5-2012

Technical Complexity as Important Factor for Green IS Solutions: Theoretical Background and Exploratory Study

Dietmar Nedbal
Upper Austria University of Applied Sciences, dietmar.nedbal@fh-steyr.at

Werner Wetzlinger
Upper Austria University of Applied Sciences, werner.wetzlinger@fh-steyr.at

Technical Complexity as Important Factor for Green IS Solutions: Theoretical Background and Exploratory Study

Dietmar Nedbal
Upper Austria University of Applied Sciences
dietmar.nedbal@fh-steyr.at

Werner Wetzlinger
Upper Austria University of Applied Sciences
werner.wetzlinger@fh-steyr.at

Abstract

The use of information and communication technologies to improve environmental sustainability has become a new focus of the IS research in the last years. Different Green IS solutions in various areas already exist, that contribute to the environmental, economic or social performance of organizations. Although these solutions are more and more used within companies, the adoption rate of these solutions varies. This paper focuses on the reasons for these differences by using the Diffusion of Innovation theory as a basis for an exploratory study. In a first step Green IS solutions that are currently available on the market are identified. Based on these alternatives, a survey among Austrian enterprises to analyze how the perceived complexity of the solutions influences their diffusion was conducted. The respondents had to classify the complexity of the respective Green IS solution and specify the realization in their company. Results showed that Green IS solutions and measures that are seen as simple in their technical complexity are adopted more frequently.

Keywords

Green IS, Green IS solution, Diffusion of Innovation, DoI theory, Technical Complexity

1. Introduction

Due to the heterogeneity of information and communication technologies within and across companies, the information infrastructure offers a very high potential to improve environmental sustainability (Huang, 2008). In addition, organizational measures to amend business processes, both internally and across organizations help to reduce emissions along the supply network (Testa & Iraldo, 2010). Therefore, the consideration of sustainability requirements offers a lot of opportunities but also carries technical and organizational challenges for the entire organization.

The decision whether to engage in green initiatives or not is complex and determined by different factors: Sarkar & Young identified managerial attitudes, government regulations, customer requirements, a cost model, and awareness programs as important aspects (Sarkar & Young, 2009). Darnall et al. found that external pressure from partners in the supply network to assess their suppliers' environmental harm is an essential factor that is even stronger when an Environmental Management System (EMS) is in use (Darnall et al., 2008). Bose & Luo (Bose & Luo, 2011) proposed a model to undertake green initiatives based on the three established IS theories technology organization environment (TOE) framework (Tornatzky & Fleischer, 1990), process virtualization theory (PVT) (Overby, 2008), and diffusion of innovation (DoI) theory (Rogers, 1995). Following related work and building upon the DoI theory, this paper introduces a theory-based exploratory study to examine an important factor for the decision of organizations to engage in Green IS, which is the technical complexity.

Therefore the objective of this paper is to investigate the connection between the technical complexity of different Green IS solutions and their diffusion in the Austrian economy. According to this objective the two research question (RQ) were:

- RQ1: Which Green IS solutions are currently available on the market?
- RQ2: How does the perceived complexity of the solutions influence their diffusion?

The remainder of the paper is arranged to answer the research questions as follows. Section 2 answers RQ1. At first, the term Green IS is defined in the context of this research. Then, Green IS solutions are identified, and based on the Diffusion of Innovation (DoI) theory the theoretical background for the research is presented. Section 3 introduces the research method used for the exploratory survey and section 4 shows the key results of the survey and answers RQ2. Section 5 discusses the results and their limitations. The paper concludes with contributions to the field of Green IS research (section 6).

2. Literature research and theoretical background

The environmental sustainability of information systems has been identified as an important topic in the mainstream of IS research (Elliot, 2007). A recent MISQ article (Watson et al., 2010) has confirmed that Green IS has not been adequately addressed in IS research, although now specific tracks exist in all top IS conferences (like the conferences of the AIS). Within the contributions in this field, terms are used inconsistently both within scientific literature and practitioner literature (Brooks et al., 2010). Therefore it is necessary to define how "Green IS" is understood in the context of this paper before Green IS solutions and the theoretical background are explained in more detail.

2.1. The term "Green IS"

According to (Brooks et al., 2010) and (Samson, 2007) "green" is usually understood to mean environmentally friendly and energy efficient. In this context we further include the aspect of "sustainability", which refers to planning and investing in an infrastructure that helps to achieve an organization's short-term objectives while conserving natural resources and helping to preserve the environment (Huang, 2008). Since this definition is rather broad and many organizations just focus on its ecological aspects, the triple bottom line perspective of sustainability was developed (Elkington, 1994, 2004). This approach claims that a more sustainable outcome can be reached by the combination of environmental performance, economic performance and social performance. Furthermore, Porter & Kramer (Porter & Kramer, 2006) argue that, to ensure long-term profitability, companies have to take social and environmental issues into consideration and incorporate them in the core frameworks that guide its business strategy.

In addition, the "IS" in the term "Green IS" needs to be distinguished from "information technology" (IT). Most current practitioners' literature exclusively addresses "information technology", which is considered as too narrow and needs to be extended to "information systems" (Watson et al., 2010). Information systems always incorporate people and IT to support business processes in fulfilling an individual or organizational task (O'Brien, 2003; Beynon-Davies, 2009). Information systems and consequently information technology can play an important and direct role in greening the company by monitoring, reporting and tracking environmental efforts. Indirectly, IS contributes to the reduction of natural resource consumption by improving productivity, reducing commute time, and avoiding the materials such as papers and plastics (Huang, 2008).

Regarding the focus of this paper we use the term “Green IS” with a broad scope (Nedbal et al., 2011): A Green IS solution needs to be planned with a strategic focus. It has to be targeted at information systems (IS) as an integrated and cooperating set of people, processes, software and information technologies (IT) to support individual or organizational goals that contribute to the environmental, economic or social performance (TBL) of the company (Watson et al., 2010).

2.2. Green IS solutions

The second step in answering the research question was to identify and classify Green IS solutions that have a high potential to reduce energy consumption. According to the Commission of the European Communities *“it is crucial to encourage structural changes aimed at realising the potential of ICT to enable energy efficiency across the economy, e.g. in business processes through the use of ICTs, e.g. substituting physical products by on-line services (‘dematerialisation’), moving business to the internet (e.g. banking, real estate) and adopting new ways of working (videoconferencing, teleconferencing). [...] All sectors of the economy, now increasingly ICT-dependent, will benefit to a varying degree, although the initial focus will be on the power grid, on energy-smart homes and buildings and on smart lighting.”* (Commission of the European Communities, 2008). The Boston Consulting Group and the Global E-Sustainability Initiative (GeSI) already examined the potential of Green IS solutions in their “SMART 2020 Addendum Germany” report. They found that the clusters with a high potential in lowering CO2 emissions were “Smart Buildings”, “Smart Logistics”, “Smart Grids”, “Smart Motors” and “Dematerialization” (The Boston Consulting Group, 2009). From these sources we chose the following Green IS solutions to be relevant for our survey as they have a high potential to enable energy efficiency, and are relevant across the most sectors:

- Smart Buildings: Building climate management systems, Automatic light control, Intelligent power control for appliances, CO2 Card
- Smart Logistics: Monitoring and training of driving behavior, Real-time display of emissions, Intelligent vehicle navigation and electronics, ICT-based urban congestion charges, ICT-optimized traffic flow control
- Smart Motors: Variable frequency drives Industrial system automation
- Dematerialization: Telecommuting, Virtual Conferencing, Electronic Invoice (E-Invoice), Electronic Documents (E-Documents), E-Media (Digital Archive)

The cluster “Smart Grids” was omitted, because the corresponding Green IS Solutions “Advanced smart meters”, “Demand side management”, “Grid monitoring and protection”, “Forecast services for renewables” and “Fleet optimization for power plants” are typically mainly adopted by large companies of the energy supply industry, which were not targeted at our study.

2.3. The DoI theory as theoretical background

This chapter provides insight into why addressing the complexity is important from the viewpoint of the diffusion of innovation (DoI) theory. The DoI theory describes factors that lead to an adoption of innovations. Rogers (Rogers, 1995) identified “relative advantage”, “compatibility”, “trialability”, “observability”, and “complexity” as the main five factors that influence this decision. Applications of the DoI theory to IS research (Cooper & Zmud, 1990; Agarwal & Prasad, 1998; Crum et al., 1996) have shown that in this context *technical compatibility, relative advantage (perceived need),* and *technical complexity* are the most important factors for the adoption of innovations.

In accordance with the previous research of (Bradford & Florin, 2003), which is also based on the DoI theory, we refer to the technical compatibility of “an innovation’s compatibility with existing systems [...], including hardware and software”. If the compatibility of the new technology with the existing technology cannot be assured, the Green IS solution will not be adopted by the company. However, the considered Green IS solutions of this study like “Telecommuting”, “Virtual Conferencing” or “Electronic Invoice” are very broad. This means that different technical implementations of these solutions exist on the market. Hence we assume the companies can choose from the existing technologies on the market and are able to find one that is technologically compatible with their existing technology. Technical compatibility is therefore a vital part for the diffusion of IS solutions, but we assume this factor as given and not relevant in the context of the defined research questions.

The second important factor, relative advantage, is not directly connected to a Green IS solution. The relative advantage refers to the “degree to which an innovation is perceived as being better than the idea it supersedes” (Rogers, 1995). To measure the performance of an idea or technology number of factors like economic terms (productivity, efficiency, costs), social terms (prestige) or personal terms (satisfaction, aesthetic perception) (Rogers, 1995) need to be included. In the case of Green IS different measure could be used (CO2 emissions, produced waste, energy used, etc.). The problem is that there is no measure that every considered Green IS solution of the study can be assessed on. The factor “relative advantage” is hard to apply if the considered alternatives do not address the same problem through similar functionalities and therefore do not produce similar and comparable outcomes like it is in this case.

Additionally in the case of Green IS the relative advantage of certain solutions in respect to measures like CO2 emissions depends heavily on the scale. The relative advantage of certain solutions like “Intelligent vehicle navigation and electronics” depends on the number of vehicles of a company and therefore presumably on the industry. More research is needed to assess the relative advantage for Green IS solutions since these factors were not in the focus of this exploratory study. A cross-industry study at larger scale would be needed and therefore we did not consider the relative advantage.

The third important factor according to (Bradford & Florin, 2003) and the DoI theory is the technical complexity of a Green IS solution. If a certain innovation is difficult to understand and use, organizations will diffuse it more slowly and with limited resources (Bradford & Florin, 2003). Thus, an easy to use Green IS solution should positively influence the decision to adopt an innovation.

3. Survey Research Method

Following the DoI theory, less complex solutions get implemented more often. This study investigated, whether this relation is also true for Green IS solutions. Therefore we conducted an exploratory study that used the questionnaire method to gather the empirical data. Our corresponding hypothesis (H) for the study was:

- H0: The lower the perceived complexity of a Green IS solution the more likely the solution will be adopted by the company.

3.1. Setting

Based on the literature research and previous studies that identified Green IS solutions we conducted a survey among Austrian enterprises to answer the main research question. The survey was carried out as a standardized online questionnaire. It contained 16 different questions that investigated the current opinion of the companies regarding topics like Green IT, Green IS and Green Supply Chain Management. In order to answer research question RQ2, the survey queried the perceived complexity of Green IS solutions and their diffusion. The survey was pre-tested with five experts before it was carried out as an online questionnaire using the tool Qualtrics. The survey was online from Apr. 11th, 2011 to May 2nd, 2011.

3.2. Subjects

Overall, 110 companies took part in the survey. After eliminating incorrect and incomplete records the number of valid responds was reduced to 52. Companies of the following sizes were included:

- 8 small companies (<50 employees)
- 12 medium-sized companies (<250 employees)
- 32 large companies (>=250 employees)

These companies represented 21 different sectors. The three largest sectors were the *information and communication industry*, the *construction industry* and the *transport and logistics industry*.

3.3. Instrument

To examine the relation between the complexity of Green IS solutions and their adoption rate we used the alternatives, identified via literature research (cf. section 2.2). Table 1 lists these Green IS solutions and shows their coding for the survey. To examine the perceived complexity of these solutions and the adoption rate for each of the solutions the following questions were asked:

- Q1: How complex do you consider the following Green IS solution? (COMP)
- Q2: Has this Green IS solution already been realized, is there a plan to realize it or do you consider it as not relevant? (REAL)

The respondents were given the choice of classifying the complexity of the respective Green IS solution on a 4-point Likert scale (4 = highly complex, 3 = rather complex, 2 = rather simple, 1 = simple or 0 = no answer). For the realization they had to choose between 3 (“realized”), 2 (“realization planned”), or 1 (“no realization”).

Cluster	Green IS solution	Coding for Q1	Coding for Q2
Smart Buildings	Building climate management systems	BUILD_1-COMP	BUILD_1-REAL
Smart Buildings	Automatic light control	BUILD_2-COMP	BUILD_2-REAL
Smart Buildings	Intelligent power control for appliances	BUILD_3-COMP	BUILD_3-REAL
Smart Buildings	CO2 Card	BUILD_4-COMP	BUILD_4-REAL
Smart Logistics	Monitoring and training of driving behavior	LOG_1-COMP	LOG_1-REAL
Smart Logistics	Real-time display of emissions	LOG_2-COMP	LOG_2-REAL
Smart Logistics	Intelligent vehicle navigation and electronics	LOG_3-COMP	LOG_3-REAL
Smart Logistics	ICT-based urban congestion charges	LOG_4-COMP	LOG_4-REAL
Smart Logistics	ICT-optimized traffic flow control	LOG_5-COMP	LOG_5-REAL
Smart Motors	Variable frequency drives	MOTOR_1-COMP	MOTOR_1-REAL
Smart Motors	Industrial system automation	MOTOR_2-COMP	MOTOR_2-REAL
Dematerialization	Telecommuting	DEMAT_1-COMP	DEMAT_1-REAL
Dematerialization	Virtual Conferencing	DEMAT_2-COMP	DEMAT_2-REAL
Dematerialization	Electronic Invoice (E-Invoice)	DEMAT_3-COMP	DEMAT_3-REAL
Dematerialization	Electronic Documents (E-Documents)	DEMAT_4-COMP	DEMAT_4-REAL
Dematerialization	E-Media (Digital Archive)	DEMAT_5-COMP	DEMAT_5-REAL

Table 1: Green IS solutions and survey coding.

4. Survey Results

Table 2 provides an overview of the absolute frequencies of the responds to the survey: Green IS solutions of the cluster Dematerialization were considered to be the least complex ones with the highest realization degree. This is due to the fact, that solutions for e.g. electronic invoices or virtual conferencing are available on the market and therefore they can be implemented without great expense and effort. The two solutions within the cluster Smart Motors had the highest number of unanswered questions ("no answer"). Therefore we assumed that respondents are lacking knowledge about these solutions. The complexity of the solutions in the cluster Smart Logistics is relatively high compared to the cluster Dematerialization, since networks of several companies are involved in the solution. The complexity of Smart Buildings solutions can be explained by structural changes and complex, intelligent IT systems.

To avoid non-reliable responses the respondents were also given the choice of "no answer" for the complexity. Consequently the number of valid cases varies (cf. rows labelled "N" in Table 3). Therefore, for the correlation analysis only data where companies chose a valid complexity and realization were considered. As raw data was of ordinal level, Kedall's tau-b was chosen as correlation coefficient. Table 3 shows the correlation coefficient ("r"), the significance level ("p"), and the number of valid cases ("N") of the two questions concerning realization (REAL) and complexity (COMP) of the individual Green IS solution. For clarity reasons, the table is split up into the four clusters Smart Buildings, Smart Logistics, Smart Motors, and Dematerialization.

	Q1: COMP					Q2: REAL		
	highly complex	rather complex	rather simple	simple	no answer	realized	realization planned	no realization
BUILD_1	15	23	11	2	1	23	17	12
BUILD_2	7	11	22	10	2	17	13	22
BUILD_3	8	18	16	8	2	12	18	22
BUILD_4	18	17	4	1	12	2	7	43
LOG_1	7	21	14	4	6	13	6	33
LOG_2	24	20	2	0	6	5	12	35
LOG_3	10	18	16	2	6	9	6	37
LOG_4	10	18	13	1	10	1	2	49
LOG_5	20	17	6	0	9	3	4	45
MOTOR_1	7	8	4	1	32	5	2	45
MOTOR_2	14	10	6	0	22	12	4	36
DEMAT_1	1	14	21	14	2	33	8	11
DEMAT_2	3	10	20	19	0	40	7	5
DEMAT_3	4	11	23	14	0	34	12	6
DEMAT_4	5	8	19	20	0	39	11	2
DEMAT_5	5	13	16	18	0	36	14	2

Table 2: Frequency counts for Q1 and Q2

To avoid non-reliable responses the respondents were also given the choice of "no answer" for the complexity. Consequently the number of valid cases varies (cf. rows labelled "N" in Table 3). Therefore, for the correlation analysis only data where companies chose a valid complexity and realization were considered. As raw data was of ordinal level, Kedall's tau-b was chosen as correlation coefficient. Table 3 shows the correlation coefficient ("r"), the significance level ("p"), and the number of valid cases ("N") of the two questions concerning realization (REAL) and complexity (COMP) of the individual Green IS solution. For clarity reasons, the table is split up into the four clusters Smart Buildings, Smart Logistics, Smart Motors, and Dematerialization.

The results in Table 3 show a significant statistical correlation between the complexity and the planned realization of seven of the 15 solutions (i.e. p-value is below 0.01 in five cases and below 0.05 in two more cases). The negative correlation value ("r") means that a high complexity correlates with a low realization level, since the complexity was rated from 4 ("highly complex") to 1 ("simple") and the realization was rated from 3 ("realized") to 1 ("no realization"). The following Green IS solutions showed significant correlations:

- Four out of five Dematerialization solutions (DEMAT_1, DEMAT_2, DEMAT_3, DEMAT_5) have a highly significant correlation. All four cases have a high level of realization (the median of respondents chose "realized") with a rather low perceived complexity (median of respondents chose "rather simple").
- The Smart Building solution "Intelligent power control for appliances" also has got a highly significant correlation (COMP median = "rather complex", REAL median = "realization planned").
- The two significant correlations "Real-time display of emissions" (LOG_2) and "Variable frequency drives" (MOTOR_1) again show a high complexity with a median of "no

realization planned" in both cases. But it has to be noted that MOTOR_1 only had the least valid responds (N=30).

All other correlations were not significant. Consequently for the other Green IS solutions the hypothesis H0 is considered to be not supported.

		BUILD_1-REAL	BUILD_2-REAL	BUILD_3-REAL	BUILD_4-REAL
BUILD_1-COMP	r	,165	-,018	,127	,052
	p	,092	,442	,153	,345
	N	52	52	52	52
BUILD_2-COMP	r	,145	-,168	-,129	,123
	p	,121	,087	,147	,168
	N	51	51	51	51
BUILD_3-COMP	r	-,110	-,032	**-,346(**)**	,021
	p	,185	,399	**,002**	,434
	N	51	51	**51**	51
BUILD_4-COMP	r	,223	-,061	,219	-,003
	p	,061	,336	,063	,493
	N	41	41	41	41

		LOG_1-REAL	LOG_2-REAL	LOG_3-REAL	LOG_4-REAL	LOG_5-REAL
LOG_1-COMP	r	,103	,000	,098	-,019	,155
	p	,219	,500	,231	,445	,126
	N	47	47	47	47	47
LOG_2-COMP	r	,000	**-,293(*)**	,331(**)	-,156	-,087
	p	,500	**,018**	,009	,138	,271
	N	47	**47**	47	47	47
LOG_3-COMP	r	,150	,025	,140	,057	,299(*)
	p	,130	,426	,145	,339	,014
	N	47	47	47	47	47
LOG_4-COMP	r	,301(*)	,340(**)	,346(**)	,040	,222
	p	,016	,008	,007	,390	,059
	N	43	43	43	43	43
LOG_5-COMP	r	,152	,169	,198	,041	,185
	p	,140	,117	,080	,390	,098
	N	44	44	44	44	44

		MOTOR_1-REAL	MOTOR_2-REAL
MOTOR_1-COMP	r	**-,343(*)**	-,300
	p	**,049**	,074
	N	**20**	20
MOTOR_2-COMP	r	,045	-,018
	p	,396	,458
	N	30	30

		DEMAT_1-REAL	DEMAT_2-REAL	DEMAT_3-REAL	DEMAT_4-REAL	DEMAT_5-REAL
DEMAT_1-COMP	r	**-,520(**)**	-,058	-,082	-,170	-,158
	p	**,000**	,328	,264	,098	,115
	N	**50**	50	50	50	50
DEMAT_2-COMP	r	-,180	**-,336(**)**	-,299(**)	-,046	-,008
	p	,076	**,004**	,009	,361	,475
	N	52	**52**	52	52	52
DEMAT_3-COMP	r	-,115	-,238(*)	**-,314(**)**	-,139	-,129
	p	,180	,030	**,006**	,139	,158
	N	52	52	**52**	52	52
DEMAT_4-COMP	r	-,099	-,129	-,104	-,177	-,184
	p	,213	,155	,204	,084	,075
	N	52	52	52	52	52
DEMAT_5-COMP	r	,002	-,064	-,092	-,274(*)	**-,419(**)**
	p	,492	,306	,230	,016	**,000**
	N	52	52	52	52	**52**

r = Correlation coefficient (Kendall's tau-b), N = Number of valid cases, p = Significance level
** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

Table 3: Correlation of Q1 and Q2

5. Discussion

This study has evaluated the relation between the realization of 15 different Green IS solutions and their perceived complexity. Results showed a significant correlation in seven cases: Low perceived complexity of the solutions "Telecommuting", "Virtual Conferencing", "E-Invoice", and "E-Media" correlate with a high adoption rate. On the other hand "Intelligent power control for appliances", "Real-time display of emissions", and "Variable frequency drives" are perceived as rather complex and showed a significant low adoption rate. These results echo other appliances of the DoI theory in IS research showing that technical complexity is an essential factor for the adoption of innovations.

Nevertheless, the survey itself has a number of limitations due to both its exploratory nature and the rather small response rate. Therefore, the findings can be considered at best preliminary and require further data before any generalization attempt can be undertaken. The small amount of data did not allow us to test the effect of other variables like the sector or size of the company which also might have influence on the realization of Green IS solutions. A cross-industry study at larger scale should also assess other factors (like the relative advantage or relative advantage) for adoption of Green IS solutions since these factors were not in the focus of this study.

6. Conclusions

The paper contributes to the field of IS research by presenting a theory-based approach for determining the adoption of Green IS solutions. The paper focused on one of the most significant drivers according to the DoI theory: The technical complexity of a Green IS solution is considered one of the main factors in the decision whether to consider realizing an environmental friendly solution. The survey showed that Green IS solutions and measures that are seen as simple in their technical complexity are adopted more frequently. Available solutions that are easy to use and manage will be sought after in the coming years. Especially the solutions in the Dematerialization cluster Telecommuting, Virtual Conferencing, E-Invoice, and E-Media showed a significant correlation with a high level of realization and a rather low perceived complexity. Despite the need for providing available Green IS solutions for the practice, future research needs to consider additional factors from related work in the field and should be build upon well established IS theories.

Acknowledgement

This work emerged from the research project 4EMOBILITY. The project is funded by the European Regional Development fund (EFRE, Regio 13) as well as by the Federal State of Upper Austria. In addition, the authors thank Matthias Losbichler for conducting the survey.

References

Agarwal, R. and J. Prasad (1998) "A conceptual and operational definition of personal innovativeness in the domain of information technology", *Information Systems Research*, (9)2, pp. 204–215.

Beynon-Davies, P. (2009) "The 'language' of informatics: The nature of information systems", *International Journal of Information Management*, (29)2, pp. 92–103.

Bose, R. and X. Luo (2011) "Integrative framework for assessing firms' potential to undertake Green IT initiatives via virtualization - A theoretical perspective", *The Journal of Strategic Information Systems*, (In Press, Corrected Proof), pp. 1–17.

Bradford, M. and J. Florin (2003) "Examining the role of innovation diffusion factors on the implementation success of enterprise resource planning systems", *International Journal of Accounting Information Systems*, (4)3, pp. 205–225.

Brooks, S., X. Wang, S. Sarker (2010) "Unpacking Green IT: A Review of the Existing Literature", *AMCIS 2010 Proceedings*, pp. 1–10.

Commission of the European Communities (2008) "Addressing the challenge of energy efficiency through Information and Communication Technologies", http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0241:FIN:EN:PDF (current Aug. 26, 2010).

Cooper, R. B. and R. W. Zmud (1990) "Information technology implementation research: A technological diffusion approach", *Management Science*, (36)2, pp. 123–139.

Crum, M. R., G. Premkumar, K. Ramamurthy (1996) "An assessment of motor carrier adoption, use, and satisfaction with EDI", *Transportation Journal*, (35)4, pp. 44–57.

Darnall, N., G. J. Jolley, R. Handfield (2008) "Environmental Management Systems and Green Supply Chain Management: Complements for Sustainability?", *Business Strategy and the Environment*, (17)1, pp. 30–45.

Elkington, J. (1994) "Towards a sustainable corporation: Win-win-win business strategies for sustainable development", *California Management Review*, (36)2, pp. 90–100.

Elkington, J. (2004) "Enter the Triple Bottom Line" in Henriques, A. and J. Richardson (eds.) *The triple bottom line, does it all add up?*, London: Earthscan, pp. 1–16.
Elliot, S. (2007) "Environmentally Sustainable ICT: A Critical Topic for IS Research?", *PACIS 2007 Proceedings*, pp. 100–112.
Huang, A. (2008) "A Sustainable Systems Development Lifecycle", *PACIS 2008 Proceedings*.
Nedbal, D., W. Wetzlinger, A. Auinger, G. and Wagner (2011) "Sustainable IS Initialization Through Outsourcing: A Theory-Based Approach" in *AMCIS 2011 Proceedings*.
O'Brien, J. A. (2003) *Introduction to information systems: Essentials for the E-business enterprise, 11. ed., internat. ed.*, Boston, Mass.: McGraw-Hill/Irwin.
Overby, E. (2008) "Process virtualization theory and the impact of information technology", *Organization Science*, (19)2, pp. 277–291.
Porter, M. E. and M. R. Kramer (2006) "Strategy and society: the link between competitive advantage and corporate social responsibility", *Harvard Business Review*, (84)12, pp. 76–92.
Rogers, E. M. (1995) *Diffusion of innovations, 4. ed.*, New York, NY u. a.: Free Press.
Samson, T. (2007) "Green tech vs. sustainable tech", http://www.infoworld.com/d/green-it/green-tech-vs-sustainable-tech-691 (current Feb. 2, 2011).
Sarkar, P. and L. Young (2009) "Managerial Attitudes Towards Green IT: An Explorative Study of Policy Drivers", *PACIS 2009 Proceedings*.
Testa, F. and F. Iraldo (2010) "Shadows and lights of GSCM (Green Supply Chain Management): determinants and effects of these practices based on a multi-national study", *Management Research Review*, (18)10-11, pp. 953–962.
The Boston Consulting Group (2009) "SMART 2020 Addendum Deutschland: Die IKT-Industrie als treibende Kraft auf dem Weg zu nachhaltigem Klimaschutz", http://www.gesi.org/LinkClick.aspx?fileticket=X7m82qhz%2F6o%3D&tabid=60 (current Feb. 11, 2011).
Tornatzky, L. G. and M. Fleischer (1990) *The Processes of Technological Innovation*, Massachusetts, USA: Lexington Books.
Watson, R. T., M.-C. Boudreau, A. J. Chen (2010) "Information Systems and Environmentally Sustainable Development: Energy Informatics and New Directions for the IS Community", *MIS Quarterly*, (34)1, pp. 23–38.