and social innovations as well. Regarding Green IT, Tekes has conducted some research and wants to encourage businesses to take the topic into account in their strategies and business models. According to Tekes, environment is a source of competitive advantage rather than something firms may take into account.

(Tekes, 2010a) Thus the organization investigated Green ICT with the aim of finding out what kinds of business effects it has in Finland currently. Their study included interviews with IT, digital media and communications businesses and the main finding was that the understanding of green ICT is narrow. Businesses understand Green ICT as a way to save energy. Half of their respondents said it is an opportunity and a challenge, and they would require more information about it. (Tekes, 2010b)

FiCOM, the Finnish Federation for Communications and Teleinformatics has started a green ICT initiative in 2008 with the aim of diffusing Green ICT among Finnish businesses. They provide a website with information about different initiatives and ways to reduce IT related emissions. FiCOM challenges businesses to take part, seek ways to make ICT more environmentally friendly and develop new solutions. (FiCOM, 2010)

Teknologiateollisuus, the Federation of Finnish Technology Industries, promotes Green IT as well. Their environmental policy, published since 2004, encourages Finnish businesses to be the forerunners in developing environmentally friendly technologies. They view competency in environmental technologies as an important component of competitiveness of the industry. Life cycle thinking, energy efficiency, low emissions solutions, material efficiency, sustainable use of natural resources, following legislation, improving environmental competence in the value chain and promoting active discussion with stakeholders are key issues listed in their newest policy. As an example of the organization's efforts for Green IT, the organization takes part in development and diffusion of environmental standards for technology and solutions for handling electronic waste. (Teknologiateollisuus, 2010)

Finland is an ideal place for green data centers because of the infrastructure and climate. Google, for example, has bought an old paper manufacturing plant from Summa, Hamina, with the intention of turning it into a data center. Finland is now being promoted as an ideal place for green data centers because of the favorable environment, infrastructure and knowhow. The cool environment allows using free cooling, which means taking the advantage of the naturally cool air, which is plenty almost year round in Finland, in cooling the data center. The energy is affordable and produced environmentally friendly, for example by the plenty lakes and rivers.

To advance these efforts, CSC, IT Center for Science, has organized two data center efficiency seminars with satisfying success. (CSC, 2009-2010) In addition to these efforts, several IT providers are already building new and greening old data centers. For example Helsingin Energia, a local electricity company offers a green data center that uses district cooling to cool the data centers. The heat generated is lead back to the system and used to heat other buildings. They argue the solution can save a client with an annual energy consumption of 2 MW some 200 000 USD and 1600 tons of CO_2 emissions yearly. (Helsingin Energia, 2010a&b)

2.2.5 Green IT Readiness Model

This section outlines the G-Readiness theory and model development for the Finnish business environment. The model related background comes from the work of Molla, Cooper and Pittayachawan (2009) and the modification is done based on the literature study on Green IT and e-invoicing in Finland. The background of the model is presented first, followed by development of the theory and construct for the purpose of this thesis.

2.2.5.1 Background and theories

The G-Readiness model's (Molla, Cooper, & Pittayachawan, 2009) strength lies within its multifaceted construct. In addition to the technicalities, it handles the softer side of business. This combination is useful from the managerial point of view too. The model itself is one of the first for Green IT. The authors consider it "a preliminary attempt to advance the Green IT research through theorization, model construction and measurement development" (Molla, Cooper, & Pittayachawan, 2009, p. 1). The model offers a significant contribution to the field.

Green IT Readiness, G-Readiness, measures how well a company has and can integrate green into their IT and utilize it. From theoretical point of view, green IT stems from IT infrastructure and a firm's capabilities. The organizational capabilities in turn can be described through the resource based view of a firm. Resource based view of the firm means that a successful firm must have diverse resources that are difficult to copy. That kind of resources lead to competitive advantage and thus to success. (Molla, Cooper, & Pittayachawan, 2009) In this sense, "resources are seen as basic inputs into gaining and maintaining competitive advantage, while organizational capabilities are the firm's capacity in acquiring and utilizing its resources to perform tasks and activities for competitive gain" (Barney, 1995; Bharadwah, 2000).

IT infrastructure comprises of three complementing parts. The first one, IT technical infrastructure is quite obvious. As per earlier research, it can be divided into three layers: IT and communication technologies, shared services and business applications (Broadbent & Weill, 1997). The technical infrastructure is defined along the above definition in this research as well. Thus the IT technical infrastructure in g-readiness model "encompasses the physical IT and communication resources of an organization, along with the shared services and business applications" (Molla, Cooper, & Pittayachawan, 2009, p. 2). The authors also note that it is important in Green IT that the technical architecture is green itself. The IT human infrastructure is the employees who ensure the technical infrastructure operates seamlessly and who design and run systems that support the business on the whole (Broadbent & Weill, 1997; Molla, Cooper, & Pittayachawan, 2009). Lastly, it is the IT managerial capability that is used to ensure the other two aspects of IT support the organization and its core competencies appropriately (Ravichandran & Lertwongsatien, 2005).

The G-Readiness model was developed on the basis of the introduced background components; IT infrastructure, resource-based view of the firm and eco-sustainability. To ensure validity and proper construct, Molla et al followed processes used in earlier research (Boudreau, Gefen, & Straub, 2001; Churchill, 1979; Hair, Black, Anderson, & Tatham, 2006). The process has four phases. First the domains of Green IT and G-

Readiness are constructed. Then the domains are given measuring items. Then the suitable way to design sample and collect data are determined. Finally, a data analysis tests the validity and reliability of the created model. (Molla, Cooper, & Pittayachawan, 2009)

2.2.5.2 The Original Green IT Readiness domain and measurements

The first phase, constructing the domains is very important in creating clarity in the definition of G-Readiness. As pointed out earlier, the definitions of Green IT vary a lot and often the understanding of the concept is too narrow. This construct clearly indicates that green IT is much more than data center efficiency, which nonetheless is an important part of it. G-Readiness describes how the business can execute Green IT:

"G-Readiness is defined as an organization's capability (and state of maturity) in applying environmental criteria to its IT technical infrastructure as well as within its IT human infrastructure and management across the key areas of IT sourcing, operations and disposal" (Molla, Cooper, & Pittayachawan, 2009, p. 4).

The second phase of creating measures for the domains included two parts. The first part was an extensive study of published green IT white papers and consultant reports. Then the researchers conducted a desk research on how companies practice Green IT.

As a result of the second phase, the authors determined five G-Readiness measures. These are attitude, policy, practice, technology and governance. Attitude describes awareness and concern for environment, thus, adding these dimensions to the construct results in the following definition:

> "G-Readiness is an organization's capability as demonstrated through the combination of attitude, policy, practice, technology and governance in applying environmental criteria to its IT technical infrastructure as well as within its IT human infrastructure and management across the key areas of IT sourcing,

operations and disposal to solve both IT and non-IT (by using IT) related sustainability problems" (Molla, Cooper, & Pittayachawan, 2009, p. 5).

The five measures describe the depth and breadth of Green IT within a business from early to later development stages companywide. In short, the measures are defined as follows:

- *Green IT Attitude* is "an organization's IT human infrastructure's sentiment towards climate change and eco-sustainability" (Molla, Cooper, & Pittayachawan, 2009, p. 5).
- *Green IT Policy* "encompasses the frameworks an organization puts in place to apply environmental criteria in its IT related activities" (Molla, Cooper, & Pittayachawan, 2009, p. 6).
- *Green IT Practice* "pertains to the actual application and realization of eco-sustainability considerations in IT infrastructure sourcing, operation and disposal" (Molla, Cooper, & Pittayachawan, 2009, p. 6).
- *Green IT Technology* "refers to technologies and information systems for (a) reducing the energy consumption of powering and cooling corporate IT assets (such as data centers) (b) optimizing the energy efficiency of the IT technical infrastructure (c) reducing IT induced greenhouse gas emissions (d) supplanting carbon emitting business practices and (e) analyzing a business's total environmental footprint" (Molla, Cooper, & Pittayachawan, 2009, p. 6).
- *Green IT Governance* is "the operating model that defines the administration of Green IT initiatives and is closely related to the policy construct" (Molla, Cooper, & Pittayachawan, 2009, p. 6).

2.2.5.3 Green IT Readiness Framework for Finland

Using the above described framework as a starting point, the model for this thesis is developed. At this point, the model is adapted to the Finnish market based on earlier country specific studies. The use of the model will be covered later on in chapters three and four.

The new model covers Green IT through somewhat narrower perspective. This is because the Green IT practices in Finland in general and currently is not as developed as the case was with the literature studies and case studies used as the basis of the earlier model. The foci in Finland are energy efficiency and efficient use of equipment, which is why these aspects lead the development of the theory. The development also took into account the focus on financial administration processes, invoicing in particular.

After careful study of the five original measures and literature review in Finland, the following conclusions were made:

- Attitude: this measure indicates a starting point and/or understanding of Green IT issues. As Green IT in Finland is at the early stages, Attitude dimension suits the new model as well.
- Policy: this measure determines whether companies have advanced their Green IT Initiatives to formal level where policies indicate the company officially employs Green IT. The concept is believed to not be at this stage in Finland yet, which is why Policy is not included as a separate measure.
- Practice: this measure indicates whether companies follow their attitude and execute their policies in practice. The practice construct is not included in the new model as such due to the same reasons indicated above for the policy construct.
- Technology: this measure studies how companies use their technical IT. This construct is believed to be familiar to the Finnish respondents as energy efficiency is about the technical features of IT. In the new model, technology is

divided into two constructs that describe the Finnish Green IT landscape and the invoicing process needs in particular

- Governance: this measure is related to the policy construct and it describes how the policies are governed throughout the business. Since the policy construct is not believed to be well developed, governance as such is not included in the new model.

The G-readiness construct that can be applied to the context of Finland and financial administration processes includes four measures:

1. *Attitude*: the company's attitude about and concern for climate change and eco-sustainability
2. *Paperless office*: the extent to which the organization aims to reduce the use of printing paper and related equipment
3. *Management*: the managerial and governance practices the company executes in terms of Green IT
4. *Virtualization*: the extent to which companies practice optimizing the number and use of IT equipment and reduction of energy consumption through virtualization

The same four latent constructs are used to explain adoption of e-invoicing. The plain models are expressed in Figure 9.

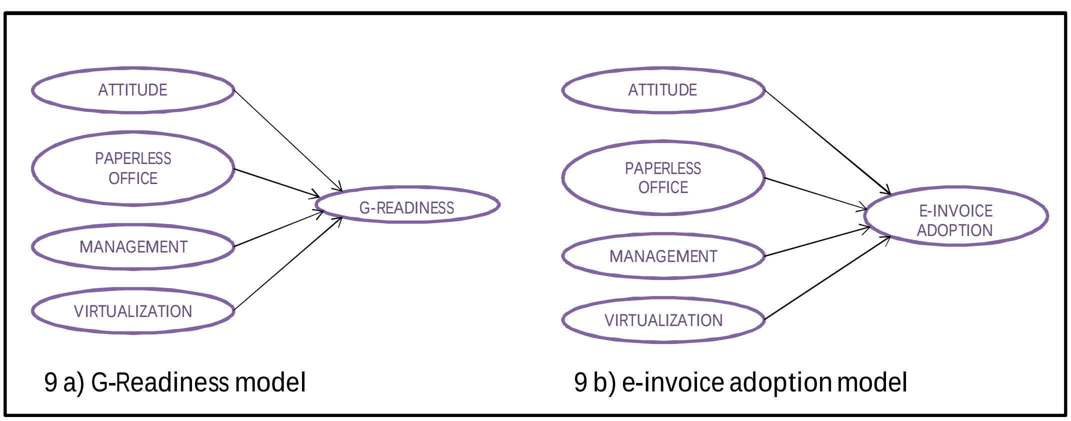


Figure 9: Theoretical structural models

The theorized constructs are hypothesized as follows:

1. G-Readiness model explains G-Readiness
    - **A.** Attitude has a positive effect on G-Readiness
    - **B.** Paperless office has a positive effect on G-Readiness
    - **C.** Management has a positive effect on G-Readiness
    - **D.** Virtualization has a positive effect on G-Readiness

2. G-Readiness model explains e-invoice adoption
    - **A.** Attitude has a positive effect on e-invoice adoption
    - **B.** Paperless office has a positive effect on e-invoice adoption
    - **C.** Management has a positive effect on e-invoice adoption
    - **D.** Virtualization has a positive effect on e-invoice adoption

3 METHODOLOGY

The practicalities of designing, collecting and analyzing the empirical data is described for both the main study, the survey, and secondary study, the case. Both quantitative and qualitative methods are used.

3.1 G-Readiness survey

The G-Readiness survey is used to quantitatively determine the level of G-Readiness in Finland.

A survey is the best choice for determining such a measurement as G-readiness, because it allows study of large amounts of data and variables. Survey helps to capture a picture of a situation at a specific point of time and the possibly large sample size allows making generalizations. (Galliers, 1992) This is important in determining G-readiness, because the goal is to determine the *current* level of it and make some generalizations based on the results.

Structural equation modeling, SEM, is used to analyze the data and the usability of the G-Readiness model. There are two approaches to SEM: covariance based structural equation modeling, CBSEM, and variance based partial least squares analysis, PLS. CBSEM, “attempts to minimize the difference between the sample covariances and those predicted by the theoretical model” (Chin & Newstead, 1999, p. 309). In contrast, PLS aims to “maximize the variance of the dependent variables explained by the independent ones instead of reproducing the empirical covariance matrix” (Henlein & Kaplan, 2004, p. 290). PLS is considered to be a softer approach because of greater flexibility. It is said to be suitable for “causal modeling applications whose purpose is prediction and/or theory building” (Henseler, Ringle, & Sinkovics, 2009, p. 297).

When deciding which approach to use, the main determinants are the sample size and the distribution it follows. PLS can handle small samples, whereas CBSEM requires large samples, 200 observations at minimum (Boomsma & Hoogland, 2001). Similarly, SBSEM assumes data to be normally distributed while PLS does not hold such requirements.

In addition, PLS can handle complex structures and both formative and reflective indicators. The formative and reflective structures describe the types of relationships between the indicators or measures and the latent variables. The structures in the final model should be reported. The indicators in reflective measurement models reflect the construct that cannot directly be measured. Causality is thus from the construct to the indicators. The reflective measurement model in turn describes a situation where the indicators cause the construct. (Henseler, Ringle, & Sinkovics, 2009 & Hulland, 1999) The two structures are illustrated in **Error! Reference source not found.**. Even though PLS has leaner requirements for the data, it may give results that represent those of CBSEM analysis. In other words, it is suitable for model development.

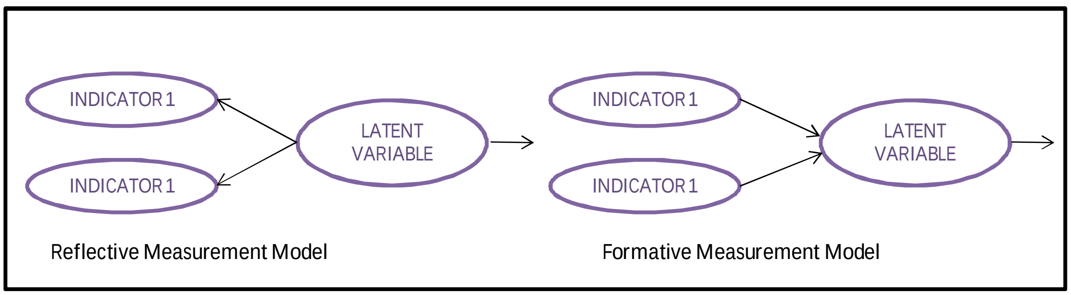


Figure 10: Formative and Reflective Measurement Models

3.2 Case study: carbon footprint of an invoice

A case study is used to determine the carbon footprint of both paper and electronic invoices. The choice of a case study can be elaborated through discussing three conditions of research question type, control over actual behavioral events and the focus of study (contemporary versus history). A typical case study answers a how or why question, focuses on a current, real life context and the investigators cannot control the events. (Yin, 2003) This is the case with the carbon footprint study.

To determine the carbon footprint of an invoice, one has to determine how the footprint is constructed and why. Then the numerical footprint (i.e. ‘what is’) can be calculated. Studying processes of a company requires observing the current operations of a company. Thus the investigator in this case has no control over the employees performing tasks.

A case study is much used in information systems science and is a good tool when capturing the reality of a situation, especially within an organization. The problem with case studies is that it is difficult to make generalizations based on findings. That is because the setting describes a specific case. (Galliers, 1992) However, in this study, a case is used to map out invoicing processes of a small and medium sized company, SME, and make quantitative calculations based on the maps. Analyzing the results of the case includes both qualitative and quantitative means. The process mapping is reviewed carefully so that the structure can be generalized. The efficiency of the processes is also estimated in order to comment on possible generalizations.

The steps taken to carry out the case study are the following. First, the processes of handling incoming and outgoing paper and electronic invoices are mapped out. The mappings are used to identify the variables or components of invoice carbon footprints. Then data is collected to account for the carbon footprints. The analysis takes into account the comparison of paper versus e-invoicing. Equally, the changes in components are noted for along with other possible observations. The numerical results are then discussed in reference to the case, the characteristics of the particular business in question, after which the results are generalized.

4 EMPIRICAL STUDY

The empirical study on G-Readiness survey and carbon footprints of invoices are discussed from data collection to data analysis.

4.1 The Green IT Readiness –survey

The survey used to test the G -Readiness framework and determine the actual level of Green IT Readiness was carried out in summer 2010 as an anonymous web based survey. The data was analyzed using PASW Statistics 18, formerly known as SPSS, and SmartPLS 2.0 M3.

4.1.1 The background of the original survey

The data collection was done through a survey directed at CIOs or their equivalents. The sample included three countries. In the end the response rate was 11%, which is lower than a suggested good response rate of 36% (+/-13%) (Baruch, 1999). However, the rate is in line with earlier results from questionnaires to CIO:s (Bhatt & Grover, 2005 and Fink & Neumann, 2007) and surveys on environmental issues (Gonzales, 2005). When compared to these results, the 11% response rate is in line with earlier results.

The data analysis in the last phase of the construct indicates that the model can give statistically valid results. Confirmatory factor analysis was done to validate the instrument on LISREL 8.8. Since the data was collected using the Likert scale, polychoric correlation and generally weighted least-squares were used to measure the parameters of the model. To measure the properties of the model, they studied convergent validity, discriminant validity and factorial validity tests. (Molla, Cooper, & Pittayachawan, 2009)

The results of this study were further described and analyzed in a working paper by Molla, Pittayachawan and Corbitt (2009). According to the findings, the main drivers for green IT are efficiency and cost cuts, implying that green IT is taken into strategic considerations. It seems that as IT budgets keep diminishing, green IT is seen as a way to make the most of the lesser resources available. Regarding green IT policy and practice, disposing IT correctly was the biggest green concern the respondents had. In addition, some attention was paid to environmental purchasing practices. The activities were still rather uncoordinated as CIOs were not leading green IT initiatives and often the costs and benefits were not known either. So, some steps towards greener IT have been taken but the companies do not seem to be at “an adequate level of readiness for green IT”. (Molla, Pittayachawan, & Corbitt, 2009, p. 1)

4.1.2 Creating G-Readiness survey for this study

The first task related to the questionnaire was to translate it to Finnish. This is because the respondents’ mother tongue is Finnish and not all companies actively use English. Thus the translation eliminates any possible misunderstandings that may arise from unfamiliar terminology. Dictionaries, Finnish IT and CSR reports and articles, literature and web sites were used to ensure that the translations were correct. The translation was first reviewed with the inspectors of this thesis. Then the questionnaire was tested with two people, one with electrical building technology background in relation to the energy efficiency issues. The other review was done regarding business view with a respondent with IT sourcing and CSR background.

The questionnaire was created as an online questionnaire using Webropol (Appendix 3). The respondents were sent an e-mail with a short note introducing the study. Answering took about 15 minutes and the responses were anonymous. The ones who did not respond to the questionnaire right after it was sent the first time were sent remainders later on.

As in the original questionnaire, the goal is to reach CIO:s or their equivalents to answer the questionnaire. The original questionnaire targeted companies with at least 100 employees, excluding those in agriculture and mining sectors. These sectors were excluded because traditionally the IT systems in such companies are less developed. This study is multi-industry study as well, but no limitation on the type of industry or size of company is made.

Several organizations who have interest in the topic cooperated by sending the questionnaire to their members who fit the above description. The organizations are FK, Teknologiateollisuus and TTL. FK is a trade body whose members are companies in the financial sector in Finland. It actively takes part in developing electronic financial solutions, such as the e-invoice. (Finanssialan Keskusliitto, 2009) FK's IT steering group has 15 finance and insurance CIO:s as members. Teknologiateollisuus is the Federation of Finnish Technology Industries, which was introduced in section 2.2.4. Its members range from small to large corporations in technology industries. Tietotekniikan Liitto ry, TTL, is the Finnish Information Processing Association has some 16 000 IT professionals and 500 companies as members. It provides the members with networking and member activities, training as well as R&D and publications. (Tietotekniikan Liitto ry, 2010) These three organizations provide with a possibility to reach the Finnish IT professionals across industries.

4.1.3 Principles of Partial Least Squares analysis

The PLS analysis discovered that the model does explain Green IT Readiness but that it does not explain adoption of e-invoicing. The assessment leading to these conclusions is explained through the statistical analysis, which covers the assessment of the reliability and validity of the measurements as well as the structural model. First analysis presented is on G-readiness, which is then followed by the analysis on e-invoice adoption.

When looking at the structural equation model and its validity, one will look at the R2 value and the latent construct loadings or weights. The R2 indicates the coefficient of determination. The value is assessed as 0.67 = substantial, 0.33 = moderate and 0.19 =

weak (Chin, 1998). The weighs of latent constructs should exceed 0.1 (Chin, Marcoling, & Newsted, 1996).

To assess the reliability and validity of the measurement model, one has to study the individual items, convergent validity and discriminant validity (Hulland, 1999). The starting point is to study Cronbach's α for internal consistency. This figure should, in early stages of study, be > 0.7. To compliment this measure, which can give underestimations of the internal consistency, composite reliability p_c is studied. At an adequate level, $p_c > 0.6$. Then one should look at the reliability of individual items, because that naturally varies. In general the individual loading > 0.7. (Henseler, Ringle, & Sinkovics, 2009, pp. 298-299)

Assessing convergent validity is about ensuring that the measures represent one construct that is shared by the measures. For this purpose, one should ensure the average variance extracted, AVE, be at least 0.5. It would mean that the construct in average could explain more than half of the variation of its indicators. (Henseler, Ringle, & Sinkovics, 2009, p. 299)

Discriminant validity, which complements convergent validity, should indicate that "a construct should share more variance with its measures than it shares with other constructs in a given model" (Hulland, 1999, p. 199). There are two indicators for discriminant validity. The first one is the Fornell-Larcker criterion uses the squared average variance extracted, AVE, "of each latent variable should be greater than the latent variable's highest squared correlation with any other latent variable" (Henseler, Ringle, & Sinkovics, 2009, p. 300). The other test are the cross-loadings, which assumes the loading of each indicator to be greater than its cross loadings.

Multicollinearity is an issue associated with formative indicators. In case there is too much collinearity, the conclusions about relevancy of indicators may be wrong, because the effects of individual measures on latent constructs may not be true. (Diamantopoulos & Winklhofer, 2001) A common way of testing for excess multicollinearity is the use of variance inflation factor, VIF. There are several cut-off points or rules of thumb for VIF, the most quoted being ten, and also four (O'Brien, 2007 and Henseler, Ringle, & Sinkovics, 2009). In general, the smaller the figure, the better. However, O’Brien (2007) notes that VIF values as high as 10, 20, 40 or even more do not directly pose a threat by themselves. A tolerance for VIF should be over 0.2. A smaller figure, especially tolerance less than 0.1 can be understood as a severe problem with collinearity (Menard, 1995).

To further study the validity of the model, confidence intervals need to be estimated. This is done by using a technique called bootstrapping. It “provides an estimate of the shape, spread, and bias of the sampling distribution of a specific statistics” (Henseler, Ringle, & Sinkovics, 2009, p. 305). The procedure generates large samples that include randomly selected cases from the original sample. This results in path model coefficients for the bootstrap distribution. It can be used as an estimate of the sampling distribution. To test the significance of the model, a student t test can be performed. A general rule is that a 95% confidence level is reached when $t > 1.96$. (Henseler, Ringle, & Sinkovics, 2009)

4.1.4 Statistical analysis and model validation

This section covers the statistical analysis run on the data. The choice of methodology accommodates for the small sample size, and the results in the end indicate that the model explains G-Readiness. IN contrast, the link between eco-sustainability and e-invoice adoption is not supported.

4.1.4.1 Sample size, response rate and normality test

The achieved response rate is 9 %. Altogether 514 questionnaires were sent out, yielding 45 responses. All responses were usable and had no missing data as respondents were required to answer each question. While the sample size is small, the response rate is close to that achieved by Molla, Cooper & Pittayachawan (2009), which was said to be in line with earlier surveys for CIO:s or on environmental topics (see section 4.1.1). The data was tested for normality on PASW Statistics. The data was found to be non-normally distributed. The frequency tables of the indicators chosen for the final model are presented in Appendix 4.

The achieved sample size and non-normality of the data at last confirmed the statistical method to be applied. For cases like this, the Partial Least Squares method, PLS, is the most suitable as it can handle small sample sizes and non-normal data. The G-Readiness model also consists of both formative and reflective structures. The reflective structure is present between indicators and latent constructs, and the formative structure is present between latent constructs and the G-Readiness construct. This is illustrated in Figure 12 in this chapter.

When using PLS, the sample size restricts the extent of the model in use. In this case, n = 45, four measures with three individual items each were chosen. This is in accordance with the rule of thumb, which suggests that the sample size should be equal or larger than "1) ten times the number of indicators of the scale with the largest number of formative indicators, or 2) ten times the largest number of structural paths directed at a particular construct in the inner path model" (Tabachnick & Fidell, 1989, p. 129).

4.1.4.2 Respondent demographics

The respondents represented IT professionals at service and manufacturing firms. Most of the respondents were either CIO:s or IT managers, while another significant occupational group was "other" (Figure 11). The other occupations included titles such as IT systems manager, executive IT advisor, service manager and development managers.

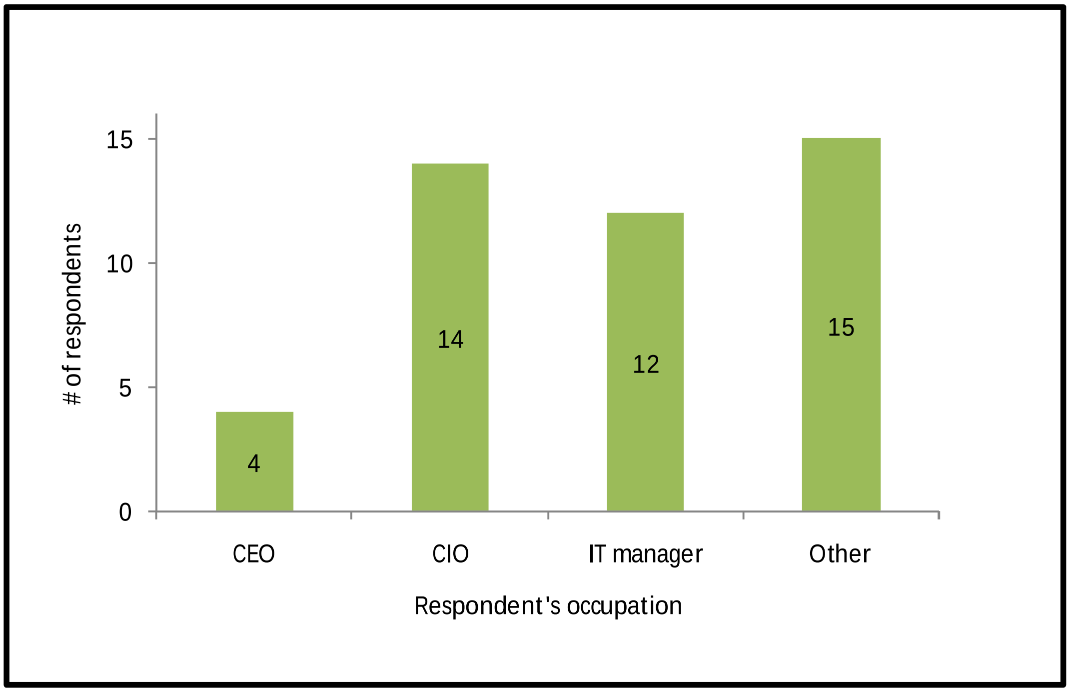


Figure 11: Respondent's occupations

The respondent companies represented both SME:s and larger companies. 42.2% comprise SME: s (maximum 250 personnel) and the rest were larger than that. A variety of industries were represented with services (Finance and insurance, ICT, other services) and manufacturing being the dominant industries. Regarding IT capabilities, half of the companies own 50 or less servers and only three own more than 1000 servers. Further information is presented in Table 2.

Table 2: Respondent demographics

Industry	Frequency	Percent
Construction	1	2,2
Education	3	6,7
Electricity, gas, steam and air conditioning supply	3	6,7
Financial and insurance activities	5	11,1
Information and communication	5	11,1
Manufacturing	10	22,2
Other	1	2,2
Other service activities	7	15,6
Professional, scientific and technical activities	3	6,7
Public administration and defense; compulsory social security	3	6,7
Real estate activities	1	2,2
Tranportation and storage	1	2,2
Wholesale and retail trade;repair of motor vehicles and motorcycles	2	4,4
Total	45	100,0

Number of employees	Frequency	Percent
1-10	5	11,1%
11-50	4	8,9%
51-250	10	22,2%
251-999	12	26,7%
1000-9999	12	26,7%
10000 and larger	2	4,4%
Total	45	100,0%

Number of servers	Frequency	Percent
0	1	2,2%
1-50	23	51,1%
51-100	9	20,0%
101-1000	9	20,0%
1001-10000	3	6,7%
Total	45	100,0%

4.1.4.3 Partial Least Squares -analysis on Green IT Readiness

The structural model with four latent constructs and three indicators in each was used to predict companies' Green IT Readiness. The detailed structure and questions are presented in Appendix 5. The model does indeed explain G-Readiness, while a larger sample size would be required to achieve high confidence levels.

The formative G-Readiness model is statistically valid. The most important indicator for this is the coefficient of determination (R^2) of the endogenous latent variable (G-Readiness). In this case, the R^2 = 0,641 and is considered as moderate. It means that 64% of G-Readiness explained by this model. The latent construct weights are all above 0.1 as required. The weights vary from 0.186 (*Virtualization*) to 0.280 (*Paperless office*), indicating that the constructs are balanced and contribute equally to G-Readiness. These measures are depicted in Table 3 along with indicator reliability measures, which are discussed next.

The reliability of the measurement model is at an acceptable level according to the tests. These include the individual item loadings, Cronbach's α and composite reliability for convergent validity as well as average variance extracted, Fornell-Larcker criterion and cross loadings for discriminant validity. The individual item loadings on the left hand side of Figure 12 are all above 0.7 as required. Looking at Table 3, Cronbach's α is above 0.7 for all other constructs except virtualization, which is slightly below (0.663). A more reliable measure for convergent validity is composite reliability, which is above 0.7 as required for all constructs. The main difference between Cronbach's α and composite reliability is that the former assumes all indicators to be equally reliable while the latter recognizes that the loadings differ between the constructs. Thus, relying mainly on the more accurate composite reliability, the measurement model passes the convergent validity tests.

Table 3: G-Readiness reliability measures

	Cronbach's alpha	AVE	Composite reliability	R2	Weights
ATTITUDE	0.893	0.825	0.934		0.261
PAPERLESS OFFICE	0.773	0.691	0.870		0.280
MANAGEMENT	0.823	0.741	0.895		0.263
VIRTUALIZATION	0.663	0.596	0.815		0.186
G-READINESS	1	1	1	0.641	

According to the tests, discriminant validity takes place as well. The average variance extracted, AVE, is above 0.5, which indicates discriminant validity and that the construct in average explains more than half of the indicator variation (Table 1). The Fornell-Larcker criterion is illustrated in Table 4. The square roots of AVE, indicated with grey background, are higher than the squared correlations with other correlations on the same row left of the square root AVE.

Table 4: The Fornell-Larcker criteria for G-readiness

	ATTITUDE	PAPERLESS OFFICE	G-READINESS	MANAGEMENT	VIRTUALIZATION
ATTITUDE	0.908	0	0	0	0
PAPERLESS OFFICE	0.423	0.831	0	0	0
G-READINESS	0.637	0.660	na	0	0
MANAGEMENT	0.758	0.735	0.751	0.861	0
VIRTUALIZATION	0.313	0.410	0.501	0.452	0.772

Another test for discriminant validity is to ensure that the items load the most to its own latent construct. It means that each item shares more variance with its construct (for example 'ATT1' with 'Attitude') than others. This is illustrated in Table 5, where the loadings are marked with grey background. It can be seen in the same table that some cross loading occurs. For example, attitude items seem to load also to construct called management. Reasons for this may be either theoretical or practical. Either the measurement model is not very distinct or the respondents had difficulty distinguishing between their attitudes and actual managerial practices. However, it can be said that the loadings for the correct constructs are distinct and the cross loading does not pose a real threat to the validity of the model in this sense.

Table 5: G-Readiness cross loadings

	ATTITUDE	PAPERLESS OFFICE	G-READINESS	MANAGEMENT	VIRTUALIZATION
ATT1	0.9017	0.3134	0.5593	0.6183	0.2772
ATT2	0.8684	0.4114	0.5310	0.7054	0.2063
ATT3	0.9529	0.4248	0.6375	0.7407	0.3580
PPR1	0.2793	0.8748	0.5179	0.5619	0.4000
PPR2	0.5030	0.7470	0.5423	0.6509	0.3570
PPR3	0.2710	0.8661	0.5780	0.6147	0.2714
MGMT1	0.5636	0.5987	0.6987	0.8807	0.3600
MGMT2	0.7595	0.6617	0.7044	0.9419	0.4182
MGMT3	0.6473	0.6598	0.5144	0.7491	0.4006
VIR1	0.1486	0.3021	0.2925	0.2672	0.7066
VIR2	0.2494	0.3137	0.3641	0.3235	0.7286
VIR3	0.3017	0.3387	0.4748	0.4304	0.8711
G-READ	0.6365	0.6597	1.0000	0.7505	0.5009

Multicollinearity does not pose a problem to the model. The variance inflation factor, VIF, is under 10 for all latent constructs as per the most quoted rule. The more strict rule of VIF < 4 is met for all but "Management", which exceeds this figure by approximately 0.8. The tolerance levels are all above the suggested 0.2 threshold. The results of multicollinearity tests are shown in Table 6.

Table 6: G-Readiness Multicollinearity measure

	Collinearity Statistics	
	Tolerance	VIF
ATTITUDE	0.385	2.595
MANAGEMENT	0.209	4.793
PAPERLESS OFFICE	0.410	2.437
VIRTUALIZATION	0.782	1.278

The final PLS G-Readiness model is illustrated in Figure 12. It can be seen that 64% of G-Readiness can be explained by the constructs. Paperless office is often assumed to be environmentally friendly, so it is logical that it had the highest loading onto G-Readiness. *Attitude* and *Management* have almost equal loadings (0.261 and 0.263 respectively), indicating that the respondents feel that companies do turn green attitude to action by coordinated activities through management. The weight of *Virtualization* varies the most from the four. As per the literature study, companies do associate virtualization with electricity (cost) cutting first and environment the next. This trend may explain the lower loading of *Virtualization* onto G-Readiness.

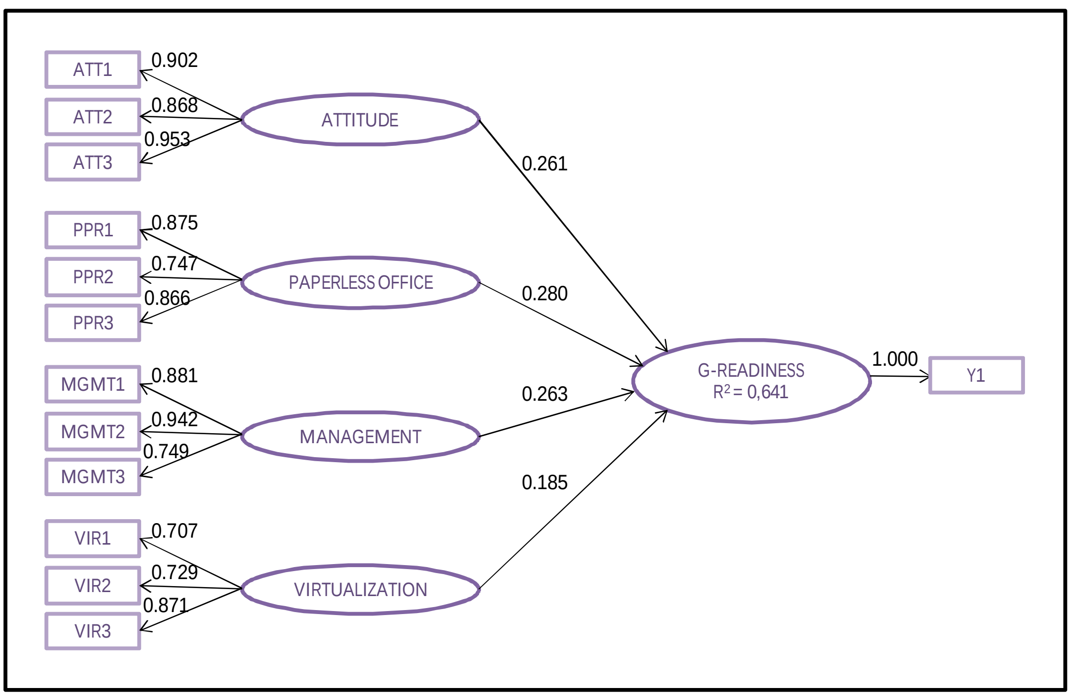


Figure 12: PLS G-Readiness model

The bootstrap performed to further validate the model indicates somewhat low confidence level. *Attitude* yields the highest confidence level of 94% ($p = 0.06$), followed by *Paperless office* ($p = 0.08$), *Virtualization* ($p = 0.14$) and *Management* ($p = 0.18$). Acceptable results would be $t > 1.96$, indicating an approximate value $p < 0.05$ for two tailed test. In this case, none of the factors yield this probability ($p < 0.05$) at sample size 45 (Table 7). To reduce possible bias, a high number of iterations (1000) were used. As resampling does not cause much additional variation, the low significance must be due to the weaknesses of the original sample. (Hesterberg, Moore, Monaghan, Clipson, & Epstein, 2005)

Table 7: G-Readiness Bootstrap

	Weight	t-statistic *	p-value
Attitude has a positive effect on G-readiness	0.261	1.85	0.06
Paperless office has a positive effect on G-readiness	0.280	1.75	0.08
Management has a positive effect on G-readiness	0.263	1.35	0.18
Virtualization has a positive effect on G-readiness	0.186	1.47	0.14

* 1000 iterations

Bootstrapping distribution mimics the distribution of the original sample, so the weaknesses are transferred to the bootstrap sample. The main problem in this case is the small sample size. The effect of variation is more significant with small sample sizes than large ones. Thus it can be assumed that a larger original sample size would yield statistically significant results. (Hesterberg, Moore, Monaghan, Clipson, & Epstein, 2005) Even though the artificial inflation of the sample size does not yield high confidence levels, otherwise the tests support accepting the hypotheses.

4.1.4.4 Partial Least Squares -analysis on E-invoice adoption

The same G-Readiness construct was also used to explain adoption of e-invoicing. In other words, the analysis checks whether environmental considerations were a driving force when the respondent companies adopted e-invoices. Only two out of the 45 respondents do not send e-invoices and one does not receive those. The analysis indicates that environment did not push companies towards this decision. This model is analyzed exactly like the G-Readiness model analysis except the final step as bootstrapping is not done. This is because it is not necessary to produce confidence limits for a model that does not meet the reliability criteria.

The overall structural model does not meet its reliability levels. First of all, the latent construct loadings give mixed results. The loadings for *Attitude* and *Paperless office* are negative, -0.264 and -0.071 respectively, indicating these constructs have a weak negative impact. *Management* and *Virtualization* in turn yield positive and strong enough loadings as both 0.479 and 0.304 respectively are over 0.1. As a matter of fact, these two loadings are stronger than those in the G-Readiness model. R^2 is 0.234, indicating that 23% of e-invoicing adoption would be explained by eco-sustainability. However, since the constructs are not valid, this figure is not valid either. The model is depicted in Figure 13.

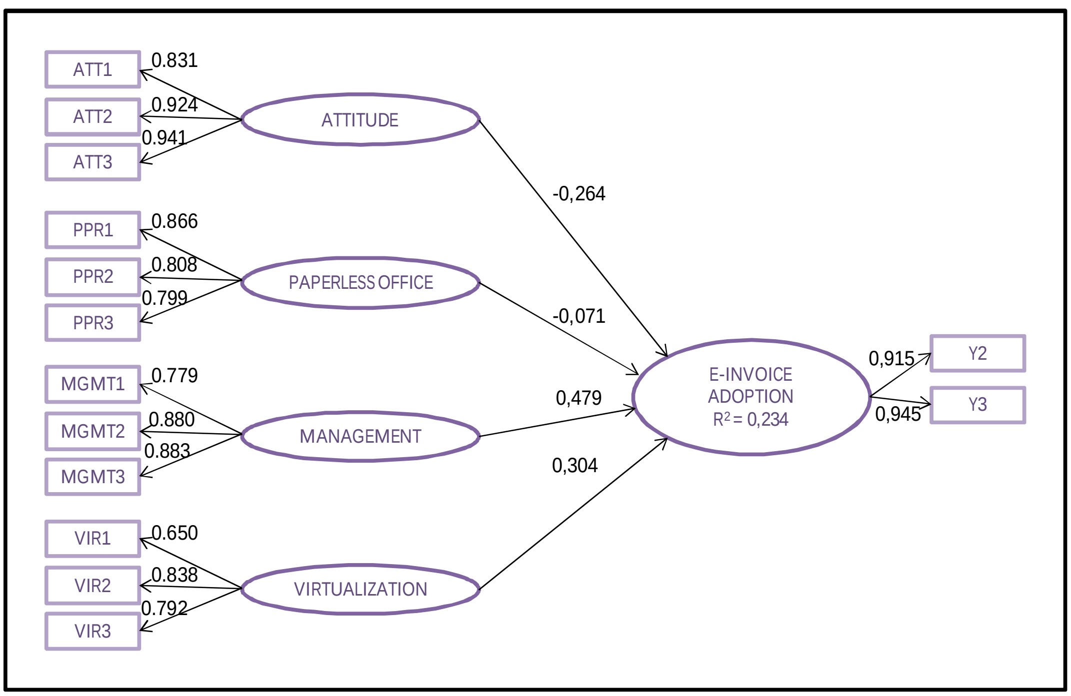


Figure 13: PLS E-invoice model

The reliability of the measurement model is mainly at an acceptable level (Table 8). Cronbach's alpha is acceptable except for virtualization, which again is slightly below the 0.7 acceptance level. Composite reliability is above 0.7 throughout constructs. Thus

Table 8: E-invoice reliability measures

the latent constructs meet the convergent validity requirement.

	Cronbach's alpha	AVE	Composite reliability	R2	Weights
ATTITUDE	0.8934	0.8103	0.9274		-0.264
PAPERLESS OFFICE	0.7732	0.6806	0.8646		-0.071
MANAGEMENT	0.8228	0.72	0.8849		0.479
VIRTUALIZATION	0.6629	0.5841	0.8065		0.304
E-INVOICE ADOPTION	0.8453	0.8649	0.9275	0.2343	

Discriminant validity is also demonstrated at measurement level. Average variance extracted is above the 0.5 limit as well (Table 8). The Fornell-Lackrer criterion is met as indicators share most variance with other indicators of the same latent construct (indicated by grey background in Table 9). Equally the cross loading table indicate the items load the most to their own constructs (indicated by grey background), even though some cross loading takes place (Table 10).

Table 9: The Fornell-Lackrer criteria for E-invoice adoption

	ATTITUDE	E-INVOICE	PAPERLESS OFFICE	MANAGEMENT	VIRTUALIZATION
ATTITUDE	0.900	0	0	0	0
E-INVOICE ADOPTION	0.164	na	0	0	0
PAPERLESS OFFICE	0.461	0.298	0.825	0	0
MANAGEMENT	0.774	0.360	0.756	0.849	0
VIRTUALIZATION	0.295	0.415	0.424	0.456	0.764

Table 10: E-invoice cross loadings

	ATTITUDE	PAPERLESS OFFICE	E-INVOICE	MANAGEMENT	VIRTUALIZATION
ATT1	0.8414	0.3264	0.0639	0.6252	0.2900
ATT2	0.9137	0.4185	0.1642	0.7067	0.1996
ATT3	0.9485	0.4270	0.1655	0.7566	0.3471
PPR1	0.2787	0.8852	0.2776	0.5852	0.4116
PPR2	0.5209	0.7692	0.2660	0.6549	0.3479
PPR3	0.2903	0.8302	0.2027	0.6322	0.2713
MGMT1	0.5795	0.5932	0.2179	0.7800	0.3552
MGMT2	0.7654	0.6639	0.2368	0.8933	0.4038
MGMT3	0.6570	0.6579	0.4051	0.8751	0.4043
VIR1	0.1497	0.3143	0.2338	0.2683	0.6854
VIR2	0.2236	0.3240	0.3756	0.3483	0.7984
VIR3	0.3094	0.3448	0.3145	0.4286	0.8185
E-INV	0.1620	0.3053	1.0000	0.3637	0.4107

It is worth discussing why eco-sustainability has not influenced e-invoice adoption. The latent constructs with negative weights were *Attitude* and *Paperless office*, which were assumed to be concepts that initially would be associated with eco-sustainability and G-Readiness. It could be possible, that even though companies do show concern for the environment and recognize that IT could be used to cut emissions, they do not recognize invoicing to be one of the green solutions. Paperless office from green perspective may be seen as a concept that improves eco-sustainability of office practices rather than a more strategic decision to cut emissions by automatic processes. Thus the traditional and measurable factors such as productivity decide whether financial processes such as invoicing are to be automated or not.

4.1.5 The discovered level of Green IT Readiness

The above discussed G-Readiness model can be operationalized to illustrate the actual level of G-Readiness. This can be done by calculating the average scores of each dimension. On a scale from one to seven, the four dimensional model would yield the maximum score of 28. This type of evaluation could be also done on company level if several staff members would rate the company and the scores would be then used to calculate the average scores and the readiness level (Molla, Cooper, & Pittayachawan, 2009).

Several issues to be considered when making generalizations based on these operationalizations. When evaluating the score, one should take variation into account. Another important point is to recall the sample size that the operationalizations are based on.

The respondents of the survey altogether average at score of 18 on the operationalizations for the Finnish G-Readiness survey. When looking at the score itself, it can be viewed as average. The results are illustrated in Figure 14. The highest score, 5.1, is gained from *Attitude*, which is the dimension describing the general concern towards the issue without requiring any action to be taken yet. It is natural that this component is the most developed. *Management* yields the lowest score just below four, indicating that green IT is not managed intentionally and in a structured way. *Paperless office* and *Virtualization* yielded average, or neutral scores. The scores are 4.7 and 4.2 respectively, indicating that these practices have been adopted but those are not clearly associated with eco-sustainability and environmental responsibility. As number four on this particular Likert scale indicates an average or neutral answer, it may be that the responses on this category may not be neutral but rather answers where the respondent did not have an opinion on the issue. Thus the yields may be slightly positive, the actual overall score should not be rated as average but rather as mediocre.

The generalization should be treated as representation of the sample only. This is because the sample size is small (n = 45). Consequently, no generalization about G - Readiness level in Finland should be made.

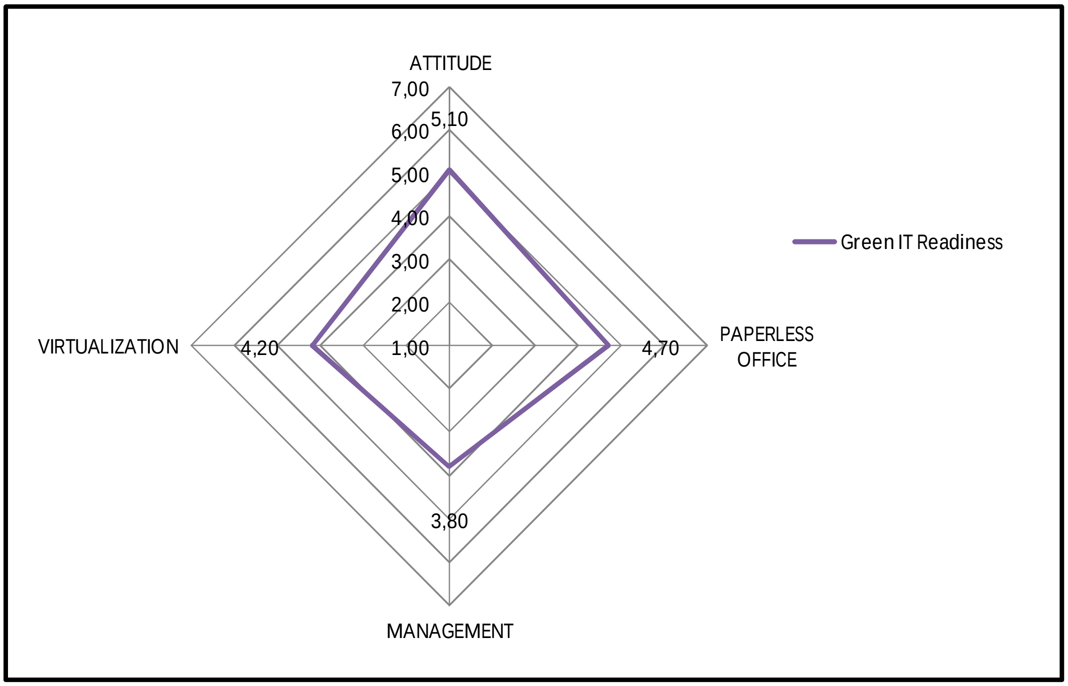


Figure 14: Green IT Readiness level in Finland

While the original Green IT Readiness model by Molla et al (2009) was not validated in this thesis, it is still interesting to see how the Finnish responses rate on that model. The comparison helps to assess the results of the Finnish G-Readiness model. With five dimensions, the maximum score is 35 on a seven point Likert scale. Their study of 143 responses averaged at a score of 19.30, which was viewed as average. The responses gathered in this thesis would average at 19.80 on this model, which would be an average score as well. It can be seen that attitude is viewed again as the most developed component, followed by practice above four as well. Technology and policy average just below three and governance at two, which all indicate underdeveloped scores.

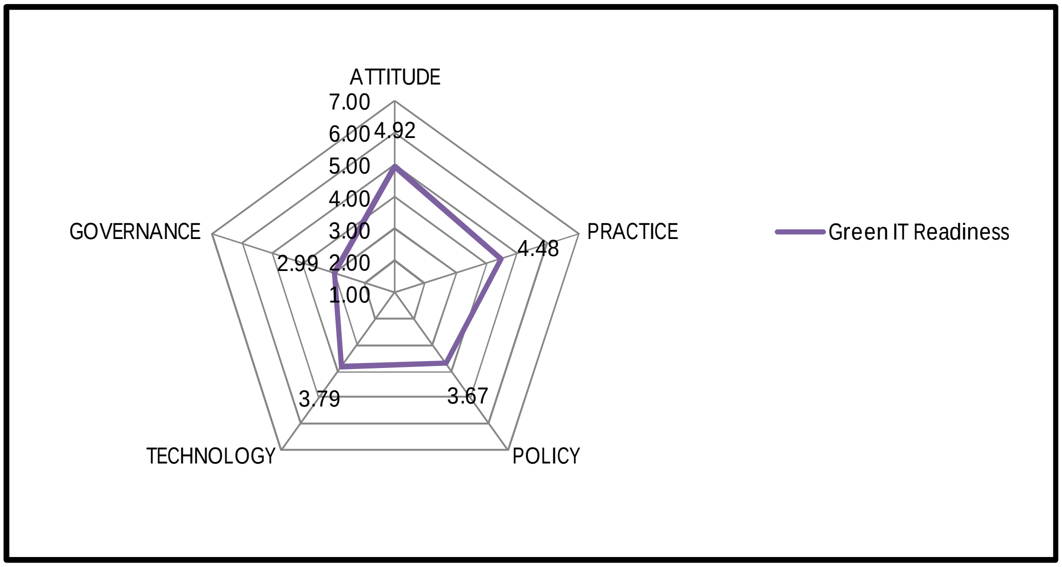


Figure 15: Green IT Readiness in Finland as per the original model

When comparing the two operationalizations, it can be seen that the respondents score a higher score on the Finnish G-Readiness model than on the original model. This is logical because the original model took into account a wider selection of issues whereas the model created in this thesis is narrower and focuses on the topics that are known in Finland. Based on the comparison, it can be said that the Finnish model gives somewhat optimistic scores.

4.2 The case study on carbon footprints of invoices

This section reviews the case on carbon footprint of paper and electronic invoices from the background to empirical research and analysis.

4.2.1 Background of the case study

As is usual with process improvements, large corporations benefit from those more than small and medium sized companies, SMEs, and thus the former adopt automated solutions more often. The case is the same with the rate of e-invoice adoption in Finland. The Federation of Finnish Financial Services, FK, is keen on promoting structured e-invoices also among the SMEs. In order to do so, it wanted to show the benefits of the solution from three viewpoints: productivity, service levels and carbon footprint. This thesis presents the carbon footprint study.

While the carbon footprint of paper invoice and several types of electronic invoices has been calculated, it has not been done for the XML-based invoice before now. Based on other studies, it can be assumed the greatest savings come from elimination of transportation, paper use and lesser need for office space and equipment. (Moberg, Borggren, Finnveden, & Tyskeng, 2008)

The case group consists of several types of participants from business, industry associations and education. FK, which in this case is the client of RTE, participates in the survey data collection as well. The case company is Finncontainers Oy, which is a logistics company that rents and leases containers in all main ports of Finland. The case company is proactive in developing and implementing electronic solutions. For example, its web store has been in service since 1999, it participated in an e-invoice pilot in 2001, started sending XML messages to port operators in 2001 and received first e-invoice in 2002. The company is implementing a new ERP system in summer of 2010. (Finncontainers Oy, 2010) Schedule wise the timing is ideal for the study as the old, manual and new electronic processes can be studied and compared easily.

Natural Interest is a Finnish expert in carbon accounting and will thus produce the actual carbon footprint accounting. It is an internationally networked consultancy who has served both SMEs and bigger corporations in Finland. (Natural Interest, 2010) Finnish State Treasury is a service agency operating under the Ministry of Finance. (Valtiokonttori, 2010) It represents the large business partner who may require the SME to provide electronic invoicing. Thus it will give the viewpoint of a large corporate partner in this case study. RTE will provide with process mapping and the overall study of the benefits.

4.2.2 Invoice process mapping

The process charts for paper and electronic invoicing were developed in cooperation with the case company. Three meetings were held to discuss the scope and details of the case. The existing data on processes was presented and discussed at this point. The further communication when developing process charts was done via phone and e-mail. The company uses modern computer systems to allow for the sales support team to serve the customers effectively and efficiently and use less time doing accounting related tasks. One part of this modernization of the information systems is the initiation of electronic invoicing at full scale in 2010. Thus it was possible to map and measure the old and new processes alike.

All in all, four invoice handling processes are mapped. These are outgoing manual invoice, outgoing electronic invoice, incoming manual invoice and incoming electronic invoice. The outgoing and incoming invoices together form an invoice lifecycle (Figure 16 below). The paper invoicing process can also be called manual invoicing, indicating that the process expects significant amount of manual work to be done. The processes of sending and receiving an invoice are separated here because these are two separate processes from the viewpoint of the firm. The case company provided with the process steps and measured the time required to carry out the processes.

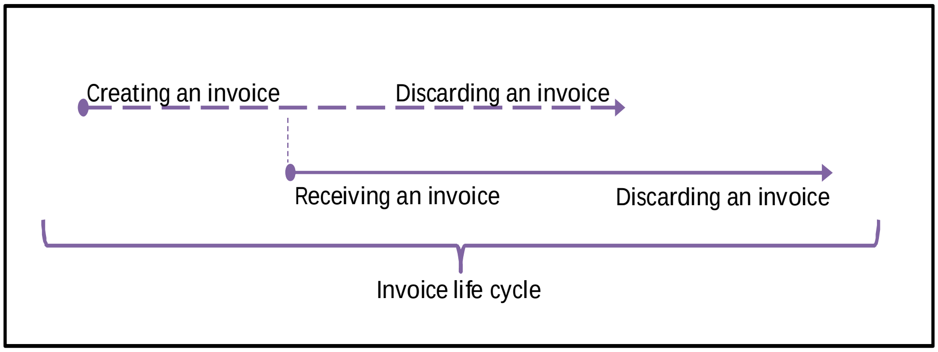


Figure 16: Invoice process ends

The outgoing manual, paper based invoicing process, presented in Figure 17, starts with creating the invoice by inserting the data from the order into the invoice form. The details are then checked and when the invoice is ready, two copies are printed out. One invoice is then put into an envelope, franked and taken to a mailbox. The other copy is put into a folder. The mail company then delivers the letter to the receiver. Next the sender retrieves payment details from the Internet bank and matches the payment received to the invoice sent. The accountant operates the accounts receivable, but no specific time is allocated to a single invoice. The invoice paper copy is archived for six years as per Finnish legislation. Then the paper is recycled.

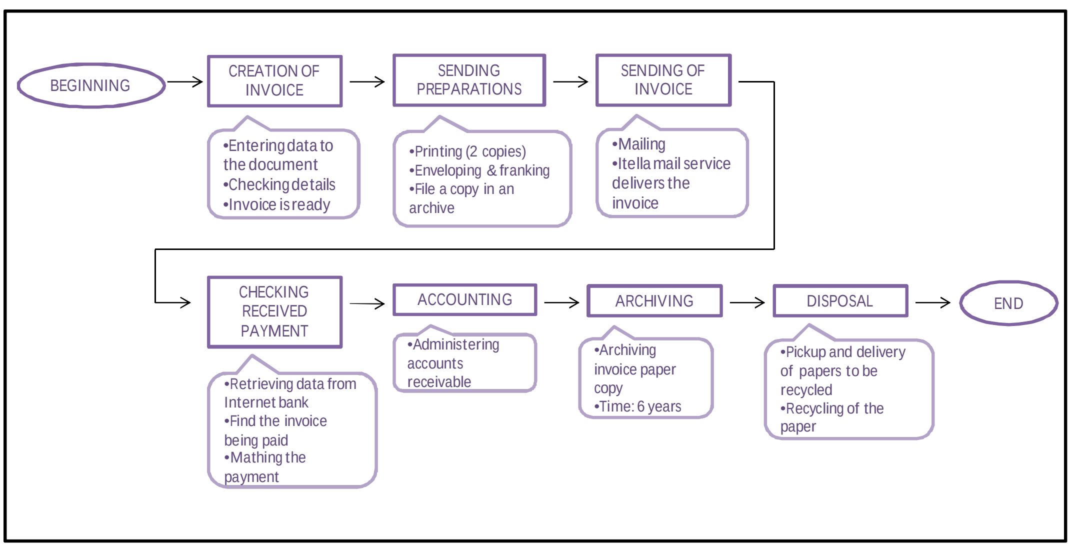


Figure 17: Outgoing manual invoicing process

Every step of the outgoing electronic invoice process, presented in Figure 182, is changed due to automation. During this process, no print copies of the electronic invoice are made. Only sales order data is needed to generate the invoice, where the invoice address acts as an identifier of the recipient. The invoice is then sent to the Internet bank from where the invoice is further sent to the recipient. The sender again retrieves payment data from the Internet bank and matches the payment which has now arrived at their account. The accountant does not need to do any invoice specific manual work since the process is automated. The invoice is archived for six years in electronic format only. The Finnish law states that an invoice can be archived either in paper or electronic format, so we assume no unnecessary paper copy is made. In the case of electronic archiving, two backup copies are required in addition to the original data on the service provider's server. The backup copies are saved on CD ROMs. In the end the old files will be deleted and the CDs disposed as burnable waste.

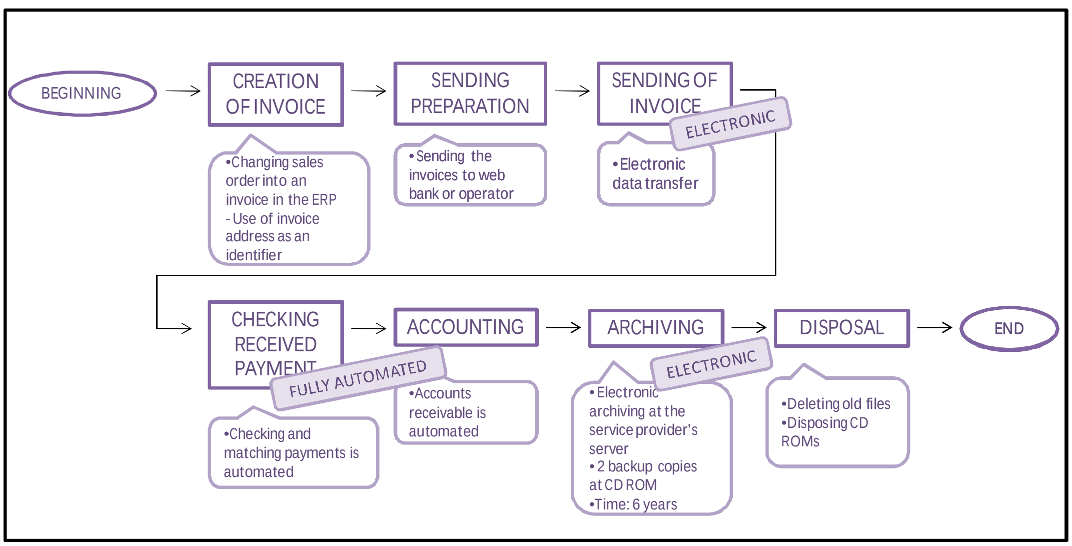


Figure 18: Outgoing electronic invoicing process

The incoming manual invoice process, presented in Figure 19, starts with receiving the invoice letter. The letter is opened and the details checked. Since the case company is a small company, there is no formal approval process. The person who opens the mail verifies the invoice against order details. The invoice is then temporarily archived because the payments are done in batches. The payment is created in the Internet bank. After confirming the payment, the invoice is again put into the archive. The accountant handles accounts payable and creates a monthly income statement. For this purpose, the invoices are sent back and forth between the case company and accountant once a month. The paper invoices are again kept in the archive for six years. The disposal is identical to that of outgoing paper invoices.

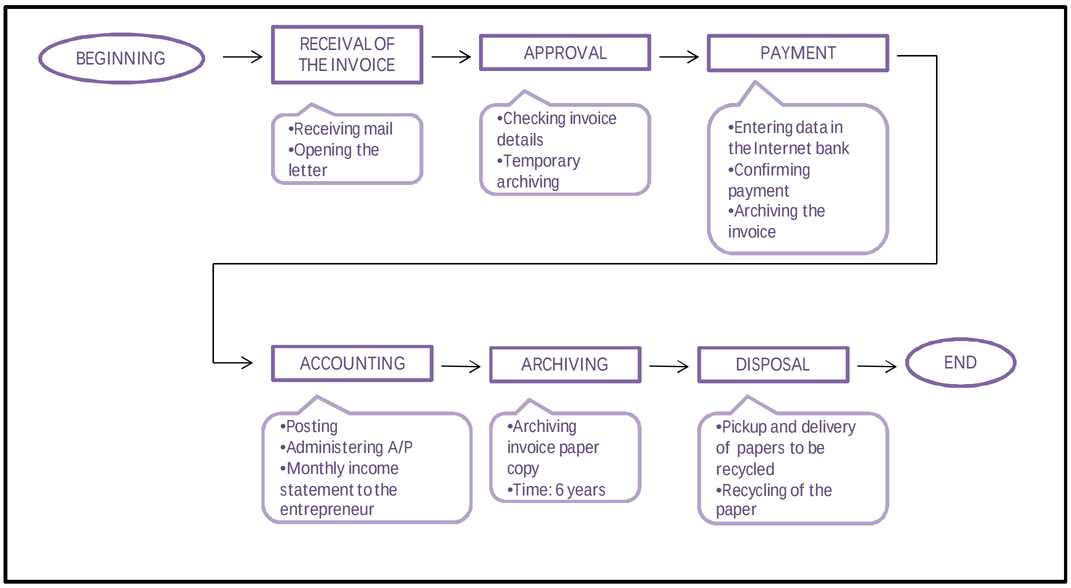


Figure 19: Incoming paper invoice handling process

The incoming electronic invoice process, presented in Figure 20, requires changes in each step of the process when compared to the manual process. Similar to the outgoing electronic invoicing, no print copies of documents are made in this case. The receival of the invoice takes place in the Internet bank where the invoices are retrieved. The invoice is then approved by checking the data and the payment is then confirmed. The software in use allows accounting to be automated in this part. Therefore the accountant does not need to process individual invoices anymore. No monthly mailing of documents to the accountant is needed either because the accountant has access to the same programs that the company uses. The electronic archive is kept for six years along with the CD ROM backups. Disposal means deleting old files and disposing CDs as burnable waste.

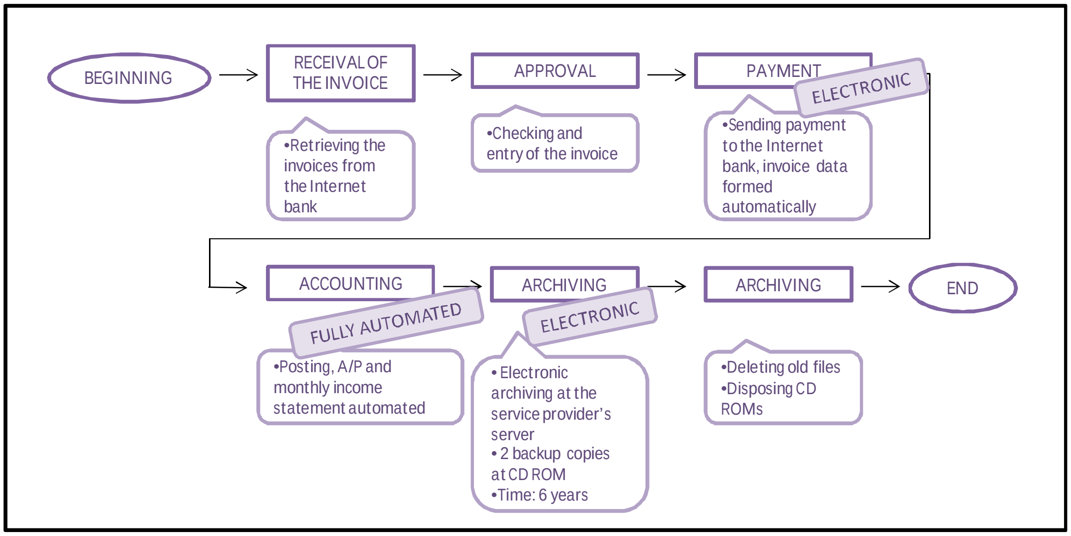


Figure 20: Incoming electronic invoice handling process

The invoice life cycle combining incoming and outgoing invoices is illustrated in Figure 215. The stamps 'electronic' and 'fully automated' illustrate the changes that automating invoice handling causes.

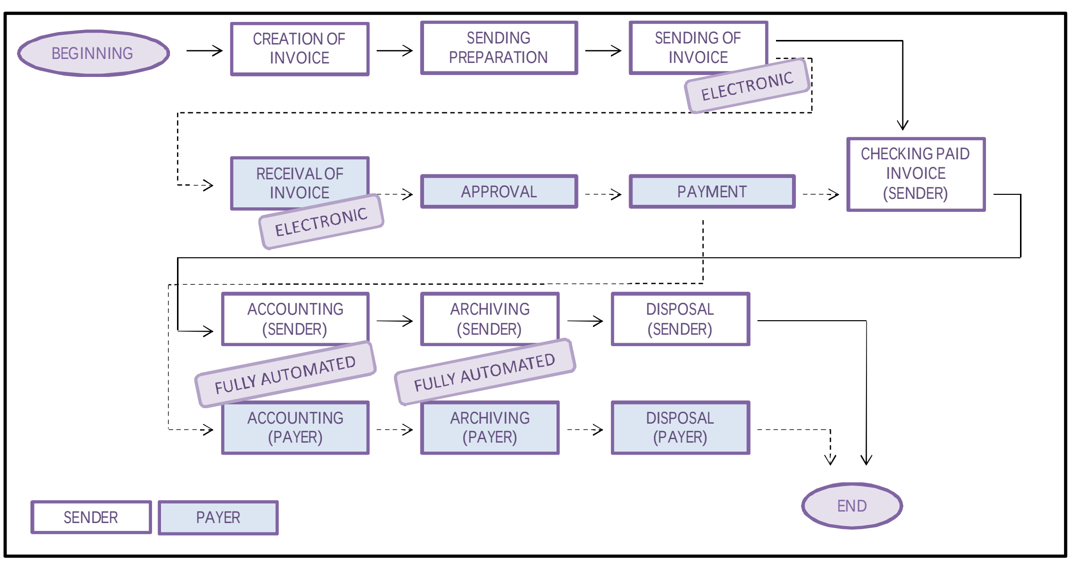


Figure 21: Invoice life cycle

4.2.3 Carbon footprint of invoices

Based on the process mapping introduced above, a carbon profile of invoices was created. The next steps are to list all assumptions and components. After that the actual calculations can be done.

4.2.3.1 Footprint composition and assumptions

The carbon footprints of invoices are composed of several inputs. Naturally one would think of paper, envelopes and mail delivery, which are the traditionally associated with invoice. These inputs form the *Distribution* –component together with the electronic data transfer and the equipment needed: PC, printer and franking machine. The operative personnel who creates, inspects and otherwise handles the invoices is accounted for in the *Work* –component. The work done by an accountant is also included there. The last component is *Archiving*, which includes the traditional paper archive as well as electronic archiving. These components are also illustrated in Figure 22.

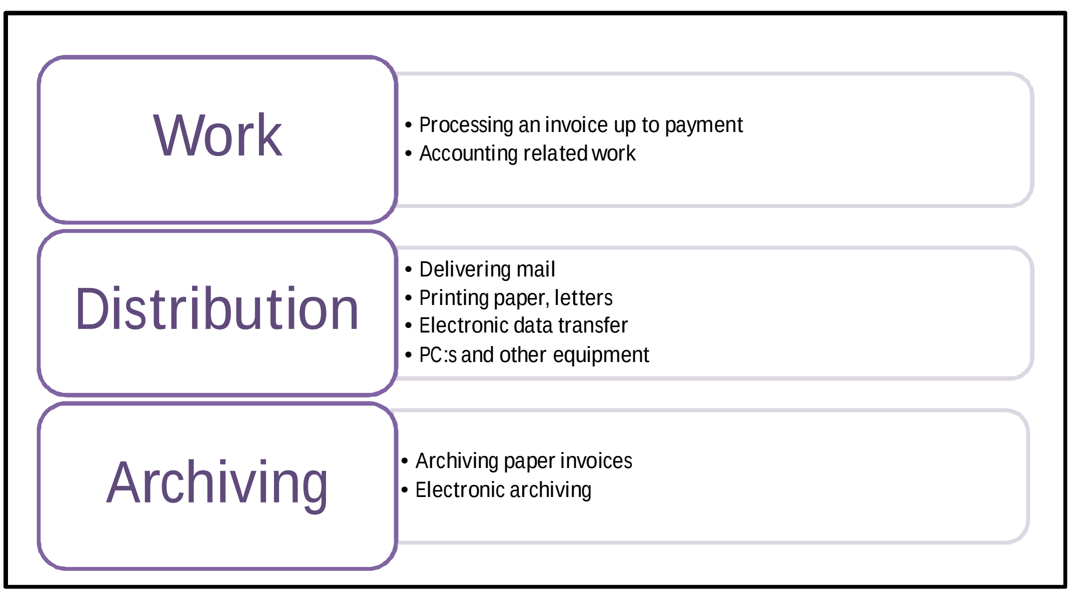


Figure 22: Invoice carbon footprint components

The carbon embodied in the abovementioned inputs is set and defined in further detail according to carbon databases that Natural Interest uses. Most inputs have static footprints, indicating one footprint per input. In contrast, paper products and work, are presented in three alternative figures; low, average and high. This is because the carbon footprints of paper and office worker vary significantly. In this study, the case company was estimated to represent the average profile. Paper, for example, can be produced from recycled material in a modern facility, which would result in a significantly lower footprint than if the paper was produced in a facility with lesser emissions control and using new material.

Similarly, the carbon footprint of an office worker depends heavily for example on the type of building (green maintenance and power or not), the type of work (business travel or not), and the mode of work commuting (private car versus public transportation). The low, average and high carbon profiles have been calculated by Natural Interest in several Finnish organizations. The more detailed list of assumptions is in Appendix 6.

4.2.3.2 Footprint results and analysis

The footprint calculations indicate that an e-invoice indeed is more environmentally friendly than a paper invoice. The paper invoice footprint ranges from 467 to 2120 gCO_2e whereas e-invoice footprint is from 148 to 697 gCO_2e (Figure 23). In other words, the electronic invoice is four times better for the environment than the paper invoice. The magnitude of the footprints can be illustrated by thinking driving a car to a grocery store. Looking at the average profiles, the paper invoice footprint is equal to the nearest grocery store being four kilometers away from home, and the e-invoice as if the store was moved closer, resulting in only one kilometer distance to the store.

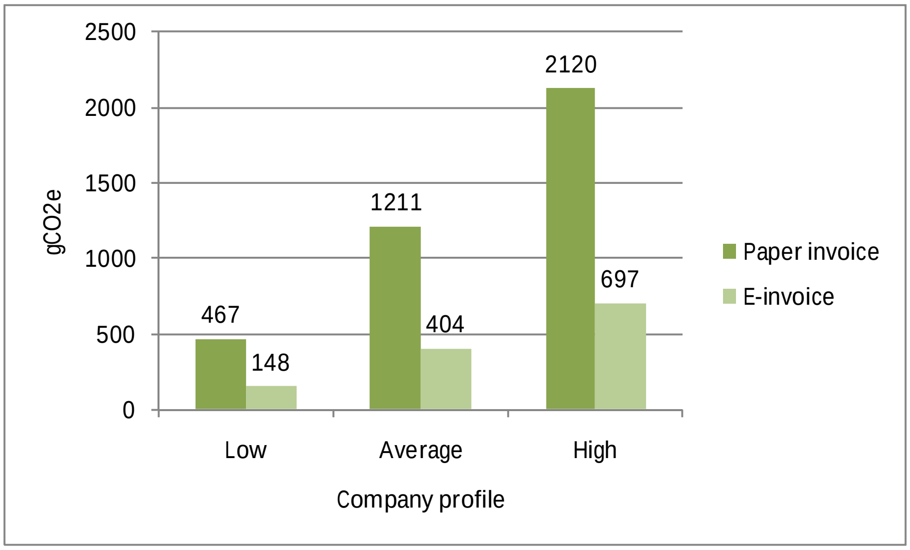


Figure 23: Invoice life cycle footprints

As explained earlier, there are three carbon profiles for office workers. The highest one is a profile of a company where business travel is regular. The average profile could describe an operative level worker whose work does not require travel. He or she would commute to work by own car. The lowest profile is similar to the average with the exception that environmental issues are taken into account for example in the form of public transport or biking to work. To get an average figure, the average profiles are studied in more detail.

It is somewhat surprising that the paper products and transportation are not the biggest polluters, but that the share of work is. Looking at the average profiles, it can be concluded that work is the major component in the carbon footprint (Figure 24). This implies that automating processes, i.e. eliminating manual, unproductive work, does not bring only monetary benefits but environmental benefits as well.

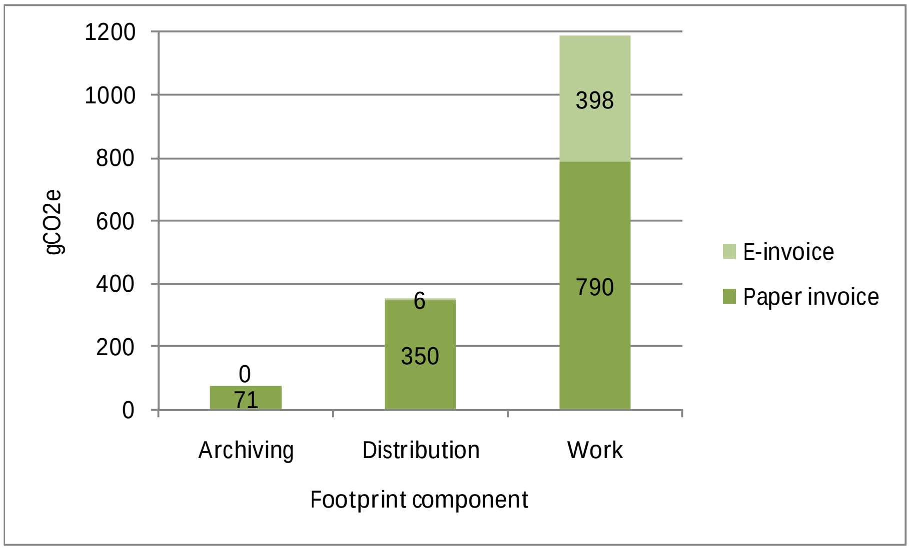


Figure 24: Invoice carbon footprint components

In this particular case, handling outgoing invoices has bigger carbon footprint than the incoming invoices. However, the percentage change is somewhat smaller; automating incoming invoices reduced the footprint by 77 % whereas automating outgoing invoices reduces the carbon footprint by 61% (Table 11).

Table 11: Invoice carbon footprint components and changes

Incoming invoice	Work	Distribution	Archiving	Total gCO2e	Saving %
Paper invoice	344	44	35	423	
E-invoice	94	3	0	97	77 %

Outgoing invoice	Work	Distribution	Archiving	Total gCO2e	Saving %
Paper invoice	446	306	35	787	
E-invoice	304	3	0	307	61 %

5 DISCUSSION AND CONCLUSION

This thesis examines the concept of Green IT and the way Finnish businesses comprehend and execute the concept. The focus is on IT enabled financial processes in particular.

According to the study, Green IT Readiness in Finland consists of four components, *Attitude*, *Management*, *Paperless office* and *Virtualization*. This model was found to be valid and it does explain G -Readiness. When operationalizing the model, the level of G-Readiness was found to be mediocre. In comparison to the original, more holistic model, the Finnish model gives slightly optimistic scores. Thus the Finnish, average score is interpreted as mediocre. Even though artificial inflation of the sample size did not produce high confidence levels, the analysis supports accepting the hypotheses concerning G -Readiness. The model was also used to test does eco-sustainability explain adoption of e-invoicing. It was found out that no such connection can be made and thus the hypotheses predicting this connection had to be declined.

The study on Green IT Readiness indicates that companies do recognize the concept and already have some activities. Yet it seems that the activities are not very coordinated and that attitude and willingness rather than planned, coordinated actions describe the current form of G-Readiness in Finland. Similarly, mechanical improvements such as virtualization and paperless office activities, are being executed but not necessarily for environmental reasons. The general notion about attitude is in line with previous findings from Tekes Green ICT study (Tekes, 2010), which indicated existing awareness and need for more information.

The second part of this thesis covers a study on carbon footprint of invoices, which indicates that an e-invoice is more environmentally friendly solution than a paper invoice. E-invoice was found to be about four times greener than a paper invoice. Reduction in manual work along with elimination of transportation and use of paper products account for the majority of reduction. Manual work was not accounted for in previous studies. As it was the most polluting component, the results clearly make new and valuable information available for academics and businesses.

5.1 Linking eco-sustainability and productivity: e-invoice as an example

Even though G -Readiness was found to be at a mediocre level, environmental reasons cannot be used to explain the transition to paperless processes in financial administration. While an e-invoice is both productive and ecological solution, it is worth discussing why do not the companies make this conclusion. Analyzing the content and level of G -Readiness in Finland from e-invoicing perspective is interesting and useful for both academics and businesses. This is because financial administration processes, often characterized as back end processes, are still often performed manually, while for example logistics processes are automated more often. High potential exists in automating financial processes. Currently about 90 % of invoices in Europe and the USA are still in paper format, indicating potential for significant productivity increases when automated. As the carbon footprint study concluded, this transition will yield environmental benefits.

5.1.1 Eco-sustainability of services and digital business practices

The case of e-invoicing offers insight to why Green IT Readiness is not yet an everyday concept and practice. On a product-service continuum, an invoice would be categorized more as a service than a product. Sustainability initiatives have first been implemented on high polluting production processes, where gains have been significant and positively affected the surrounding society. As industries in developed countries are now turning from product oriented to service oriented industries, the general understanding may be that economies as whole are becoming less pollutant. However, at current consumption levels, today's way of living does harm the environment. Equally, there is less information available about eco-sustainability of services than there is of products.

Sustainability activities related to manufacturing and products has yielded monetary gains as well as improved company image. The intangible benefits are an important part of sustainability. Without sustainability, the negative image of the company especially during environmental disasters can drive companies to bankruptcy. On the other hand, the tangible, monetary gains from improved processes help to justify and measure the effect of environmental decisions.

Invoicing, and other such supporting activities, is not viewed as a process or service that poses a threat to the surrounding environment. Thus the brand value of e-invoicing as a green option is rather inexistent. Instead, companies associate it with productivity gains and the environmental gain from paperless office is more goodwill than a solid decision on improving business processes. The e-invoicing case illustrates a setting where environmental factor can be viewed as a quality factor. The quality of the service is improved by measures of time, quality of information and carbon footprint, which all contribute to lower costs as well. It is the interlinkedness of the issues that businesses should recognize.

The link between productivity and sustainability must be established if green initiatives are to become successful both among businesses and in regard to the end results. Environment and intangible benefits are not enough. E-invoicing has been identified as a significant source of productivity increases for businesses of all size. This thesis proves that an e-invoice can also be source of environmental gains in terms of lower carbon emissions. As the concept can be easily transferred to other similar processes, it is natural to establish the link between productivity and sustainability.

5.1.2 Measuring eco-sustainability

It is important to understand the relation of eco-sustainability to productivity and quality. This link is crucial from business point of view because performance measurement. It is often criticized that it is difficult to put a price on sustainability practices and even more difficult to measure and prove that those generate returns.

Green IT activities are easily linked with productivity, which makes the whole concept more justifiable than other, less concrete sustainability practices. Carbon footprint is a valid unit of measure.

First of all, eco-sustainability can be a by-product of productivity. For example, moving to e-invoicing reduces inputs (office workers) needed to carry out invoicing. This benefits the environment as well, which can be viewed as increased quality of the good or service. This notion is important because it helps companies to both identify current green solutions and develop new ones. A company that is initiating corporate responsibility reporting could look into current solutions and identify those where productivity increase has improved eco-sustainability as well. When improving processes or developing new solutions, companies could select the solution that does increase productivity and eco-sustainability.

An important feature of the eco-sustainability - productivity link is the reach to the whole value chain rather than focus on a single process. This is because focus on the link to productivity of a single process alone does not result in highest reductions in the company carbon footprint possible. The final carbon footprint measure of a product or a service depends on the inputs of each particular value chain. The production, be it of a tangible product or of an invoice generation and handling, will always account for a significant portion of the carbon footprint. In the case of invoicing, if the office worker who previously did invoicing would be moved into other duties, the overall emissions of the company would not reduce so greatly because the office worker’s footprint is not eliminated. Thus companies should pay attention to promoting an eco-sustainable value chain, the way of working being a significant factor in labor intensive processing. In practice, this means efficiency in terms of office building, equipment use, waste management and travel for instance.

5.2 Limitations of the research

This research was limited due to both statistical and case related issues. The G-Readiness survey was mainly limited due to the small sample size. A slightly larger (n = 60) sample size would have allowed reaching acceptable confidence limits for the current model. A significantly larger sample size, (at least n = 200) would have enabled full replication of the original G-Readiness model either using PLS or CBSEM. It could be assumed that a larger sample size would have yielded more accurate and reliable results when testing the model. The results of the current operationalizations of the model with n = 45 do not represent Finnish businesses comprehensively.

The case study is limited because it focuses on the movements of one invoice in one case company only. This limitation is eased with the fact that the case company did handle invoicing extremely efficiently compared to an average SME. Therefore the results are not overestimations and can be comfortably used when referring to the invoice carbon footprint of an SME. However, the results cannot be used to quote the invoice carbon footprints of a large corporation.

5.3 Suggestions for further study

There are several interesting research options for advancing both G-Readiness and invoice carbon footprint studies. Regarding this particular study and the methods, studying G-Readiness either company or sector wide or gathering a large sample size altogether would further help determine the actual levels of G-Readiness in companies.

In case of carbon footprinting, it would be interesting to replicate the study in other companies. Determining a carbon footprint of a paper invoice in SME:s that have average or unproductive ways of working would give idea of the variance. This information could further add to the effectiveness of the green argument when selling e-invoicing to SME:s. Studying the carbon footprint of these processes in large corporations could further underline the link between productivity and eco-sustainability. Both corporations and SME:s can use this information in sustainability reporting as well.

Measuring eco-sustainability, i.e. establishing a link between productivity and eco-sustainability is a topic that can interest academics in theory building and businesses in evaluating the worth of their practices at a more comprehensive, triple bottom line style. This area covers several interesting research areas and viewpoints, for example creating and measuring value with sustainability indices.

6 APPENDICES

Appendix 1: Green IT articles in leading IS journals

Journal Name	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
European Journal of Information Systems											
Information Systems Journal				1							
Information Systems Research											
Journal of MIS											
MIS Quarterly											2
MIS Quarterly Executive										1	1

The above mapped journals were European Journal of Information Systems, Information Systems Journal, Information Systems Research, Journal of MIS, MIS Quarterly and MIS Quarterly Executive, of which the latter two produced the only hits. Melville used the following search words: environment, environmental management practices, environmental sustainability, sustainable business, green business, green supply chain and ISO 14001. In addition, I used search words green IT, green ICT, sustainability and green for the search in 2008-2010. The appearance of these words was limited to the title of the article. Regarding environment, only the articles with reference to natural environment, not for example business environment or IT environment, were accepted. The hits on 'green' were filtered so that only environmental articles were included.

Appendix 2: An introduction to published Green IT conference papers

Conference name	Abbreviation	Track/ topic name	Track type	Year
European conference on information systems	ECIS	Green IT	Track	2010
American conference on information systems	AMCIS	Sustainability, Green Information Systems & Technology	Minitrack	2010
Pacific conference on information systems	PACIS	Green IT and Management	Track	2010
Australasian Conference on Information Systems	ACIS	Green IT/IS	Track	2010
International conference on information systems	ICIS	Green information technology	Track	2009
European conference on information systems	ECIS	Green IS	Ancillary meeting	2009
Pacific conference on information systems	PACIS	Green IT	No specified track	2009
Australasian Conference on Information Systems	ACIS	New Frontiers and Evolving Boundaries	Track	2009
American conference on information systems	AMCIS	Environmental ommunication and Decision Support	Minitrack	2008
Pacific conference on information systems	PACIS	Theme papers: Leveraging ICT for Resilient Organizationa and Sustainable Growth in Asia-Pacific Region, Electronic Waste Management and Environmental Sustainability	Tracks	2008
Australasian Conference on Information Systems	ACIS	IS and Society: Ethics, Social Responsibility and Sustainability	Track	2008
American conference on information systems	AMCIS	Environmental Decision Support Systems	Minitrack	2007
Australasian Conference on Information Systems	ACIS	Environmetal Sustainability of ICT	Track	2007
Pacific conference on information systems	PACIS	Social and Cultural Aspects of IT Use	Track	2007

Appendix 2: An introduction to published Green IT conference papers (continued)

Paper theme	Example	References
Decision support system (DSS), databases and mobile systems	Systems targeted at avoiding environmental hazards or disaster aid management and warnings	Burkhard (2007), Linden & Courtney (2007), Hastings (2007), Roy, Asem (2007), Scherner & Muntermann (2007)
Green IT/IS definition	Defining Green IT and IS, sustainability, literature reviews, research agenda definition, connecting Green IT to climate change	Elliot (2007), Elliot & Binney (2008), Molla, Cooper & Pittayachawan (2009), Lacobelli, Olson & Merhault (2010), Brooks, Wang & Sarker (2010), van Osch & Avital (2010), McLaren, Manatsa & Babin (2010), Ijab, Molla, Kassahun & Teoh (2010), Hasan & Dwyer (2010)
Adoption and drivers of Green IT&IS	Factors, drivers, enablers and barriers to Green IT Adoption	Chen, Watson, Boudereau & Karahanna (2009), Schmidt, Erek, Kolbe & Zarnekow (2010), Dick (2010), Seidel, Recker, Pimmer & vom Brocke (2010)
Green IT/IS in the supply chain	Green IT/IS in relation to IS service providers, global outsoutcing and green procurement	Babin & Nicholson (2009), Dada, Staake & Fleisch (2010), Tarafdar, Modi, Roy & Datta (2010)
Green IT/IS and costs	Drivers of Green IT linked to cost cuts, energy efficiency	Sarkar & Young (2010), Molla (2010), Hedwig, Malkowski & Neumann (2009), Dick (2010), Kim & Ko (2010), Schlieter, Juhrisch & Niggemann (2010)
Consumer point of view	Pricing of green consumer goods, use of IS to increase sustainability awareness, demand for green PC:s	Cazier, Shao & Louis (2010), Hovorka & Auerbach (2010), Schmidt, Schmidtchen, Erek, Kolbe & Zarnekow (2010)
Smart device, green software	Software and devices for energy consumption monitoring and community use	Hovorka & Auerbach (2010), Capra, Formenti, Francalanci & Gallazzi (2010), Kranz, Gallenkamp & Picot (2010)
Green grid	Linking green IT objectives and benefits of grid technology, cloud computing	Vykoukal, Wolf & Beck (2009), Vykoukal (2010)
Business models for sustainability	Business models for sustainability	Lee & Casalegno (2010)
Managerial attitudes towards green IT	Importance of Green in IT and link to costs	Sarkar & Young (2010), Molla, Cooper & Pittayachawan (2009)
Types of green IT activities	A model for evaluating the reach and richness of green IT activities	Molla (2009)
Green IT and IS	Distinguishing between the two	Chen, Watson, Boudereau & Karahanna (2009), Lacobelli, Olson & Merhault (2010), Brooks, Wang & Sarker (2010), Dick (2010)
Succes in Green IT	Identifying green IT leaders and laggers	Kim & Ko (2010)

Appendix 3: The G-readiness survey

Green IT -kysely

Tämä kysely on osa Aalto-yliopiston kauppakorkeakoulun Real-Time Economy -ohjelmaa. Tämän kyselyn tavoitteena on selvittää suomalaisten yritysten Green IT -valmiutta.

Tässä kyselyssä Green IT tarkoittaa systemaattista ekotehokkuuden ja kestävän kehityksen mittariston käyttöä IT infrastruktuurin sekä työntekijöiden ja johtajien IT:n käytössä läpi IT-laitteiston elinkaaren. Tavoitteena on vähentää IT:n, prosessien ja toimitusketjun aiheuttamia päästöjä ja parantaa energiatehokkuutta.

Green IT valmius tarkoittaa yrityksen valmiutta ja maturiteettia sisällyttää ympäristönäkökulma yrityksen tekniseen IT infrastruktuuriin ja työntekijöistä koostuvan IT infrastruktuuriin IT:n hankinnan, operaatioiden ja kierrätyksen näkökulmasta.

Kyselyyn vastaaminen vie noin 15-20 minuuttia.

1) Asemanne yrityksessä

- Tietohallintojohtaja
- IT-päällikö
- Muu, mikä

2) Toimiala

Maatalous, metsätalous ja kalatalous

3) Yrityksen henkilöstömäärä

1-10

4) Yrityksenne liikevaihto viimeksi päättyneellä tilikaudella (v. 2009)

1-199 000 euroa

5) Yrityksenne näkökulmasta, oletteko samaa vai eri mieltä seuraavien toteamusten kanssa

	Täysin eri mieltä	Eri mieltä	Jokseenkin eri mieltä	Ei samaa eikä eri mieltä	Jokseenkin samaa mieltä	Samaa mieltä	Täysin samaa mieltä
Yrityksemme on kiinnostunut tulevista kasvihuonekaasuja koskevista määräyksistä	○	○	○	○	○	○	○
Yrityksemme on kiinnostunut IT:n energiankulutuksesta	○	○	○	○	○	○	○
Yrityksemme on kiinnostunut jäähdytyksen ja valaistuksen aiheuttamasta energiankulutuksesta datakeskuksissamme	○	○	○	○	○	○	○
Yrityksemme on kiinnostunut IT infrastruktuurimme (muisti, serverit, verkko) energiatehokkuudesta	○	○	○	○	○	○	○
Yrityksemme on kiinnostunut IT:n tuottamista kasvihuonekaasuista	○	○	○	○	○	○	○
Olemme kiinnostuneita yrityksemme ympäristöjalanjäljestä	○	○	○	○	○	○	○
Yrityksemme on kiinnostunut IT-toimittajiemme ympäristöjalanjäljistä	○	○	○	○	○	○	○
Yrityksemme on kiinnostunut asiakkaidemme ympäristöjalanjäljistä	○	○	○	○	○	○	○
Yrityksemme on kiinnostunut ympäristövaikutuksista, joita aiheutuu IT-laitteistojen elinkaaren loputtua	○	○	○	○	○	○	○

6) Kuinka kehittyneitä seuraavat politiikat ovat yrityksessänne?

	Erittäin puutteellinen	Puutteellinen	Jokseenkin puutteellinen	Keskimääräinen	Jokseenkin kehittynyt	Kehittynyt	Erittäin kehittynyt
Yrityksen yhteiskuntavastuu	○	○	○	○	○	○	○
Vihreä toimitusketjun hallinta	○	○	○	○	○	○	○
Kestävän kehityksen ympäristönäkökulma	○	○	○	○	○	○	○
Ympäristöystävällisiin energianlähteisiin siirtyminen	○	○	○	○	○	○	○
Ympäristöystävällinen IT -hankintapolitiikka	○	○	○	○	○	○	○
Ympäristöystävällinen datakeskuspolitiikka	○	○	○	○	○	○	○
Käytännöt IT:n hyödyntämisestä yrityksen hiilijalanjäljen pienentämisessä	○	○	○	○	○	○	○
Työntekijöiden energiatehokas IT:n käyttöpolitiikka	○	○	○	○	○	○	○
Käytöstä poistuvien IT-laitteiden kierrätys	○	○	○	○	○	○	○
Vihreä IT-politiikka	○	○	○	○	○	○	○

7) Kuinka laajalti yrityksenne harjoittaa seuraavia käytäntöjä?

	Erittäin suppeasti	Suppeasti	Jokseenkin suppeasti	Keskimääräisesti	Jokseenkin laajalti	Laajalti	Erittäin laajalti
Suosimme IT-toimittaja, jotka ottavat huomioon ympäristöasiat	○	○	○	○	○	○	○
Otamme ympäristökohdat huomioon IT-hankinnoissa	○	○	○	○	○	○	○
Uudistamme IT-laitteistoa useammin kuin aikaisemmin energiatehokkuuden lisäämiseksi	○	○	○	○	○	○	○
Huomioimme ympäristönäkökulman datakeskuksen infrastruktuurin (valaistus, energiantuotanto/-jakelu, jäähdytys) ja ITn infrastruktuurin (serverit, muisti ja verkko) suunnittelussa	○	○	○	○	○	○	○
Mittaamme nykyisten tietojärjestelmien ja teknologioiden energiatehokkuutta	○	○	○	○	○	○	○
Sammutamme datakeskusten valot ja laitteet silloin, kun niitä ei tarvita	○	○	○	○	○	○	○
Operoimme nykyisiä tietojärjestelmiämme energiatehokkaalla tavalla	○	○	○	○	○	○	○
Käytämme tietokoneissamme virransäästöominaisuuksia	○	○	○	○	○	○	○
Toteutamme IT-projekteja, jotka mittaavat yrityksen hiilijalanjälkeä	○	○	○	○	○	○	○
Tulostamme kaksipuoleisia dokumentteja	○	○	○	○	○	○	○
Käsittelemme IT:n käytöstä johtuvat sähkölaskut erillään muista sähkölaskuista	○	○	○	○	○	○	○
Datakeskuksen siirto uusiutuvien energialähteiden ulottuville	○	○	○	○	○	○	○
Kierrätämme esimerkiksi paristoja, mustepatruunoita ja paperia	○	○	○	○	○	○	○
Hävitämme IT-laitteemme ympäristöystävällisellä tavalla	○	○	○	○	○	○	○
Käytämme ympäristöystävällisesti tuotettua energiaa	○	○	○	○	○	○	○
Käytämme vihreitä IT-palveluita tarjoavia yrityksiä	○	○	○	○	○	○	○
Suosimme laitetoimittajia, jotka huolehtivat laitteiden kierrätyksestä niiden elinkaaren päätyttyä	○	○	○	○	○	○	○
Lähetämme kehittyneitä verkkolaskuja	○	○	○	○	○	○	○
Vastaanotamme kehittyneitä verkkolaskuja	○	○	○	○	○	○	○

8) Kuinka laajalti yrityksenne käyttää seuraavia toimia ja laitteistoja?

	Erittäin suppeasti	Suppeasti	Jokseenkin suppeasti	Keskimääräisesti	Jokseenkin laajalti	Laajalti	Erittäin laajalti	En osaa sanoa
Servereiden yhteensovittaminen ja virtualisointi	○	○	○	○	○	○	○	○
Työpöydän virtualisointi	○	○	○	○	○	○	○	○
Muistin virtualisointi	○	○	○	○	○	○	○	○
Tiedon deduplikointi	○	○	○	○	○	○	○	○
Muistikapasiteetin yhdistäminen	○	○	○	○	○	○	○	○
Tulostuksen optimointi	○	○	○	○	○	○	○	○
IT-laitteiston minimointi	○	○	○	○	○	○	○	○
Datakeskuksen ilmastoinnin hallinta	○	○	○	○	○	○	○	○
Vapaajäähdytysjärjestelmä suurissa datakeskuksissa	○	○	○	○	○	○	○	○
Vesijäähdytteinen jäähdytyskone, jossa on säädettävät puhaltimet ja pumput	○	○	○	○	○	○	○	○
Nk. lämpimien ja kylmien käytävien suunnittelu	○	○	○	○	○	○	○	○
Päivitys tehokkaampiin muuntamoihin ja katkottomiin tehonlähteisiin / UPS-järjestelmiin	○	○	○	○	○	○	○	○
Veden tai ilman esilämmitys	○	○	○	○	○	○	○	○
IT-laitteiden nestejäähdytys	○	○	○	○	○	○	○	○
Energiatehokkaampien valaisimien asentaminen	○	○	○	○	○	○	○	○
Korkeajännitteinen (AC) vaihtovirtasyöttö	○	○	○	○	○	○	○	○
Tasavirtasyötön (DC) käyttö	○	○	○	○	○	○	○	○
Energiatehokkaat stand by-järjestelmät tietokoneissa	○	○	○	○	○	○	○	○
Energiatehottomista IT-järjestelmistä luopuminen	○	○	○	○	○	○	○	○
Tietokoneiden virranhallintaominaisuuksien hyödyntäminen	○	○	○	○	○	○	○	○
Pilvipalveluiden käyttö ympäristösyistä	○	○	○	○	○	○	○	○
Pilvipalveluiden käyttö ympäristösyistä tulevaisuudessa	○	○	○	○	○	○	○	○

9) Oletteko samaa vai eri mieltä seuraavista väittämistä yrityksenne käytäntöjen perusteella?

	Täysin eri mieltä	Eri mieltä	Jokseenkin eri mieltä	Ei samaa eikä eri mieltä	Jokseenkin samaa mieltä	Samaa mieltä	Täysin samaa mieltä
Yrityksemme on asettanut CO2 tavoitteita pienentääksemme yrityksemme hiilijalanjälkeä							
Yrityksemme ympäristöhankkeita koordinoi siihen nimetty vastuuhenkilö							
Yrityksen johto käsittelee ympäristöön liittyviä IT-asioita korkealla prioriteetillä							
Jokaisen vihreän IT-hankkeen vastuut ovat selkeästi määritellyt							
Yrityksemme tietohallintojohtaja on johtavassa asemassa kaikissa ympäristöhankkeissa (IT ja ei-IT)							
Olemme varanneet osan budjetistamme ja muista resursseista vihreää IT:tä varten							
Käytämme mittaristoa vihreiden IT-hankkeiden vaikutuksien arvioinnissa							
Yrityksellämme on käytössä työkaluja, joiden avulla voidaan valvoa IT -toimittajien ympäristöystävällisyyttä							
IT -osasto on vastuussa omista energiakustannuksistaan							
Yrityksellämme on riittävä valmius ympäristöystävällisen IT:n käyttöön							
Käsittelemme vihreää IT:tä kestävän kehityksen - tai yritysvastuuraportissamme							
Onko kestävän kehityksen - tai yritysvastuuraporttinne GRI-ohjeiston mukainen?							

10) Mitkä seuraavista ympäristöystävällisen IT:n näkökulmista ovat merkityksellisiä yrityksellenne?

	Täysin merkityksetön	Merkityksetön	Jokseenkin merkityksetön	Keskimääräinen	Jokseenkin merkityksellinen	Merkityksellinen	Erittäin merkityksellinen
IT:n käyttö hiilidioksidipäästöjä tuottavien toimintojen (kuten liikematkustus) eliminoimiseksi							
Datakeskuksien energiatehokkuuden parantaminen							
Datakeskuksien käyttökustannuksien pienentäminen							
IT-infrastruktuurin sähkökustannuksien pienentäminen							
IT:n tuottamien kasvihuonekaasujen vähentäminen							
Ympäristölainsäädännön noudattaminen							
Ympäristöystävällisemmän IT:n hankinta							
IT:n kierrätys ympäristöystävällisellä tavalla							
Muut näkökulmat							

11) Viitaten edelliseen kysymykseen, listatkaa mahdolliset muut merkitykselliset näkökulmat.

12) Pääasialliset ajurit yrityksenne näkökulmasta ympäristöystävällisen IT:n käytölle ja implementoinnille ovat:

	Täysin eri mieltä	Eri mieltä	Jokseenkin eri mieltä	Ei samaa eikä eri mieltä	Jokseenkin samaa mieltä	Samaa mieltä	Täysin samaa mieltä
Lainsäädäntö							
IT -alan valmius ympäristöystävällisten IT-tuotteiden tarjoamiseen							
Kilpailijoiden toimet							
IT -toimittajien painostus							
Asiakkaiden tai kuluttajien painostus							
Yritysstrategiamme							
Ympäristönäkökulma							
Ympäristöystävällisen IT:n kustannukset							
IT:n kustannuksien pienentäminen							
Yleinen, sosiaalinen hyväksyntä globaalissa ja paikallisissa yhteisöissä							
Valtion tuki							
Ympäristöystävällisen IT:n yleistyminen							
Yritysjärjestöt							
Muut ajurit							

13) Viitaten edelliseen kysymykseen, listatkaa mahdolliset muut ajurit.

14) Mitkä seuraavista asioista rajoittavat yrityksenne ympäristöystävällisen IT:n implementointia?

	Täysin eri mieltä	Eri mieltä	Jokseenkin eri mieltä	Ei samaa eikä eri mieltä	Jokseenkin samaa mieltä	Samaa mieltä	Täysin samaa mieltä
Ympäristölainsäädännön puuttuminen							
Johtajuuden puuttuminen ympäristöystävällisen IT:n saralla							
Ympäristöystävällisten IT-ratkaisujen kustannukset							
Ympäristöystävällisen IT:n käytön yleisyys alalla							
Ympäristöystävällisen IT:n epäselvä businessarvo							
Nykyisten IT-järjestelmien riittävä tehokkuus							
Riittämättömät taidot ja koulutus							
Valtion tuen puuttuminen							
Muut rajoitteet							

15) Viitaten edelliseen kysymykseen, listatkaa mahdolliset muut rajoitteet.

16) Vastatkaa yrityksenne osalta

Kuinka monta serveriä on käytössä (noin)?

Kuinka monta PC:tä ja kannettavaa tietokonetta on käytössä (noin)?

Kuinka suuri vuosittainen (operatiivinen) IT-budjettinne on?

Kuinka suuri IT-henkilöstönne on?

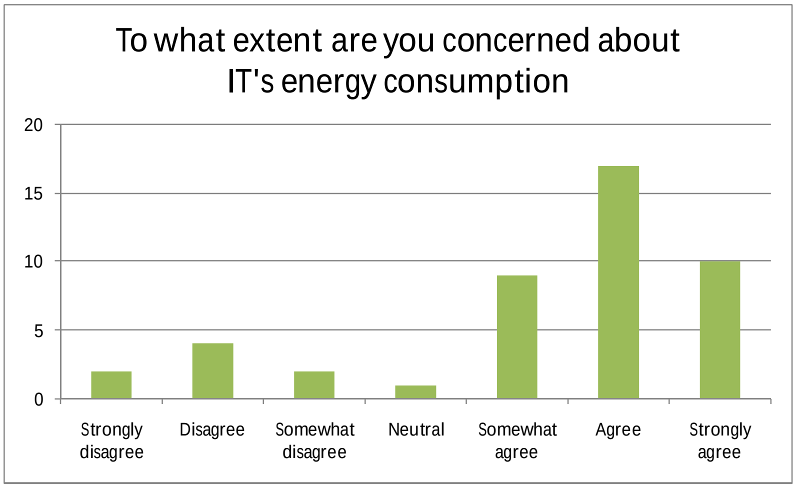
Kuinka suuri osa (%) IT-työstä on ulkoistettu?

17) Mahdolliset kommentit

Lähetä

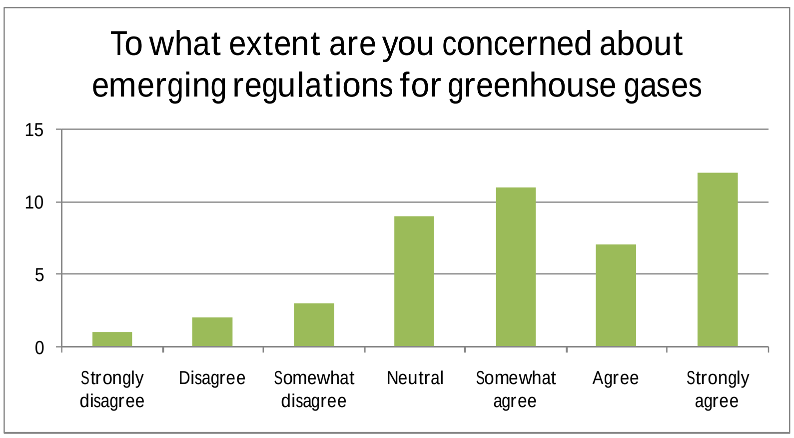
Appendix 4: Frequency tables of G-Readiness questions

Attitude



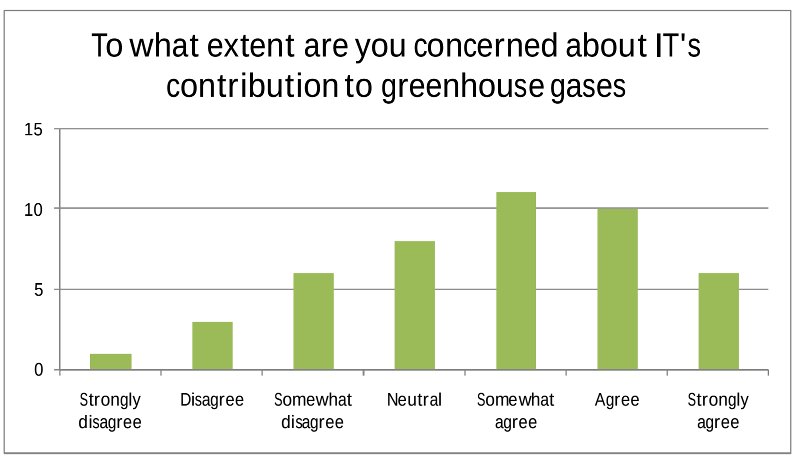
Concern about IT’s energy consumption

Response average 5,3; n = 45



Concern about regulations on GHG:s

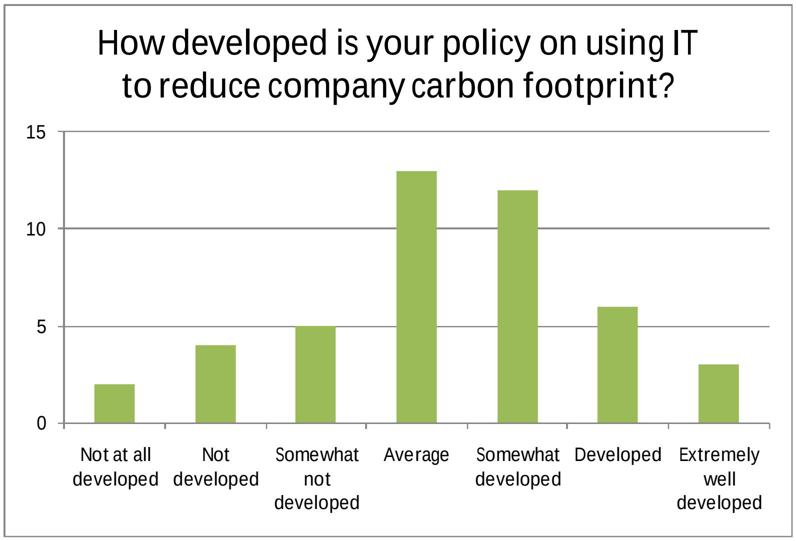
Response average 5,1; n = 45



Concern about IT’s contribution to GHG:s

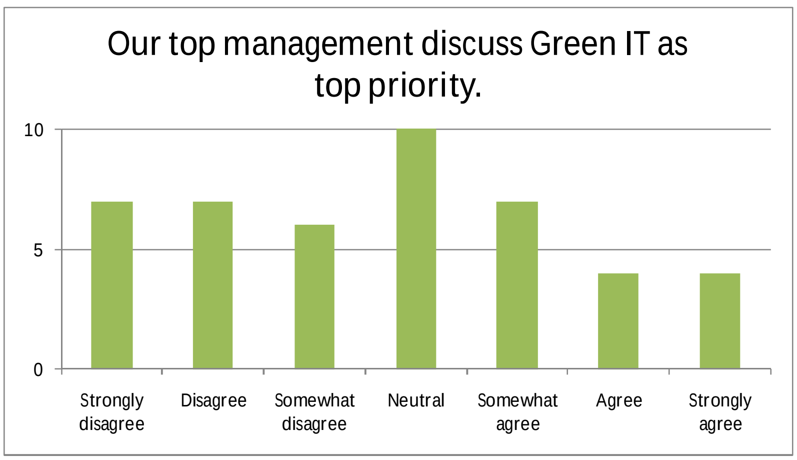
Response average 4,8; n = 45

Management



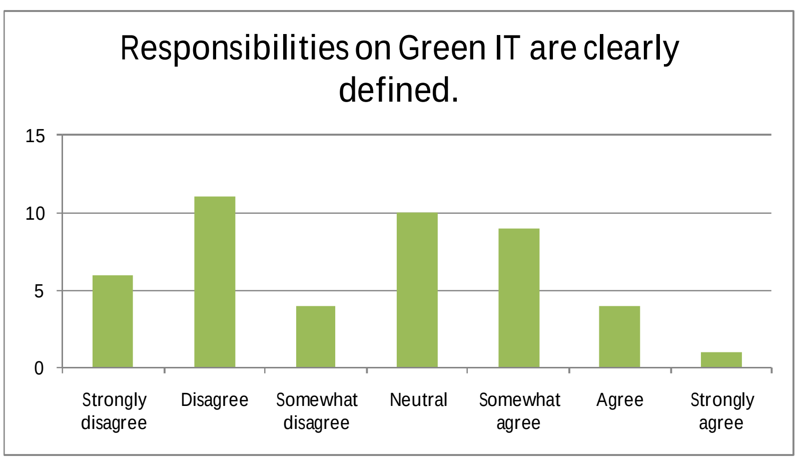
Policy about use of IT to reduce carbon footprint

Response average 4,3; n = 45



Green IT a top priority to top management

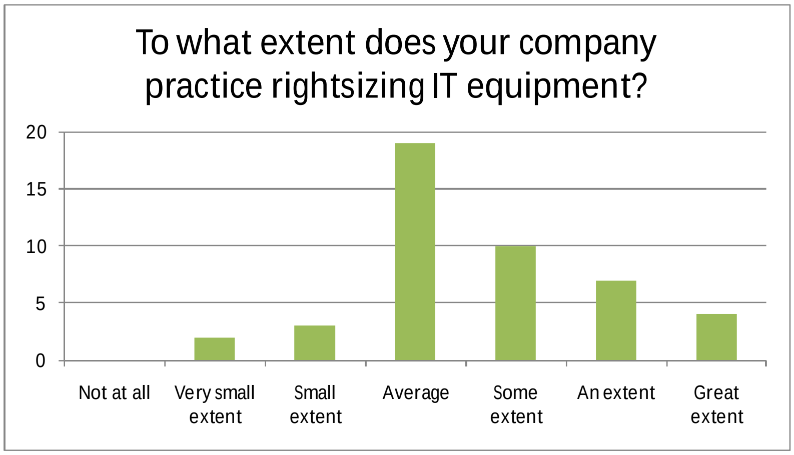
Response average 3,7; n = 45



Defining responsibilities on Green IT

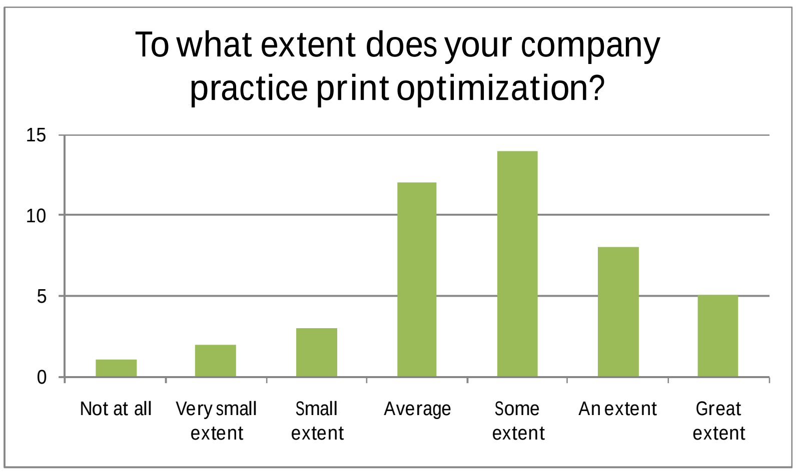
Response average 3,5; n = 45

Print optimization



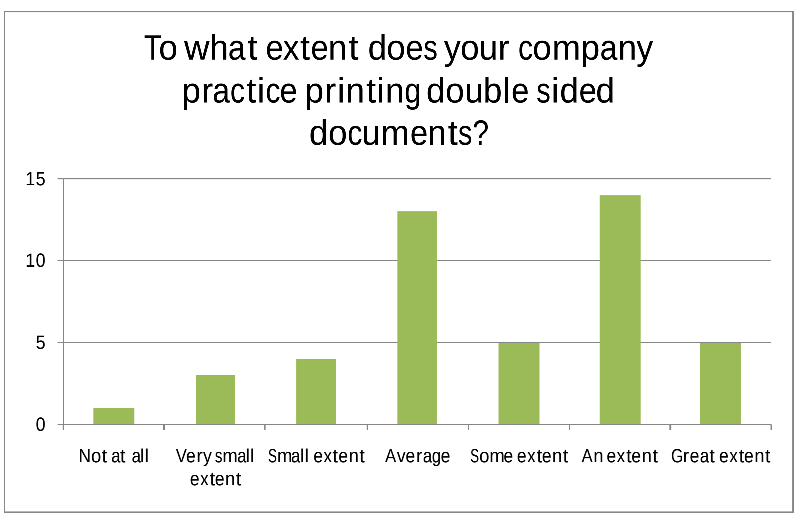
Rightsizing IT equipment

Response average 4,6; n = 45



Print optimization

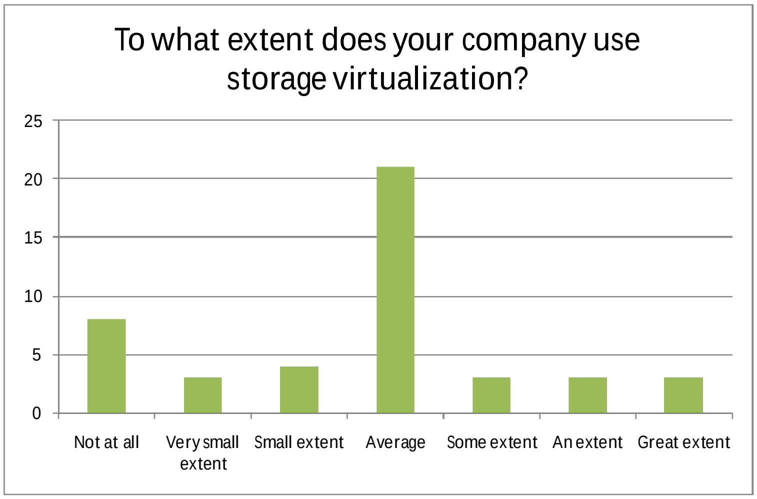
Response average 4,8; n = 45



Double sided printing

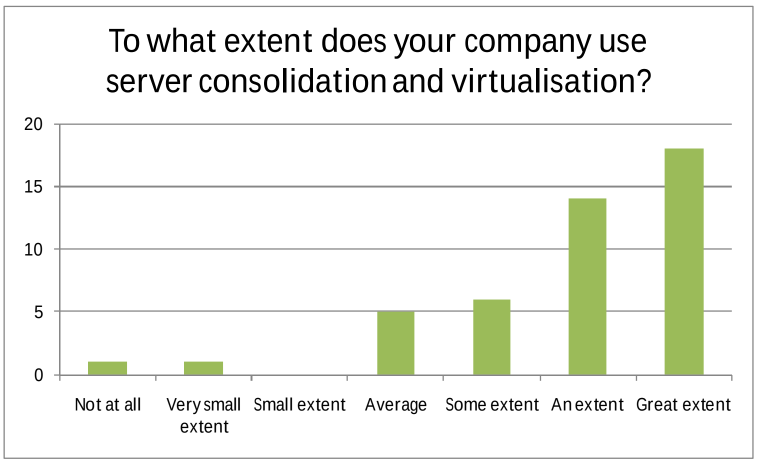
Response average 4,8; n = 45

Virtualization



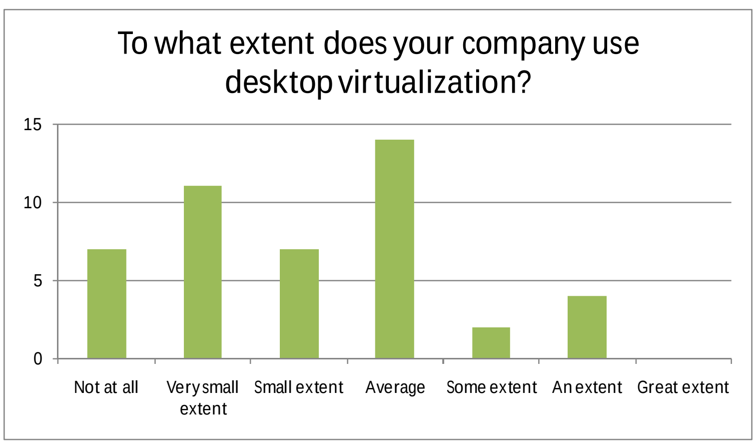
Storage virtualization

Response average 3,6; n = 45



Server consolidation and virtualisation

Response average 5,8; n = 45



Desktop virtualisation

Response average 3,1; n = 45

Appendix 5: G-Readiness Survey Indicator coding

Latent construct	Abbreviation	Question
Attitude	ATT1	Concern for IT energy consumption *
	ATT2	Concern for emerging regulations in greenhouse gas emissions *
	ATT3	Concern for IT's contribution to greenhouse gases *
Paperless office	PPR1	Print optimization **
	PPR2	Printing double sides on paper **
	PPR3	Rightsizing IT equipment **
Management	MGMT1	Clear responsibilities in Green IT initiatives ***
	MGMT2	Green IT is a top management priority ***
	MGMT3	Policy on use of IT to reduce company carbon footprint ***
Virtualization	VIR1	Desktop virtualization **
	VIR2	Server consolidation and virtualization **
	VIR3	Storage virtualization **

Based on your company's view,
*To what extent are you concerned about...
**To what extent do you practice...
***To what extent do you agree with the following regarding your company...

Appendix 6: Invoice carbon footprint inputs and assumptions

Volume details	
Incoming invoices per year	840
Outgoing invoices per year	1310

Invoice lengths	
Paper invoice	1 A4
Envelope	1 A4
Electronic invoice	20kb

Paper carbon profiles	tCO2e
Low	0.78
Average	1.68
High	3.6
Envelope	incl. plastic

Equipment used	
Computer	accounted in office worker's footprint
Color laser printer	
Franking machine	
Barcode reader	

Other components	
Mail delivery/letter	22 gCO2
Paper archive	office spare room heat and light
Electronic archive	server energy and cooling

Equipment used	
Computer	accounted in office worker's footprint
Color laser printer	
Franking machine	
Barcode reader	

Office worker carbon profiles	kgCO2e per year
Low	2031
Average	5874
High	10272

Timing process tasks	
Outgoing paper invoice	
Work at computer	4 min 40s
Printing, franking etc	3 min 4 s
Mail to mailbox	42 s
Checking received payment	25 s
Outgoing e-invoice	
Work up to archiving	5 min
Checking received payment	0 min
Incoming paper invoice	
Work at computer	1 min
Manual work	2 min
Accountat's work	2 min
Incoming e-invoice	
Work up to archiving	1 min 30 s
Matching payment	0 min
Accountat's work	0 min

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