A. Foundations

This part provides the reader with background information of this cumulative dissertation. The introduction in Section A.1 highlights the relevance of the research topic. The methodology in Section A.2 describes the pursued research approaches. Finally, Section A.3 provides insights from related research.

1 Introduction

In the following sections, the motivation for this work (Section A.1.1), the derived research questions (Section A.1.2), the structure (Section A.1.3) and the anticipated contributions (Section A.1.4) are presented.

1.1 Motivation

"Green is worth it," stated Peter Löscher (2011) Chief Executive Officer (CEO) of Siemens AG at the annual shareholders' meeting. The German engineering giant plans a radical restructuring to attain a better position in the growing green technology market, especially in the world's expanding urban areas (Fuhrmanns & Crawford, 2011). This example shows how important the green factor has become in the economy. Until recently, managers associated "green" with chaos, costs and campfires. Today, managers and legislators realize that environmental sustainability is a key driver of economies and businesses.

The global market for green[1] technologies has become a multi-billion euro business with enormous growth potential. The sector reached about €1.6 trillion in spending at the end of 2010, with a projected €3.0 trillion by 2020 (Roland Berger Strategy Consultants GmbH, 2011). The job markets also reflect this trend. Since 2004, the number of green jobs in Germany has more than doubled to 340,000, and is expected to increase by at least 31% by 2030 (Lehr et al., 2010). In the USA, 750,000 green jobs account for less than half a percent of total jobs. Estimations are that 4.2 million new green jobs will be added to the US economy over the next 30 years (Diaz et al., 2008).

This development is the result of the global population's expansion, which is characterized by rising demands, scarcity of natural resources, global warming's effects and a political and societal shift regarding environmental protection. Worldwide, governments have agreed to work towards

[1] In this thesis, the term "green" is used as a synonym for environmental sustainability, environmentally friendly, and eco-friendly, which refer to goods and services, laws, organizations, technologies, behaviors, guidelines and policies aimed at inflicting minimal or no harm on the environment.

environmental sustainability, especially by reducing greenhouse gas emissions, such as carbon dioxide (CO_2), to keep the rise in global temperature below 2° C (United Nations Environment Programme, 2011). Employers are challenged by young professionals, who expect eco-awareness and social consciousness, even in office energy use. Nearly one quarter of young professionals consider it very important to work in a green, environmentally conscious workplace (Hewlett et al., 2009). Therefore, the private sector has responded with green products, services, processes, investments, and technologies.

Global environmental consciousness also affects the information technology[2] (IT) industry. In terms of sustainability, IT plays two conflicting roles: Owing to its use of resources and energy, it is part of the problem but IT also contributes to the global environmental solution (Chen et al., 2009b; Elliot, 2011).

IT-enabled information systems that aim for environmental sustainability are referred to as green information systems (Green IS). Green IS enables environmentally oriented business models, processes, reporting systems, and communication strategies. It is estimated that by the year 2020, Green IS applications in business functions such as energy, manufacturing, buildings, and transportation will globally have saved about 7.8 billion tons of CO_2 emissions and €600 billion of costs (Climate Group and Global eSustainability Initiative, 2008).

This thesis mainly focuses on IT's environmental impact and Green IT's ability to mitigate this impact. In 2007, IT's energy use accounted for about two percent of the global CO_2 emissions[3] (Buhl & Laartz, 2008; Climate Group and Global eSustainability Initiative, 2008; Gartner Inc., 2007). IT's global CO_2 emissions are expected to grow each year by 6% until 2020, regardless of potential technological developments (Climate Group and Global eSustainability Initiative, 2008). Owing to economic growth, rising incomes and growing affordability, especially in developing countries such as China and India, the demand for IT-related goods and services will increase. The share of the global population that owns a PC is expected to grow from 2% in 2008 to 33% in 2020. By then, 50% will own a mobile phone and 5% will have broadband connection (Climate Group and Global eSustainability Initiative, 2008). Manufacturing and disposal of IT also have other environmental effects. Manufacturing requires energy, as well as valuable and rare resources, such as gold, copper, tantalum, and coltan. Furthermore, the disposal of IT equipment containing

[2] Here, the term "information technology" (IT) is synonymous with the broader term "information and communication technologies" (ICT).

[3] In this thesis, CO_2 generally refers to the carbon dioxide equivalent CO_2e. CO_2e represents, for a given mixture of greenhouse gas, the amount of CO_2 that would have the same global warming potential.

toxic substances, such as mercury or lead, represents a severe environmental threat (Chen et al., 2008).

Green IT is not only important for reducing IT's environmental impact, but also for decreasing resource consumption and thereby cutting costs. Symantec (2009) conducted a global survey of 1,052 companies in 2009, and consequently showed that 16% to 20% of the IT budget is being spent on electricity for data centers. It is estimated that in 2020 an average data center will consume as much power as 25,000 US households (Nguyen et al., 2009).

Examples of the environmental impact of IT services

Facebook.com: The social networking site Facebook has come under public pressure from Greenpeace International, due to Facebook's construction of a data center in Prineville in the US that will be powered by PacifiCorp, a company that gets 58% of its energy from burning coal (Ross, 2010).

Google.com: The search engine Google operates about 450,000 servers, which consume approximately 800 GWh of electricity per year, and is therefore indirectly responsible for tremendous amounts of CO_2 emissions (Chou, 2008). Controversial estimates of the CO_2 emissions caused by one search request are between 1g and 10g (Glass, 2009; Leake & Woods, 2009).

Market estimations highlight this topic's practical future relevance. Pike Research's market analysts forecast that by 2015, Green IT in data centers will provide a market opportunity in excess of US$40 billion worldwide (Woods & Wheelock, 2010). The consulting company Experton Group expects the German Green IT market to grow from €12.1 billion in 2010 to €19.3 billion in 2012 (Schwab, 2011), at an annual growth rate of approximately 26%. These figures must be treated with caution, because many authors are active in the Green IT market and therefore might be biased. Nevertheless, the figures confirm that Green IT's importance will continue to rise.

Despite the practical relevance, not much academic research explains and describes phenomena related to sustainability and IS, Green IS, and Green IT (Bengtsson & Agerfalk, 2011; Jenkin et al., 2011). The implications of sustainability and corporate social responsibility (CSR) has primarily been researched in the general management literature (see for example Elkington, 1997; Esty & Winston, 2006; Marrewijk, 2003; Porter & Kramer, 2006; Porter & van der Linde, 1995; Porter & Reinhardt, 2007). Regarding technical issues, research primarily focuses on single IT practices, such as cloud computing (Weinhardt et al., 2009) or virtualization (Gibbs, 2008), without linking them clearly to sustainability, Green IS or Green IT. A holistic view that connects the conceptual level with the technical level is absent in IS research. Such research would enable integrated environmental management at all company levels, down to the IT department.

In summary, the following research gaps can be identified:

- descriptions of the connections and differences between sustainability, Green IS, and Green IT;
- models, concepts, and methods that illustrate how sustainability can be incorporated and managed in IT organizations;
- demonstrations of how IS can contribute to environmental sustainability;
- theories that explain IT organizations' behavior regarding Green IT; and
- models, concepts, and methods that illustrate how Green IS and Green IT can be managed in IT organizations.

Although in the past twenty years sustainability has occasionally been explored in IS research, the issue has gained considerable momentum in the academic community since 2007 (Section A.3.1).

Given the above facts, the motivation for this thesis becomes apparent when following Benbasat and Zmud (1999) who recommended: "The foremost criterion to be applied in selecting research topics should be directly related to the future interest that key stakeholders (journals, colleagues, and practitioners) are likely to hold in a topic." Owing to the global development and the social, practical, and theoretical interest in environmental protection, it seems that sustainability, Green IS, and Green IT will remain a long term issue in IS research, providing substantial motivation for this thesis.

Based on the identified research gaps, specific research questions are derived in the next section, which are answered throughout the thesis.

1.2 Research Questions

This thesis aims to bridge the identified research gaps and to contribute to the emerging knowledge base on sustainability and IS by developing a model for environmentally sustainable information management (ESIM). The central research question of this thesis is therefore:

How should ESIM be incorporated into IT organizations?

To answer this research question, two major research objectives are pursued. First it is necessary to gain an understanding of the research area and the practical relevance of sustainability, Green IS, and Green IT. Second, practical solutions need to be developed.

These two objectives correspond with the objectives of behavioral and design science research (Section A.2), and can be formulated as follows:

- describing theories that explain why and how sustainability, Green IS, and Green IT are perceived, implemented, and managed by IT organizations (behavioral oriented);

- developing and evaluating concepts to incorporate, implement, and manage sustainability, Green IS, and Green IT by IT organizations (design oriented).

From the central research question and the outlined objectives, twelve partial research questions are derived. These research questions are answered in ten corresponding articles in Part B, and in two sections in Part A. The research questions are ordered according to the outside-inside approach, starting with the all-encompassing sustainability concept, then Green IS, and ending with the concrete measurement of Green IT success in the IT department. The central research question is answered in Section C.1.4 by consolidating the findings from all research questions in a model for environmentally sustainable information management.

The understanding of sustainability was predominantly shaped by the Brundtland Commission's definition in 1987, which described sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Hauff, 1987). Although the sustainability topic has been discussed in terms of general management, it still lacks a theoretical foundation in IS management. Porter and Reinhardt (2007) argue that the question concerning sustainability has moved from *whether* to *how* corporate sustainability can be integrated into day-to-day management decisions. This also applies to the IS field. When these thoughts are considered in the context of IS, the following questions emerge:

1. What theories and concepts provide a foundation for incorporating sustainability into IS?
2. How can sustainability be managed in IS?

Regarding the three dimensions of sustainability, practitioners and researchers particularly emphasize the environmental aspect. IS can play a critical role in enabling environmental sustainability (Jenkin et al., 2011; Watson et al., 2010). Various applications in different business functions and industries can facilitate such initiatives. To emphasize the importance of IS as an environmental enabler, three cases are investigated. These cases belong to the fields of marketing, processes, and business models, and are considered in order to answer the following research questions:

3. What is the market potential of IT with green features?
4. What is the potential of IT-enabled green business models?
5. What is the green advantage of IT-enabled processes?

This thesis especially focuses on the environmental impact of IT organizations and IT departments, and their endeavors to reduce IT's environmental impact. Practices that address energy and resource consumption, as well as waste and emissions associated with the use of hardware and software, are referred to in this thesis as Green IT (Jenkin et al., 2011). Green IT denotes IT departments' activities and efforts to incorporate green technologies and processes into the entire

IT life cycle in order to align itself with the corporate objectives, environmental strategy, and relevant stakeholders. Owing to limited scientific knowledge of Green IT, descriptive and explanatory research is needed for theory building. Therefore, the following questions need to be answered:

6. What is Green IT's scope in practice?
7. What Green IT objectives are pursued by IT departments?
8. Why is Green IT adopted by IT departments?

This behaviorally oriented research is complemented by design science research, as suggested by Hevner et al. (2004). Design science aims to develop and evaluate new innovative artifacts to attain practically relevant objectives. Accordingly, the thesis aims to develop methods to support practitioners in their Green IT management. This is highlighted by the following research questions:

9. How should Green IT governance be designed?
10. How should Green IT planning be conducted?

To provide useful information for Green IT management, a summary of possible Green IT practices and metrics, based on a literature research, is provided. This summary aims to answer the last research questions, namely:

11. What Green IT measures are applicable?
12. What metrics are available to evaluate Green IT success?

Research questions 1 and 2 highlight sustainability's relevance and possible inclusion in IS. These two questions are investigated in Publications B.1 and B.2. Research questions 3 to 5 investigate exemplary potentials of Green IS (Publications B.3, B.4, and B.5). The research focus of this thesis is on Green IT; therefore, research questions 6 to 8 analyze Green IT, mainly from a behavioral perspective (Publications B.6, B.7, and B.8). Thereafter, research questions 9 and 10 consider the development of artifacts for managing Green IT (Publications B.9 and B.10). To complete the analysis, research questions 11 and 12 describe concrete Green IT practices and metrics (Sections A.3.3.3.3 and A.3.3.3.4).

All the research questions' findings are used to design a reference model for environmentally sustainable information management in Section C.1.4 and to answer the central research question of this thesis.