Association for Information Systems
AIS Electronic Library (AISeL)

AMCIS 2010 Proceedings

Americas Conference on Information Systems (AMCIS)

8-2010

Predictors of Green IT Adoption: Implications from an Empirical Investigation

Nils-Holger Schmidt
University of Goettingen, nils-holgerschmidt@web.de

Koray Erek
Berlin Institute of Technology (TU Berlin), koray.erek@tu-berlin.de

Lutz M. Kolbe
University of Goettingen, lkolbe@uni-goettingen.de

Rüdiger Zarnekow
Berlin Institute of Technology (TU Berlin), ruediger.zarnekow@tu-berlin.de

Predictors of Green IT Adoption: Implications from an Empirical Investigation

Nils-Holger Schmidt
University of Goettingen
nschmid@uni-goettingen.de

Koray Erek
Berlin Institute of Technology (TU Berlin)
koray.erek@tu-berlin.de

Lutz M. Kolbe
University of Goettingen
lkolbe@uni-goettingen.de

Rüdiger Zarnekow
Berlin Institute of Technology (TU Berlin)
ruediger.zarnekow@tu-berlin.de

ABSTRACT

The increasing attention towards the environmental impact of IT (information technology) demands reorientation from IT departments. Research has outlined that the importance of Green IT is related to IT business alignment and environmental initiatives while uncertainty potentially derives from missing standards, measurements, or missing internal support for Green IT. We assume that importance and uncertainty are main determinants for Green IT adoption. These theoretical assumptions still lack empirical validation. As a contribution to the ongoing discussion of Green IT, we analyze data from 116 IT departments on the predictors of Green IT adoption using multinomial logistic regression. It is shown that the outlined assumptions prove to be statistical significant. These findings contribute to existing knowledge on Green IT and provide practical recommendations for CIOs, IT managers, environmental and sustainability managers as well as new opportunities for further research in this field.

Keywords

Green IT, IT departments, importance, uncertainty, adoption, multinomial logistic regression

INTRODUCTION

The movement of eco-awareness has reached IT (information technology) departments. There, the environmental impact of IT is being discussed under the term of Green IT. Green IT has been driven primarily by business, and is one of the major concerns for chief information officers (CIOs) (Kurp 2008; Molla et al. 2008). Scientific research and practical literature outline the relevance of Green IT by referring to its multifaceted benefits (Erek et al. 2009; Mines & E. Davis 2007; Molla 2008).

The underlying hypothesis of this study is that the adoption of Green IT is dependent on the perceived importance and uncertainty of Green IT. Literature indicates that the importance is related to IT business alignment initiatives in the scope of environmentally sustainable business strategies and practices (Elliot & Binney 2008; Molla 2009; Molla et al. 2008). Uncertainty might derive from missing standards, measurements, or missing internal support for Green IT (Elliot 2007; Erek et al. 2009; Molla 2009; Molla et al. 2008; Molla 2008; Schmidt et al. 2009). Despite growing research in this area, these theoretical assumptions still lack empirical validation.

Therefore, we strive to contribute to the emerging field of research on Green IT by using empirical evidence and answering the three following research questions:

1. Which factors predict the importance of Green IT for IT departments?
2. Which factors predict the uncertainty about Green IT for IT departments?
3. How do importance and uncertainty predict the planning and implementation of Green IT?

In order to address these questions, we need to create a clear view of Green IT. Building on this, we develop an exploratory research model to illustrate the assumed connections between organizational factors, importance, uncertainty and Green IT adoption. The research questions are answered using results from a large cross-sectoral survey with 116 German enterprises. We apply multinomial logistic regression to evaluate the assumed relationships. Our findings contribute to existing knowledge on Green IT and provide practical recommendations for CIOs, IT managers, environmental and sustainability managers as well as new opportunities for further research in this field.

THEORETICAL BACKGROUND OF GREEN IT

Green IT represents an important topic for information systems (IS) research (Elliot 2007). It is used as a generic term for measures and activities of an enterprises' IT department which aim to contribute to the environmentally oriented objectives of corporate sustainability and corporate social responsibility (Chen et al. 2008; Schmidt et al. 2009). A comprehensive overview of current research on Green IT is provided by Molla (2009).

Even though Green IT has been extensively used by marketing departments to label their IT products and services as environmentally friendly, the term and its underlying measures have stayed rather vague. Green IT can be seen as a holistic and systematic approach to address challenges of the IT infrastructure, the environmental impacts of business IT activities, IT's support for environmentally sustainable business practices, and IT's role in the low-carbon economy (Molla et al. 2008). This view does not solely comprise IT focused issues but also business related topics, in which IT is an enabler for environmental improvements on the corporate side. This aspect has been also labelled as "Green IS" (Boudreau et al. 2008).

For our survey the participants were provided with a practical oriented definition of Green IT, which comprised the above mentioned aspects under the given limitations of space and perceivability: *"Green IT comprises the management of all activities and measures of the IT department, which are aimed to reduce the resource consumption by IT, e.g. in terms of energy, material or paper. Furthermore, it includes instruments to control, steer, and communicate the success."* This is a broad view on Green IT, which also includes management aspects. The environmental impact, e.g. in form of CO2 emissions, was not pointed out explicitly since we see this as the consequence of reduced resource consumption.

CONCEPTUAL FRAMEWORK

In this section we develop a conceptual framework to be tested using empirical evidence (Figure 1). We assume that the adoption of Green IT depends on its perceived importance and uncertainty. The adoption is formalized by the *extent of Green IT planning and implementation*, which refers to Green IT policies, practices, technologies and systems as mentioned by Molla (2009).

An *important* topic is recognized as substantial by people who are knowledgeable in the field. Furthermore it has potential to positive contribution to the company or the IT department. The importance of a technology is also related to its usefulness, which according to the TAM (Technology Acceptance Model) determines the intention to use it (Venkatesh & Davis 2000). From this we suggest that increased perception of the importance of Green IT increases the extent of Green IT planning and implementation.

Uncertainty describes a situation in which the outcome or success of an activity is not known (Hubbard 2007). Research on online exchange relationships from a principal-agent perspective indicates that perceived uncertainty negatively influences a buyer's intentions to purchase products online (Pavlou et al. 2007). Uncertainty about the benefits of a new technology is one of the factors slowing down the speed of diffusion (Hall & Khan 2003). We therefore propose that uncertainty about Green IT leads to a lower extent of Green IT planning and implementation.

The *corporate management* and the overall *environmental strategy* of an enterprise are generally seen as major drivers for a Green IT strategy (Elliot & Binney 2008; Molla 2009; Molla et al. 2008). IT departments are urged to align their strategy according to the business needs (Ward & Peppard 2002). Therefore, we conclude that if the corporate management demands Green IT or, if the enterprise is highly engaged in environmental activities then this should raise the importance of Green IT.

The effects of the *experience* curve can be a source of competitive advantage for enterprises (Ghemawat 1985). Therefore we assume that IT departments possessing a higher level of experience with Green IT are more aware of benefits and best practices regarding Green IT. They should also be less uncertain about the future relevance of Green IT.

Power emission and power utilization are important parameters, which need to be measured to assess IT's environmental impact (Molla 2009). Environmental strategies make it desirable to *measure* and monitor the entire life cycle costs of products and services (Elliot 2007). Researchers have proposed the idea to implement Green IT measures into management systems such as the IT balanced scorecard (Schmidt et al. 2009). Therefore, we assume that measurements for Green IT will decrease the uncertainty about Green IT.

Closely related to measurements are *standards* for Green IT. The absence of standards is often seen as an obstacle for Green IT implementation (Erek et al. 2009). Molla (2008) outlines the importance of developing Green IT standards across the enterprise. In our research framework we assume that the existence of defined and accepted standards for Green IT decreases the uncertainty about Green IT.

Hypes are associated with over inflated expectations and potential disillusionment (Gartner 2009). Green IT is frequently prejudiced as a hyped topic (Erek et al. 2009). We therefore assume that considering Green IT as a hyped topic increases the uncertainty about Green IT.

Researchers have indicated the importance of *staff involvement* for the success of Green IT projects (Molla et al. 2008; Molla 2008). We assume that there is less uncertainty if the IT staff initiates Green IT.

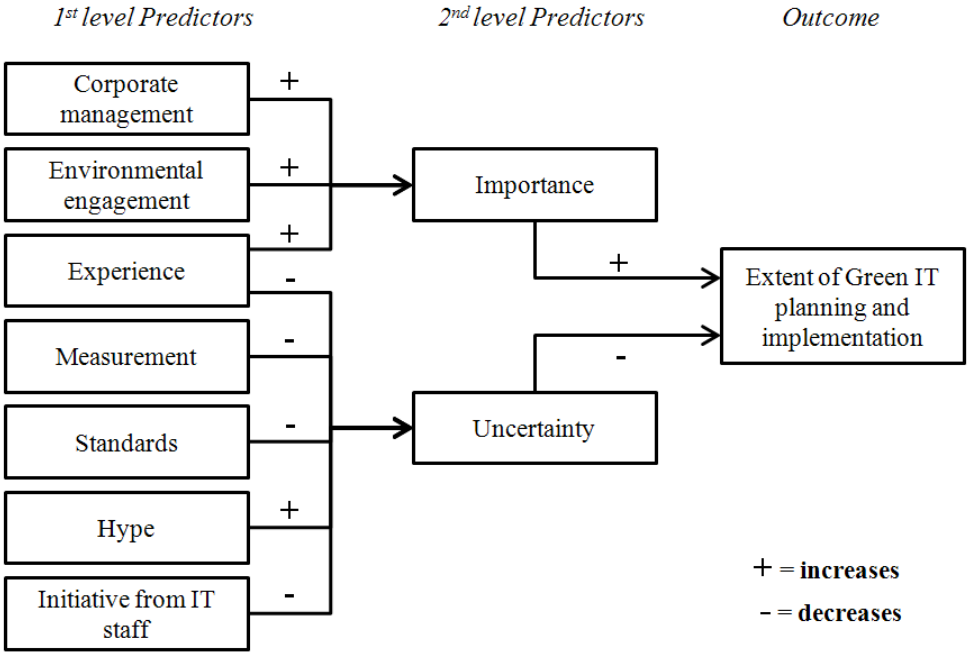

Figure 1. Proposed research framework of predictors for Green IT adoption

The initial exploratory research framework is shown in Figure 1. We assume that factors such as corporate management, environmental engagement, and experience with Green IT have a positive impact on the importance of Green IT. Conversely, experience, measurements, standards, and IT staff initiative regarding Green IT are factors, which potentially decrease uncertainty about Green IT. The perception of Green IT being a hyped topic tends to increase uncertainty. As mentioned earlier the finals step tests, whether importance and uncertainty are predictors for the planning and implementation of Green IT. Our framework does not claim to be complete. It has to be considered that other relevant predictors have not been included. Nevertheless, we consider it as an initial starting point to be refined by future research.

METHODOLOGY

A cross-sectional survey was conducted to evaluate the proposed research model. A paper based questionnaire was sent out via postal mailing in September 2009. Additionally, each letter included a covering letter, a self-addressed envelope and the basic definition of Green IT mentioned above. The addressees were CIOs, IT managers, environmental managers and staff responsibles for Green IT from 619 major companies listed in German stock indexes. To increase the response rate respondents were offered a report of the results. Over the time of three weeks we received 116 anonymous replies, amounting to a response rate of 18.7%. This response rate is consistent with rates in similar surveys in IS research (Mani et al. 2010; Poppo & Zenger 2002).

The questionnaire was compiled based on a previous survey from the scope of CSR (Corporate Social Responsibility) (Wagner 2007). Additional questions were developed based on findings from fifteen case studies conducted on Green IT (Erek et al. 2009). Further questions were added from the survey results of Fujitsu Australia (2009). General questions regarding the enterprise and the perception of Green IT were integrated. A panel of five academic experts reviewed the questions to confirm that the constructs were adequately described by the item wording. The statistical analysis was done using the software SPSS Statistics 17.0. The relevant sample items for the exploratory research framework are shown in Table 1.

To evaluate the proposed research framework three multinomial logistic regressions are applied to the data. This type of logistic regression is used to predict membership of more than two categories (Field 2009). In logistic regression linearity, no

multicollinearity and independence of errors are assumed (Field 2009). The correlation matrix indicates that no predictors correlate too highly with each other, r > .9 (Field 2009). For all models the VIF (Variance Inflation Factor) values confirm that multicollinearity is not a problem (Backhaus et al. 2008; Field 2009). A visual inspection of the residuals shows no indication of heteroscedasticity or non-linearity. The histogram and normal probability plot test of the data prove the normality of residuals. The Durban-Watson values for all assumed models indicate little correlation between the residual terms, which is still acceptable (Field 2009). The recommended sample size for multinomial logistic regression should be 10 times the number of predictors, with a minimum sample size of 100 (Long 1997). The maximum number of predictors used in the three regression models is five (Uncertainty about Green IT). All three models have at least 111 valid samples. Therefore the sample size is considered as adequate for multinomial logistic regression.

Scale	**Response anchors**	**Sample item**
Corporate management	Likert 5-point scale, "strongly disagree/ strongly agree"	The IT department is approached frequently by the corporate management with the topic of Green IT.
Environmental engagement	Likert 5-point scale, "sufficiently engaged/highly engaged"	How would you rate the environmental engagement of your enterprise?
Experience	Likert 5-point scale, "strongly disagree/strongly agree"	Our enterprise possesses a lot of experience with Green IT.
Initiative from IT staff	Dichotomous, "yes/no"	Did IT staff instigate the Green IT initiative?
Measurement	Likert 5-point scale, "strongly disagree/strongly agree" (reversed)	The success of Green IT is difficult to measure. Reversed to: The success of Green IT is easy to measure.
Standards	Likert 5-point scale, "strongly disagree/strongly agree"	There are defined and generally accepted standards for Green IT.
Hype	Likert 5-point scale, "strongly disagree/strongly agree"	Green IT is a hyped topic and is overrated.
Importance	Likert 5-point scale, "very unimportant, very important", recoded to a 3-point scale, "unimportant, neutral, important"	How important is Green IT for the IT division of your enterprise?
Uncertainty	Likert 5-point scale, "strongly disagree, strongly agree", recoded to a 3-point scale, "high uncertainty, average uncertainty, little uncertainty"	The future significance of Green IT for our enterprise is uncertain.
Green IT planning and implementation	Likert 4-point scale, "not planned or implemented, planned, implemented, implemented and planned"	Green IT measures in our enterprise are…

Table 1. Questionnaire response formats and sample items

The key terms of multinomial logistic regression can be explained as follows. The fit of the model is shown by the -2 log-likelihood statistic and its associated chi-square, which should be significant with p < .05 (Field 2009). The Pearson and deviance statistics test whether the predicted values are significantly different from the observed values. For a good fit of the model these measures should not be significant (Field 2009). R and the corresponding R^2-value tell how much of the variance in the outcome is accounted for by the regression model from the sample (Field 2009). In logistic regression Cox and Snell's R^2 and Nagelkerke's R^2 can be considered as being similar to R^2 from linear regression. The Wald statistic, which has a chi-square distribution, indicates whether the b coefficient for that predictor is significantly different from zero. If the coefficient is significantly different from zero, then it can be assumed that the predictor is making a significant contribution to the prediction of the outcome (Field 2009). Most important for the interpretation of logistic regression is the value of the odds ratio, which is an indicator of the change in odds resulting from a unit change in the predictor (Field 2009). The odds ratio can be interpreted in terms of change in odds.

$$\text{odds ratio} = \Delta\text{odds} = \frac{\text{odds after a unit change in the predictor}}{\text{original odds}}$$

A value greater than 1 indicates that as the predictor increases, the odds of the outcome occurring increases. A value less than 1 indicates that as the predictor increases, the odds of the outcome occurring decrease.

FINDINGS

All finding are based on the sample profile shown in Table 2. The participating enterprises belong to a variety of industries, such as manufacturing (35%), trade and commerce (19%), information and communication technologies (16%), and others (30%), which are representative for Germany.

Annual turnover 2008 in millions of Euros			**Employees of the enterprise**			**Employees of the IT department**		
	Percent	Frequency		Percent	Frequency		Percent	Frequency
1-4	6%	7	1-99	9%	10	1-4	10%	12
5-9	3%	4	100-499	16%	19	5-9	8%	9
10-49	5%	6	500-999	9%	11	10-49	29%	34
50-499	25%	29	1,000-4,999	30%	35	50-499	18%	21
500+	53%	62	5,000+	35%	41	500+	35%	40
Missing values	7%	8			N=116			N=116
		N=116						

Table 2. Turnover and employees of the enterprises

The annual turnover and the number of employees indicate that large enterprises dominate the sample. The total number of employees significantly corresponds to the number of employees in the IT department, $r_s=.74, p < .001$.

To test for non-response bias, the responses were split into two groups based on their chronological return. There is a difference between early and late respondents when cross-tabulated with, "extent of Green IT planning and implementation": 61% of the early respondents had "planned" or "implemented and planned" Green IT, but this proportion decreases to 29% of the late respondent group. The chi-square statistic was significant at $p < .05$. An explanation for this could be that respondents which are currently planning Green IT activities are more likely to answer the questionnaire. It can be assumed that non-response bias has not caused any significant problems with the study.

Importance of Green IT (Research question 1)

To increase the explanatory power of the model and to reduce the problem of large standard errors the sample item for the importance of Green IT is recoded from a 5-point to a 3-point scale. The sample distribution regarding the three final categories is shown in Table 3.

Categories: Importance of Green IT	**N**	**Marginal Percentage**
unimportant	21	18.4%
neutral	29	25.4%
important	64	56.1%
Valid	114	100.0%
Missing	2	

Table 3. Importance of Green IT

The model for the importance of Green IT is a significantly good fit of the data (-2 log-likelihood = 103.716, $\chi^2 = 70.303$, $p < .001$). This is supported by the Pearson and deviance statistics (both $p > .05$), which are not significant. The model explains between 46% (Cox & Snell) and 53.5% (Nagelkerke) of the variance of Green IT importance. Therefore the model has a good explanatory power of the importance of Green IT.

For simplification we only compare the most converse Green IT categories: Green IT is important with Green IT is unimportant. The category of average importance is not further compared and investigated. This leads to the following results (Table 4).

Importance of Green IT		b	Std. Error	Sig.	Odds Ratio	95% Confidence Interval for odds ratio	
						Lower Bound	Upper Bound
important vs. unimportant	Intercept	-9.498	1.935	.000			
	Corporate management	1.168	.524	.026	3.216	1.152	8.982
	Environmental engagement	1.734	.424	.000	5.664	2.466	13.010
	Experience	1.140	.393	.004	3.128	1.448	6.758

Table 4. Parameter estimates for the importance of Green IT

- **Corporate management:** The extent to which the corporate management approaches the IT department with the topic of Green IT significantly predicts whether Green IT is considered as important or unimportant, b = 1.168, Wald $\chi^2 = 4.969$, $p < .05$. The odds ratio indicates that as this variable increases by one unit, the change in the odds of Green IT being important is 3.216. In short, Green IT is likely to be more important when the IT department is approached by the corporate management.
- **Environmental engagement:** The extent of environmental engagement of the enterprise significantly predicts whether Green IT is considered as important or unimportant, b = 1.734, Wald $\chi2 = 16.707$, $p < .001$. The odds ratio indicates that as this variable increases, the change in the odds of Green IT being important is 5.664. In other words, Green IT is likely to be more important when the enterprise is engaged in environmental protection.
- **Experience:** The experience with Green IT significantly predicts whether Green IT is considered as important or unimportant, b = 1.140, Wald $\chi^2 = 8.420$, $p < .01$. The odds ratio shows that as this variable increases, the change in the odds of Green IT being important is 3.128. In other words, it is more likely to consider Green IT important than unimportant if a higher level of experience with Green IT exists.

The odds ratios show that corporate management, environmental engagement, and experience are predictors for the importance of Green IT. The strongest effect size comes from the environmental engagement of the enterprise. The effect size of the corporate management and the experience are comparable. Therefore, we assume that the overall attitude of the enterprise towards ecological issues has the highest impact on the importance of Green IT.

Regarding the first research question it can be stated that corporate management, environmental engagement and experience are good predictors of Green IT importance.

Uncertainty about Green IT (Research question 2)

According to the previous model the uncertainty about Green IT is recoded from a 5-point to a 3-point scale. The sample distribution regarding the three final categories is shown in Table 5.

Categories: Uncertainty about Green IT	N	Marginal Percentage
little uncertainty	41	36.9%
average uncertainty	32	28.8%
high uncertainty	38	34.2%
Valid	111	100.0%
Missing	5	

Table 5. Uncertainty about Green IT

The model for the uncertainty about Green IT is a significantly good fit of the data (-2 log-likelihood = 165.158, $\chi^2 = 73.442$, $p < .001$). This is supported by the deviance statistics ($p > .05$), which is not significant. Pearson indicates that predicted values are significantly different from the observed values ($p < .001$). However, the dispersion parameters (Pearson = 1.38,

Deviance = 0.83) are both close to the ideal value of 1 and therefore no cause for the concern of overdispersion (Field 2009). The model explains between 48.4% (Cox & Snell) and 54.5% (Nagelkerke) of the variance of the uncertainty about Green IT. Therefore the model has a good explanatory power of the uncertainty about Green IT.

For simplification we only compare the most converse Green IT categories: little uncertainty about Green IT with high uncertainty about Green IT. The category of average uncertainty is not further compared and investigated. Table 6 illustrates the findings.

Uncertainty about Green IT		b	Std. Error	Sig.	Odds Ratio	95% Confidence Interval for odds ratio	
						Lower Bound	Upper Bound
little uncertainty vs. high uncertainty	Intercept	-3.659	1.746	.036			
	Experience	1.082	.355	.002	2.952	1.471	5.924
	Measurement	.838	.345	.015	2.312	1.175	4.549
	Standards	1.025	.411	.013	2.788	1.246	6.239
	Hype	-.948	.325	.003	.387	.205	.732
	Initiative from IT staff (no = 0)	-2.047	.688	.003	.129	.034	.498
	Initiative from IT staff (yes = 1)	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

Table 6. Parameter Estimates for the uncertainty about Green IT

- **Experience:** The experience with Green IT significantly predicts whether the uncertainty about Green IT is little or high, b = 1.082, Wald $\chi^2 = 9.273$, $p < .01$. The odds ratio shows that as this variable increases, the change in the odds of having little uncertainty about Green IT is 2.952. In other words, little uncertainty is more likely than high uncertainty if a higher level of experience with Green IT exists.
- **Measurement:** The extent to which the measurement of Green IT success is perceived as easy significantly predicts whether the uncertainty about Green IT is little or high, b = 0.838, Wald $\chi^2 = 5.888$, $p < .05$. The odds ratio indicates that as this variable increases by one unit, the change in the odds of having little uncertainty about Green IT is 2.312. In short, perceiving the measurement of Green IT success as easy makes it more likely to reduce uncertainty about the topic.
- **Standards:** The existence of defined and generally accepted standards for Green IT significantly predicts whether the uncertainty about Green IT is little or high, b = 1.025, Wald $\chi 2 = 6.228$, $p < .05$. The odds ratio indicates that as this variable increases by one unit, the change in the odds of having little uncertainty about Green IT is 2.788. This means known standards for Green IT make it more likely to reduce uncertainty.
- **Hype:** The perception of Green IT as an overrated and hyped topic significantly predicts whether the uncertainty about Green IT is little or high, b = -.948, Wald $\chi^2 = 8.533$, $p < .01$. The odds ratio indicates that as this variable increases by one unit, the change in the odds of having little uncertainty about Green IT decreases to .387. This means that perceiving Green IT as a hyped topic makes it more likely to increase uncertainty about Green IT.
- **Initiative from IT staff:** The origin of initiative for Green IT significantly predicts whether the uncertainty about Green IT is little or high, b = 0.838, Wald $\chi^2 = 5.888$, $p < .05$. The odds ratio indicates that as the initiative for Green IT changes from "no, not from IT staff" (0) to "yes, from IT staff" (1) the change in the odds of possessing little uncertainty compared to high uncertainty is .353. In other words, the odds of having little uncertainty about Green IT compared to high uncertainty is 1/0.353 = 2.833 times higher if the initiative for Green IT comes from the IT staff.

The odds ratios show that experience, measurement of Green IT success, Green IT standards and the initiative from the IT staff decrease the uncertainty about Green IT. Considering Green IT as a hype increases the uncertainty. Experience with Green IT and Green IT standards have the strongest effect size. Though, measuring Green IT success is also important.

Regarding the second research question it can be stated that experience, measurement, standards, hype, and initiative from IT staff are good predictors of the uncertainty about Green IT.

Planning and implementation of Green IT measures (Research question 3)

The sample distribution regarding the categories of Green IT planning and implementation is shown in Table 7.

Categories: Green IT planning and implementation	N	Marginal Percentage
not planned or implemented	23	19.8%
planned	32	27.6%
implemented	37	31.9%
implemented and planned	24	20.7%
Valid	116	100.0%
Missing	0	

Table 7. Planning and implementation of Green IT

The model for the planning and implementation of Green IT is a significantly good fit of the data (-2 log-likelihood = 69.252, χ^2 = 57,531, $p < .001$). This is supported by the Pearson and deviance statistics (both $p > .05$), which are not significant. The model explains between 39.1% (Cox & Snell) and 41.8% (Nagelkerke) of the variance of the planning and implementation status of Green IT. Therefore the model has a good explanatory power. For simplification we only compare the most converse Green IT categories: implemented and planned with not planned or implemented. The other categories are not further compared and investigated. Table 8 illustrates the results.

Green IT planning and implementation		b	Std. Error	Sig.	Odds Ratio	95% Confidence Interval for odds ratio	
						Lower Bound	Upper Bound
implemented and planned vs. not planned or implemented	Intercept	-2.119	1.987	.286			
	Importance	2.214	.610	.000	9.149	2.766	30.265
	Uncertainty	-1.195	.532	.025	.303	.107	.859

Table 8. Parameter estimates for planning and implementation of Green IT

- **Importance:** The importance of Green IT significantly predicts whether Green IT measures are implemented and planned, b = 2.214, Wald χ^2 = 13.153, $p < .001$. The odds ratio indicates that as the importance of Green IT increases by one unit, the change in the odds of Green IT measures being implemented and planned is 9.149. Therefore, it is more likely to have Green IT measures implemented and planned than not if Green IT is considered to be an important topic.
- **Uncertainty:** The uncertainty about Green IT significantly predicts whether Green IT measures are implemented and planned, b = -1.195, Wald χ^2 = 5.047, $p < .05$. The odds ratio indicates that as the uncertainty about Green IT increases by one unit, the change in the odds of Green IT measures being implemented and planned (rather than not planned or implemented) is .303. In short, it is unlikely to have Green IT measures implemented and planned if the uncertainty about Green IT is high.

Regarding the third research question it can be stated that importance and uncertainty are good predictors for the planning and implementation of Green IT measures. The findings also show that explanatory power of importance and uncertainty increases along the four adoption levels of Green IT.

IMPLICATIONS AND LIMITATIONS

The above findings verify our proposed research framework. From this we draw practical implications for CIOs and IT managers as well as environmental and sustainability officers. The implications come with specific limitations mentioned below.

CIOs and IT managers should be aware of the factors influencing the importance and uncertainty concerning Green IT, thereby avoiding mistakes when dealing with it. The needs of the corporate management and the environmental strategy of the enterprise are determinants of Green IT importance, which should be considered. Green IT can be a powerful initiative to align the activities of the IT department with the overall environmental strategy. On the other hand, if the business needs and the environmental strategy are not congruent with the ideas of Green IT, the chances of adoption seem to be limited. The corporate management as well as the environmental and sustainability managers can push the topic of Green IT by actively approaching the IT department and creating the appropriate setting in the context of an environmental strategy.

The findings also indicate the existence of an experience curve (Ghemawat 1985). Increasing experience with Green IT raises its importance and decreases its uncertainty. CIOs and IT managers should consider this effect when thinking about initial Green IT activities. Additional workshops or trainings on Green IT would support these activities.

Standards and measurements are needed to decrease the uncertainty about Green IT. Special consortiums, such as "The Green Grid" or the "Uptime Institute", are working on standards and measurements in the scope of Green IT (The Green Grid 2010; Uptime Institute 2010). Still, only a few generally accepted standards and measurements are existent (Erek et al. 2009). Therefore, CIOs and IT managers as well as researchers have to develop or adapt new metrics and standards.

The discussion about Green IT being a hyped topic creates confusion and uncertainty. CIOs and IT managers should focus on facts not on marketing slogans and political agendas. As the findings indicate, personal experience with Green IT seems to be the best marketing for Green IT.

Environmental and sustainability managers as well as corporate management should consider the advantages if the initiative for Green IT comes from the IT staff. This reduces the uncertainty which can potentially lead to a greater adoption of Green IT practices. Planning and implementing Green IT should therefore be facilitated by a business wide task force including the staff from the corporate management, environmental and sustainability managers as well as IT executives.

The sample selection and the applied statistical methods impose specific limitations to the findings. Due to the sample selection the results of this study are only representative for German IT departments. The perception of Green IT might vary from region to region (Molla et al. 2008). Nevertheless, Green IT has been a topic of international scale with comparable awareness as indicated. Limitations also derive from the application of regression analysis. Conclusions are restricted to the sample collected and generalizations of the results can be achieved only if analysis using different samples reveals the same outcome (Field 2009). Furthermore, it has to be considered that there are important underlying predictors which have not been included in this analysis, e.g. the image or the perceived ease of implementation of Green IT.

Despite the given limitations these results provide insights and guidelines for CIOs, IT managers, environmental and sustainability managers to promote implementation of Green IT projects.

CONCLUSION AND FURTHER RESEARCH

In this research we have shown a set of predictors of Green IT adoption. We provided an initial conceptual framework and suggested practical recommendations. Our findings enable CIOs, IT managers as well as environmental and sustainability managers to gain further insights about Green IT and to take the appropriate actions to link Green IT with the IT and business strategy.

The results demand further investigation and validation. To refine the suggested model a cross-validation of the proposed conceptual framework is necessary. Therefore, future research should replicate the survey in other countries to determine if the results are repeatable. The findings should be refined and evaluated further using in-depth case study analysis (Eisenhardt 1989; Yin 2002). Since uncertainty plays an important role in the scope of Green IT, further investigations from the perspective of principal-agent theory offer promise to gain new insights (Pavlou et al. 2007).

The findings indicate that there is a need for the development of standards and measurements. Further research should therefore aim to provide key performance indicators which serve for internal and external reporting. This could be done within the concept of an IT balanced scorecard. Also, the organizational context of Green IT should be investigated, since actors from different divisions are involved. An ideal reference model defining processes, tasks, roles and responsibilities in the scope of Green IT for the entire enterprise seems useful.

IT departments have to be aware that environmental topics need to be addressed in order to remain competitive in the future. Given the rising prices for energy and other resources and the increasing awareness of all stakeholders to environmental issues the relevance of ecological oriented IT is destined to gain even more importance in the future. As a result, we reason that following the outlined recommendations can have a positive impact on Green IT management and the business performance.

REFERENCES

1. Backhaus, K., Erichson, B., Plinke, W. & Weiber, R., 2008. *Multivariate Analysemethoden: Eine anwendungsorientierte Einführung* 12. ed., Springer, Berlin.

2. Boudreau, M., Watson, R.T. & Chen, A., 2008. From Green IT to Green IS. *Cutter Benchmark Review*, 8(5), 5-11.

3. Chen, A.J., Boudreau, M. & Watson, R.T., 2008. Information systems and ecological sustainability. *Journal of Systems and Information Technology*, 10(3), 186 - 201.

4. Eisenhardt, K.M., 1989. Building Theories from Case Study Research. *The Academy of Management Review*, 14(4), 532–550.

5. Elliot, S., 2007. Environmentally Sustainable ICT: A Critical Topic for IS Research? *PACIS 2007 Proceedings*, (Paper 115). Available at: http://www.pacis-net.org/file/2007/1302.pdf.

6. Elliot, S. & Binney, D., 2008. Environmentally Sustainable ICT: Developing Corporate Capabilities and an Industry-Relevant IS Research Agenda. *PACIS 2008 Proceedings*, (Paper 209). Available at: http://aisel.aisnet.org/pacis2008/209/ [Accessed November 5, 2009].

7. Erek, K., Schmidt, N., Zarnekow, R. & Kolbe, L.M., 2009. Sustainability in Information Systems: Assortment of Current Practices in IS Organizations. *AMCIS 2009 Proceedings*. Available at: http://aisel.aisnet.org/amcis2009/123 [Accessed November 4, 2009].

8. Field, A., 2009. *Discovering Statistics Using SPSS* Third Edition., Sage Publications.

9. Fujitsu Australia, 2009. Green IT: The Convenient Truth. Available at: https://www-s.fujitsu.com/au/whitepapers/convenient_truth.html.

10. Gartner, 2009. Gartner's 2009 Hype Cycle Special Report Evaluates Maturity of 1,650 Technologies. Available at: http://www.gartner.com/it/page.jsp?id=1124212 [Accessed March 1, 2010].

11. Ghemawat, P., 1985. Building strategy on the experience curve. *Harvard Business Review*, 63(2), 143-149.

12. Hall, B.H. & Khan, B., 2003. Adoption of New Technology. *SSRN eLibrary*. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=410656 [Accessed April 20, 2010].

13. Hubbard, D.W., 2007. *How to measure anything*, John Wiley and Sons.

14. Kurp, P., 2008. Green computing. *Communications of the ACM*, 51(10), 11.

15. Long, J.S., 1997. *Regression models for categorical and limited dependent variables*, SAGE.

16. Mani, D., Barua, A. & Whinston, A., 2010. An Empirical Analysis of the Impact of Information Capabilities Design on Business Process Outsourcing Performance. *MIS Quarterly*, 34(1), 39-62.

17. Mines, C. & Davis, E., 2007. Topic Overview: Green IT. Available at: http://www.forrester.com/Research/Document/Excerpt/0,7211,43494,00.html [Accessed November 5, 2009].

18. Molla, A., 2008. GITAM: A Model for the Adoption of Green IT. *Australasian Conference on Information Systems 2008*, 658-668.

19. Molla, A., 2009. The Reach And Richness Of Green IT: A Principal Component Analysis. In 20th Australasian Conference on Information Systems. Melbourne, pp. 754-764. Available at: http://infotech.monash.edu/about/news/conferences/acis09/Proceedings/pdf/074.pdf.

20. Molla, A. et al., 2008. E-Readiness to G-Readiness: Developing a Green Information Technology Readiness Framework. *Australasian Conference on Information Systems 2008*, 669-678.

21. Pavlou, P.A., Huigang Liang & Yajiong Xue, 2007. Understanding and Mitigating Uncertainty in Online Exchange Relationships: A Principal Agent Perspective. *MIS Quarterly*, 31(1), 105-136.

22. Poppo, L. & Zenger, T., 2002. Do formal contracts and relational governance function as substitutes or complements? *Strategic Management Journal*, 23(8), 707-725.

23. Schmidt, N., Erek, K., Kolbe, L.M. & Zarnekow, R., 2009. Towards a Procedural Model for Sustainable Information Systems Management. In *Hawaii International Conference on System Sciences*. pp. 1-10.

24. The Green Grid, 2010. The Green Grid. Available at: http://www.thegreengrid.org/ [Accessed March 1, 2010].

25. Uptime Institute, 2010. The Uptime Institute - Improving data center uptime and the world's IT productivity through benchmarking and collaborative learning. Available at: http://www.uptimeinstitute.org/ [Accessed March 1, 2010].

26. Venkatesh, V. & Davis, F.D., 2000. A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science*, 46(2), 186-204.

27. Wagner, M., 2007. Der Sustainable Economic Value von sozialer Nachhaltigkeit und Umweltmanagement: Konzept und empirische Anwendung. In M. Müller & S. Schaltegger, eds. *Corporate Social Responsibility: Trend oder Modeerscheinung?* oekom, pp. 229-245.

28. Ward, J. & Peppard, J., 2002. *Strategic Planning for Information Systems* 3. ed., John Wiley & Sons.

29. Yin, R.K., 2002. *Case Study Research: Design and Methods, Third Edition, Applied Social Research Methods Series, Vol 5* 3. ed., Sage Publications, Inc.