

# Antecedents of Green IT Adoption in South African Higher Education Institutions

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**Abstract:** Organizations are now increasingly expected to address the sustainability of their information technology (IT) and communication infrastructure. This research investigates the antecedents for the adoption of Green IT in South African higher education institutions (HEI), namely which drivers and readiness factors influence Green IT adoption. Green IT comprises of server virtualization, storage virtualization, storage consolidation, environment-friendly IT procurement, electronic waste management policies and measuring the environmental impact of IT. For the purpose of this research, Green IT drivers were classified into economic, ethical, response and regulatory drivers as per Molla's (2008) Green IT model. Additionally, we also investigated the role of the following Green IT readiness factors: institutional, organisational and value network Green IT. IT managers at all South Africa's HEIs were approached through an online survey. Given the small number of HEIs in South Africa, sample size was necessarily limited but the responses received represent a significant and representative portion of the South African HEIs and encouraging results were found. All Green IT drivers were found to be significant antecedents in the adoption of green IT, although the overall adoption of green IT is relatively low. However, most HEI stakeholders in the HEI value network, i.e. suppliers, investors, competitors and government, do not seem to exert a significant influence on green IT adoption. We condensed these antecedents into a revised Green IT adoption model. Our research instrument and proposed resultant Green IT model should be of interest, not only to HEI stakeholder in South Africa and elsewhere in the world, but also to researchers in the field of sustainability of information technologies and the manufacturers of green and sustainable technologies.

**Keywords:** green IT, adoption drivers, readiness, sustainability, higher education institutions (HEIs), South Africa

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## 1. Introduction

People are becoming increasingly aware of the environmental impact of ICT and the necessity to reduce this impact on the environment (Jenkin, Webster & McShane, 2011). ICT components consume vast amounts of electricity during their lifetime and ICT carbon emissions are estimated to be equal to that of the aviation industry (Hanne, 2011). This awareness has resulted in a call for organizations to address the sustainability of the information technology and communication infrastructure (Jenkin et al. 2011). Although data-centre sustainability accounts for a significant portion of IT sustainability, client side IT equipment is often overlooked and is one of the primary contributors to carbon emissions of ICT. For example, the amount of carbon dioxide emitted over the average lifetime of a single desktop computer is said to be 1096kg (Paruchuri 2011). Discarded ICTs, known as electronic waste or e-waste, are one of the major and fastest growing contributors to waste disposal. It is thus imperative that a comprehensive approach to adoption of Green IT is employed in order for it to be successful (Molla & Cooper 2010).

The adoption of Green IT is said to have additional motivational factors beyond those of standard IT adoption (Molla 2008; Molla & Abareshi 2011). These motivational factors may include economic benefits, regulation requirements, stakeholder obligations and ethical reasons, which all need to be taken into account when exploring and analysing factors that may influence the adoption of Green IT. Few studies have studied the adoption of Green IT from a higher education perspective and apart from research in the Green IS field (Petzer et al. 2011), none seem to have studied Green IT from a South African perspective.

This research aims to address the question, "Which drivers and readiness factors motivate higher education institutions to adopt green and sustainable IT solutions?" The results of this study will assist in providing insight into the reasons behind the adoption of Green IT within the higher educational sector and from an emerging economy perspective. These insights are of use to HEI stakeholders and sustainability researchers alike. The empirical validation of the theoretical framework used here, and the new research instrument which we developed, make a theoretical contribution to the academic research in the field of Green IT evaluation.

## 2. Literature review

There is an increasing call on organizations to address the sustainability of their information technology and communication infrastructure (Cooper & Molla 2010; Jenkin et al. 2011). Until recently information technology sustainability has received very little attention in terms of research (Chen et al. 2008; Molla 2008; Nazari & Karim 2012). As a result of this, there is still no mutual agreement on the exact definition of Green Information Technology (Green IT).

Green IT is often viewed purely from a data-centre perspective (Molla et al. 2008; Petzer et al. 2011). Although the sustainability of the data-centre plays an important role in the sustainability of information technology, it is necessary to adopt a comprehensive approach when addressing environmental sustainability (Murugesan 2008; Molla & Cooper 2010). Client side IT equipment is one of the primary contributors to carbon emissions of ICT with an average of 1096kg of carbon dioxide emitted over the average lifetime of a single desktop computer (Paruchuri 2011). Energy consumption can be significantly reduced by adapting the way in which we use these computers (Murugesan & Gangadharan 2012). This can be achieved through the application of relevant technology for the activity, power management features and powering down the computer when not in use (Murugesan 2008; Harmon & Auseklis 2009). The majority of ICT components end up in landfills once they have reached their end of life (Murugesan 2008). These discarded components, labelled electronic waste or e-waste, are one of the major and rapidly growing contributors to waste disposal.

The design and manufacturing of sustainable ICT can also assist in reducing the overall carbon footprint of ICT. By reducing the amount of raw materials, increasing the use of non-toxic materials and by recycling parts, manufacturers may assist in reducing their impact on the environment. Additionally, the design of energy-efficient technologies can also help in reducing the overall energy consumption of ICT.

Inevitably the decision to adopt sustainable ICT comes down to either the individual or the organization. Although IT adoption and the motivation of individuals and organization have been researched at length, the adoption of Green IT is said to have additional motivational factors other to that of standard IT adoption. This has prompted the development of Green IT-specific models and frameworks. Although research in the area of Green IT adoption is still young, a number of studies have attempted to explain the adoption of Green IT from various viewpoints (Molla 2008; Nazari & Karim 2012; Schmidt & Ereik 2010). However, few of these studies have studied the adoption of Green IT from a higher education perspective and, apart from research in the Green IS field (Petzer et al. 2011), none seem to have studied Green IT from a South African perspective.

### 2.1 Defining green IT

In order to accurately assess the status of Green IT, it is important to have a clear understanding of the meaning and extent of Green IT, and the closely associated but different concept of Green IS. Green IT, also referred to as Green for IT or Green IT 1.0, is the application of sustainability to the design, manufacturing, use and disposal of IT. It is perceived to be the more mature and original form of Green IT. Lamb (2009) defines Green IT as, "Using IT more efficiently to achieve reductions in energy consumption, and therefore, considering the acquisition of energy-efficient IT solutions." This definition highlights two areas of Green IT: Sourcing of environmentally sustainable ICT equipment and efficient usage of ICT equipment. However, Green IT does not only refer to the economics and energy-efficiency of information technology but also environmental sustainability concerns within the design and manufacturing phases as well as indirect costs such as disposal and recycling (Murugesan 2008). The majority of ICT emissions are not a direct result of the ICT equipment but rather a result of the entire lifecycle of these components (Murugesan & Gangadharan 2012). Wallace and Webber (2009) offer a slightly enhanced approach and define Green IT as, "*the reduced environmental impact from running an Information Technology (IT) department*". They continue by highlighting three primary characteristics of Green IT: energy efficiency, correctly suited equipment and proper disposal of retired equipment. Although this covers a large portion of Green IT, they fail to take into account the design and manufacturing of the ICT equipment. Murugesan's (2008) definition incorporates additional components of the ICT lifecycle, such as the design and manufacturing together with the usage and the disposal of ICT equipment: "*the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment*" (S Murugesan, 2008).

However, this earlier definition still fails to take into account the sourcing of energy-efficient ICT (Molla et al., 2008). Molla et al. (2008) therefore suggest a more comprehensive approach and define Green IT as: “A systematic application of ecological-sustainability criteria (such as pollution prevention, product stewardship, use of clean technologies) to the design, production, sourcing, use and disposal of IT products and services in order to reduce IT, business process and supply chain related emissions, waste and water use, improve energy efficiency and generate tangible and intangible green economic rent” (Molla et al., 2008). This is a more holistic definition which covers each of the areas within Green IT and as a result of this we have chosen to adopt this definition for this research.

As research has progressed, a new area has become increasingly prominent, referred to as Green IS. Butler (2012) refers to Green IS as IT software applications that focus on sustainability and the effect of people, processes and technology. It facilitates a reduction in overall emissions of an organization. The application of Green IS can vary based on the context in which it is used. Butler (2012) lists various functions of Green IS including monitoring and reporting on GHG emissions, controlling waste, toxic and hazardous materials use, management of energy-consuming buildings, redesigning business processes (including logistics) to make them more energy efficient. Thus Green IS can contain elements of Green IT but Green IT does not necessarily contain elements of Green IS (Ijab 2010; Butler 2011).

As Green IT is still a relatively new topic, there has been very little empirical research in this area until recently. One study in Sweden made use of a comparative case study on the adoption of Green IT between a municipality and a higher education institution (Nazari & Karim 2012). The results of the two case studies showed a definite contrast in the factors influencing the adoption of Green IT. Petzer et al. (2011) did a study on the adoption of Green IS from a South African perspective. Given the few similarities between Green IT and Green IS this research may offer some insight into the reasons behind the adoption of Green IT in South Africa. This study provided empirical evidence that adoption of Green IS is more due to economic benefits rather than regulatory or ethical reasons (Petzer et al. 2011). Other than this research, there appears to be no research around the adoption of Green IT from a developing country perspective and more specifically from a South African perspective.

## **2.2 Green IT adoption and drivers**

This section explores the potential drivers of Green IT as outlined in the existing literature.

*Economic Drivers*, namely cost reduction is one of the more significant drivers of Green IT, particularly in a South African context (Petzer et al. 2011). As a result of the rising cost of energy, the most recognized method of cost reduction in the ICT environment is through the reduction of energy consumption (Murugesan 2008; Murugesan & Gangadharan 2012).

*Regulatory* drivers such as regulatory and government compliance play an important role in the intention of organizations to adopt Green ICT. Certain regulatory acts require organizations to report their carbon emissions if they are above a certain level (Molla 2008; Murugesan & Gangadharan 2012). However, legislation around the adoption of Green IT is less of a concern in a South African context as there are no repercussions due to the absence of compulsion (Petzer et al. 2011)

*Market opportunity* drivers include the growing awareness of ICT’s impact on the environment as well as ICT as a solution to the impacts of ICT on the environment. Businesses now have the opportunity of not only implementing sustainable ICT solutions, but also supplying green ICT equipment, products and software (Unhelkar 2011; Murugesan & Gangadharan 2012).

*Social, cultural and political* pressures can become a significant driving force in the awareness and subsequent adoption of Green IT. This may happen when the society becomes aware of the degradation of the environment and realizes the importance thereof, thus driving the organization to change their approach (Murugesan & Gangadharan 2012). Organizations may also be compelled to adopt and implement Green IT solutions as a result of the requirements of the *industry* i.e. other organizations. Once one organization chooses to adopt sustainable methods, other associated organizations will invariably be driven towards the adoption of sustainable practices (Murugesan & Gangadharan 2012). Molla & Abareshi (2011) merge the

market opportunity driver, industry drivers as well as the social, cultural and political drivers into so-called *response drivers*.

*Self-Motivation* can be seen as the *ethical* driver in the implementation of Green IT. Organizations can implement Green IT based on overall perception and beliefs of the organization and in order to do a common good. This can be due to a realisation of the cost benefit, to instil employee confidence or even to aspire towards a better brand image (Murugesan & Gangadharan 2012).

### 2.3 Green IT adoption models

A number of Green IT adoption models have been developed based on the existing literature on IT adoption. Nazari et al. (2009) (Figure 1) combine the TOE framework and DOI model in order to identify factors influencing the adoption of Green IT at an organizational level. This framework highlights three sets of factors that may influence the adoption of Green IT: Innovation, Organizational and Environmental Factors.



Figure 1: Green IT Adoption Model (Nazari & Karim, 2009)

Another Green IT adoption framework, posited by Schmidt & Erekat (2010) (Figure 2) hypothesizes that the extent of Green IT planning and implementation is influenced positively by the perceived importance but negatively by the uncertainty around Green IT. The framework suggests a number of first level predictors which can either positively or negatively influence the importance of IT (corporate management, environmental engagement, experience) and uncertainty surrounding Green IT (experience, measurement, standards, hype and IT staff initiative) (Schmidt & Erekat 2010).

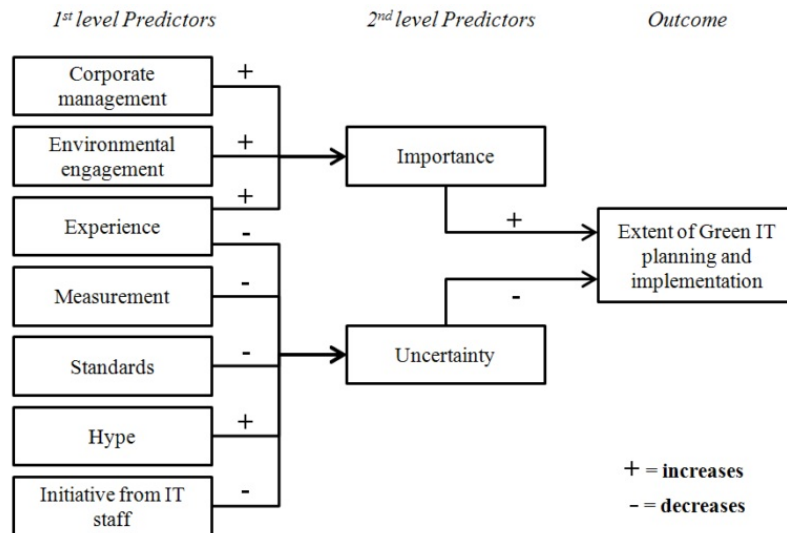
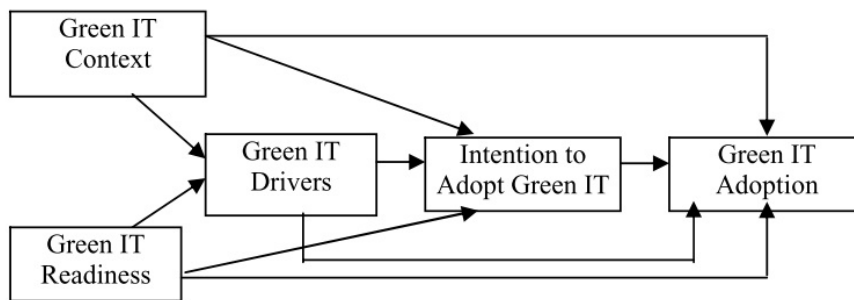


Figure 2: Green IT Adoption Model (Schmidt & Ere, 2010)

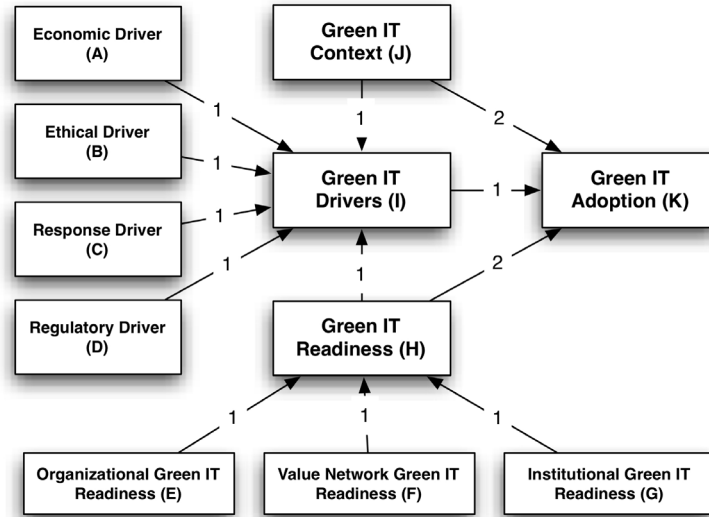
Molla (2008) poses a new theory relating to the adoption of Green IT based on existing innovation and adoption models. His Green IT Adoption Model (GITAM) (Figure 3) poses that an organizations intention to adopt Green IT and the adoption of Green IT, is influenced by factors such as Green IT Readiness, Green IT Context and Green IT Drivers. The Green IT context assesses the existing characteristics of the available technology adoption models. Based on the TOE model, the GITAM framework divides these contexts into a technological, an organisational and an environmental context. The Green IT Readiness is an assessment of an organizations readiness to adopt Green IT (Molla 2008). Based on the PERM model (Molla & Licker 2005), Green IT Readiness is categorized into the perceived organization Green IT Readiness, the perceived value network Green IT Readiness and the perceived Institutional Green IT Readiness. Molla (2008) identifies three drivers of Green IT: economic, regulatory and ethical. Molla and Abarreshi (2011) pose an additional driver that may influence the adoption of Green IT: the eco-responsiveness driver which refers to other external pressures such as social, cultural and political pressures, industry pressure and new market opportunities.



3: GITAM: The basic model (Molla 2008)

### 3. Research methodology

The purpose of this research is descriptive as well as exploratory. A positivist stance and deductive approach were adopted. The theoretical framework for this research is based on the GITAM model developed by Molla (2008), although the intention to adopt was not measured explicitly. Figure 4 below shows the final research model, with each of the arrows representing a proposed impact for which a corresponding hypothesis was formulated.



**Figure 4:** Logical mapping of hypotheses against the proposed model

This leads to the following hypotheses:

A1: Economic benefits affect the adoption of Green IT in HEIs in South Africa positively.

B1: Overall perception and ethical beliefs of an institution affect the adoption of Green IT in HEIs in South Africa .

C1: External pressures affect the adoption of Green IT in HEIs in South Africa .

D1: Government and Professional bodies affect the adoption of Green IT in HEIs in South Africa .

E1: The perception of an institutions Green IT readiness affects the perception of an institution’s *overall* Green IT Readiness in HEIs in South Africa .

F1: The perception of an institution’s value network Green IT readiness affects the perception of an institution’s *overall* Green IT Readiness in HEIs in South Africa

G1: The perception of an institution’s institutional Green IT readiness affects the perception of an institution’s *overall* Green IT Readiness in HEIs in South Africa

H1: The perception of an institution’s *overall* Green IT Readiness affects the Green IT drivers in HEIs in South Africa

H2: The perception of an institution’s *overall* Green IT Readiness affects the adoption of Green IT in HEIs in South Africa

I1: Green IT Drivers affect the adoption of Green IT in HEIs in South Africa

K: The overall level of Green IT adoption in HEIs in South Africa is fairly low

H: The overall Green IT Readiness of HEIs in South Africa is low

The survey questionnaire instrument that was used for this research accommodates questions for each of the factors that may influence the adoption of Green IT. The Green IT driver section of the survey questionnaire was adapted from an existing instrument developed by Molla & Abareshi (2011) on the adoption of Green IT from a motivational perspective as well as one self-developed question. The Green IT Readiness section of the survey questionnaire was predominantly adapted from an existing instrument developed by Molla & Licker (2005) on the adoption of ecommerce in developing countries, together with other instruments developed by Schmidt & Ere (2010) and Molla & Cooper (2010). Green IT adoption was operationalized as the use of server virtualization, storage virtualization, storage consolidation, having an environment-friendly IT procurement policy, having a policy on managing electronic waste and measuring the environmental impact of IT. Most questions were re-phrased for a higher-education context. Where pre-developed questions were not available for the construct that was being measured, the questions were self-developed. The final questionnaire is available from the authors on request. The research was targeted at the information technology staff in two to three IT departments at each of South Africa’s 23 public higher education institutions. The survey was launched end-July 2013 and follow-ups were done via email and telephone to encourage responses.

#### 4. Data analysis and results

All data analysis was completed using the statistical tool R. Of the 48 responses that were received, 28 incomplete responses and 1 erroneous response were discarded and a total of 19 complete responses remained.

##### 4.1 Sample description

Out of the 23 higher education institutions that were contacted, only 9 institutions provided valid responses to the survey. However, six of the seven South African provinces that have HEIs are represented, with no province having more than two HEIs. Thus the sample is geographically very representative. The distribution of individual responses from institutions (most HEIs had two individual responses) was similar, apart from the Western Cape Province, which had averaged 3 individual responses per university.

##### 4.2 Instrument validity

As the research instrument consists of multi-point questions and summated scales and as some of the questions were self-developed, it was necessary to validate the reliability of the instrument before proceeding with data analysis (Cronbach 1951). Cronbach's alpha was used to measure the internal consistency reliability of items within the instrument. In order to get an accurate representation of the instruments reliability an additional three measures were analysed, including Guttman's lambda 6 (Guttman 1945; Kadjevich 2003), standardized alpha based on correlations (Schmitt 1996) and the average inter-item correlation (Kuder & Richardson 1937; Gulliksen 1945). Using George and Mallory's (2003) rule of thumb for the assessment of the results, any item with a Cronbach's alpha below 0.7 was reassessed and as a result three items (ETH3, RES2 and COM4) were dropped from the instrument. Once these items had been dropped, the Cronbach alpha of the remaining items was above 0.7 (Table 1).

Table 1: Instrument validity

Instrument validity for instrument variables				
Variable	Cronbach's alpha	Standardized alpha	Guttman's Lambda 6	Average inter-item correlation
Economic Drivers	0.9159	0.9167	0.8911	0.7857
Ethical Drivers	0.7326	0.7326	0.5780	0.5780
Response Drivers	0.7340	0.7145	0.7400	0.4548
Regulatory Drivers	0.7236	0.7386	0.7490	0.4140
Commitment	0.7340	0.7145	0.7400	0.4548
Awareness	0.8364	0.8408	0.8251	0.5691
Resources	0.9044	0.9109	0.9285	0.6717
Suppliers	0.9345	0.9406	0.9207	0.8407
Competitors	0.8597	0.8608	0.8689	0.6073
Investors	0.9224	0.9281	0.9229	0.8114
Government	0.8564	0.8572	0.8040	0.6668
ADOPTION	0.7174	0.7544	0.8190	0.3385

Unfortunately, the sample size was too small to do validity analysis by means of exploratory factor analysis.

##### 4.3 Exploratory data analysis

Tukey's (1977) exploratory data approach was used to present the data. A diverged stacked bar chart was produced; this chart is preferred to pie or normal bar charts which make the data difficult to interpret without a common baseline (Robbins & Heiberger 2011). Figure 5 shows that responders seem to agree to a greater percentage with Green IT Drivers, which is weighted to the right of the plot, shown in blue. In contrast, responders generally tend to disagree to a greater percentage with the Green IT readiness constructs and the adoption construct, shown to the left of the plot, in red (Figure 5). This may possibly indicate a low level of Green IT readiness as well as Green IT adoption as the questions for both readiness and adoption are phrased around the state to which institutions have implemented the construct (Figure 5).

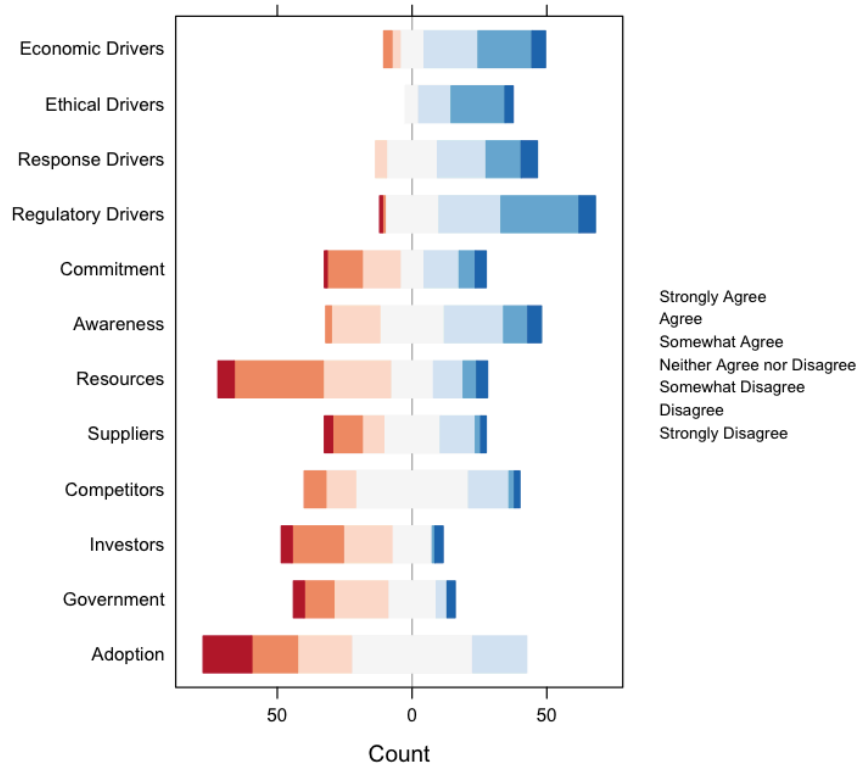


Figure 5: Diverged and stacked bar chart of the responses to the instrument constructs

#### 4.4 Correlation analysis

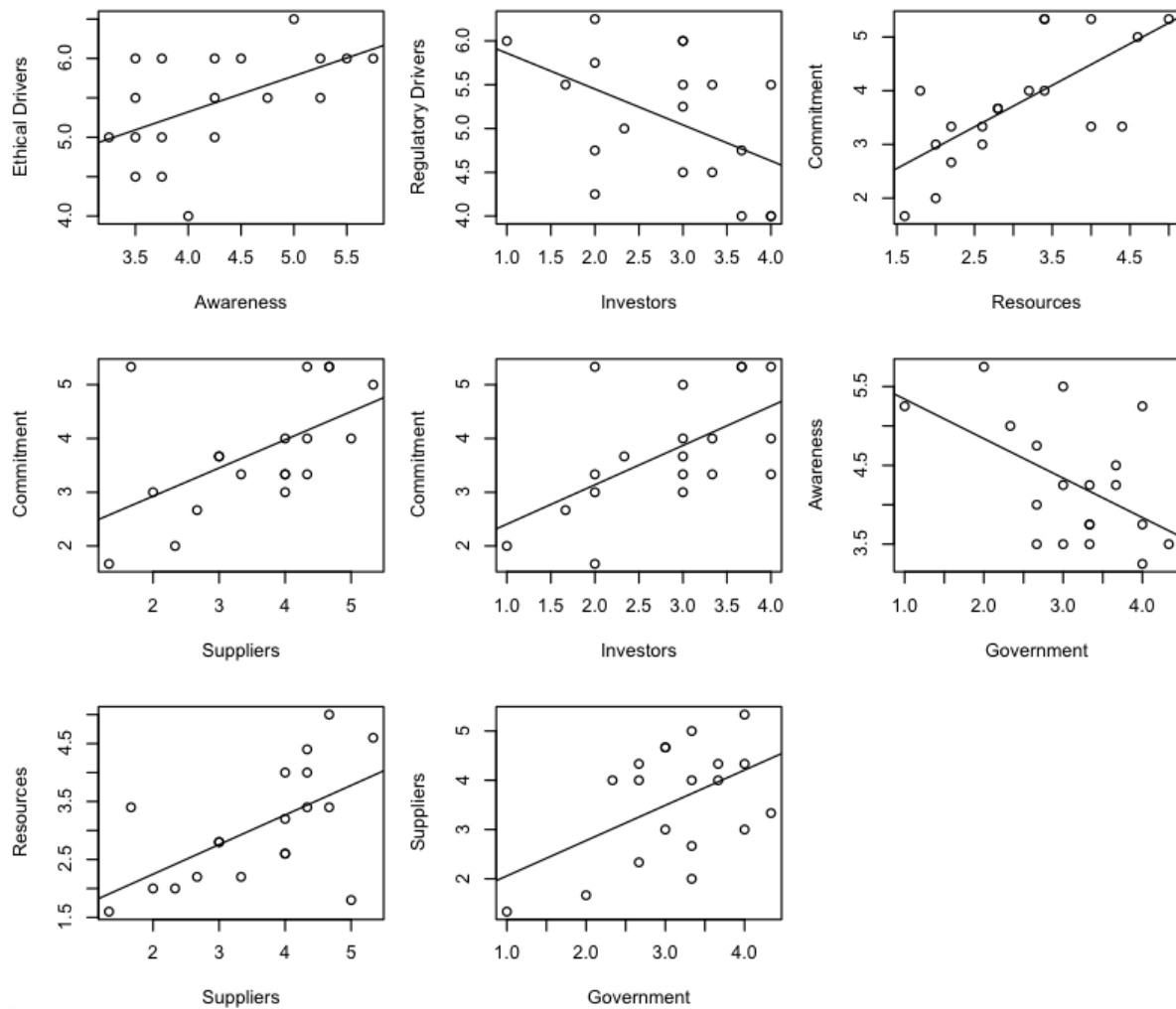
Correlation matrices between individual items and between constructs were created using Pearson’s correlation coefficients to identify any relationships (Sedgwick 2012). Figure 6 shows the correlations between constructs and a graphic representation. The left matrix gives the actual correlation coefficients below the diagonal and the corresponding p-values above the diagonal; the right matrix gives a visual interpretation with blue for positive and red for negative correlations; size and intensity of the cell block indicate magnitude.



Figure 6: Pearson’s correlation matrix for constructs

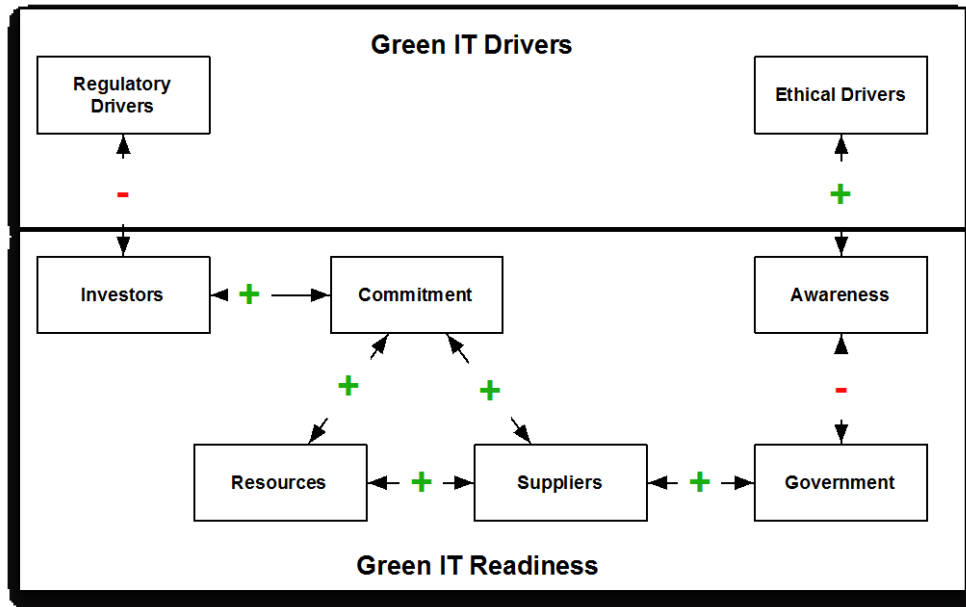
Figure 6 shows significant positive and negative correlations between constructs. There are some strongly significant positive correlations within Green IT Readiness between constructs Organizational Green IT Readiness, Value Network Green IT Readiness and Institutional Green IT Readiness. A significant positive correlation is also evident between Commitment and Resources, between Commitment and Suppliers and between Resources and Suppliers. Additionally, within Green IT readiness, a significantly positive relationship

exists between Commitment and Investors and a significant negative correlation exists between Government and Awareness. The scatter plots for the constructs with significant correlations are shown in Figure 7.



**Figure 7:** Scatterplots for significantly correlating constructs shown in the refined model.

This results in a more finely tuned proposed sub-model of antecedents driving Green IT adoption as shown in Figure 8.



**Figure 8:** Significant correlations within green IT drivers

Correlation results show that there are no significant correlations between any of the constructs within Green IT Drivers (Figure 8). There are however two significant correlations between Green IT Drivers and Green IT Readiness, namely a significant positive correlation between Ethical Drivers and Awareness and the significant negative correlation between Regulatory Drivers and Investors. Once the relationships between constructs had been investigated, the hypotheses were tested.

**4.5 Hypothesis testing**

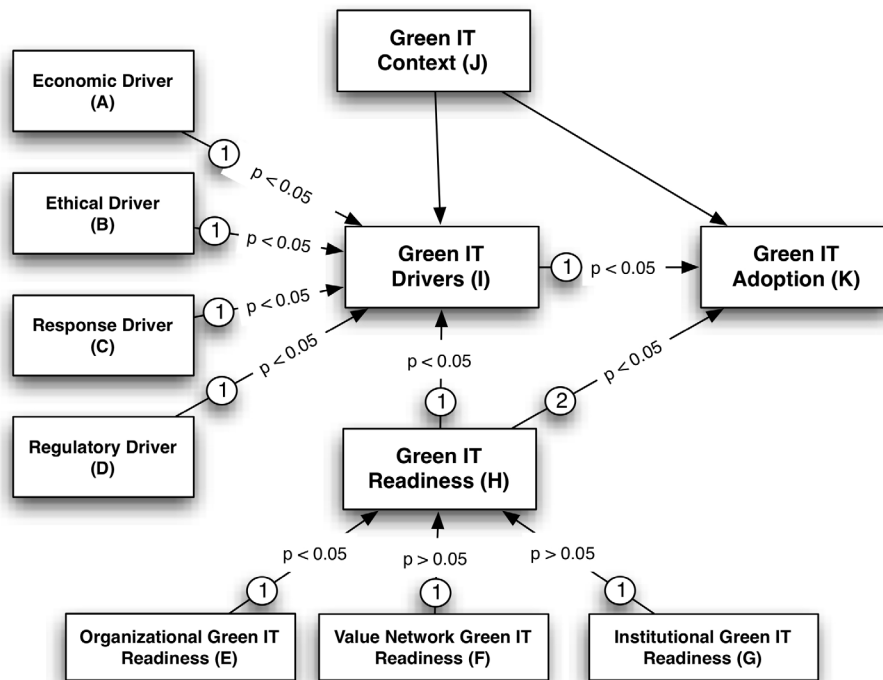
Given the relatively small sample size of this study, a Fishers exact test was used in addition to the Chi-squared test as a non-parametric approach for hypothesis testing (Lancaster & Seneta 1969; Routledge 1998). Although both Chi-squared and Fishers Exact tests were provided for comparison, final deductions were based on the results of the Fisher’s exact test alone. The results from the Fishers exact test showed that for the hypotheses, shown in Table 1, all but two of the hypotheses of this study were significant (Table 2). Note that the hypotheses refer to Figure 4 i.e. H2 is the hypothesis that Green IT Readiness (H) impacts on Green IT Adoption (Arrow 2).

**Table 2:** Results for chi-squared test and Fishers exact test for hypothesis testing

Chi-Squared and Fishers Exact Test			
Hypothesis	Fishers Exact p-value	Chi-square	Chi-square p-value
A1*	< 0.05	76.98	< 0.05
B1*	< 0.05	93.54	< 0.05
C1*	< 0.05	60.45	< 0.05
D1*	< 0.05	88.16	< 0.05
E1*	< 0.05	26.77	< 0.05
F1	> 0.05	NA	> 0.05
G1	> 0.05	NA	> 0.05
H1*	< 0.05	43.66	< 0.05
H2*	< 0.05	NA	> 0.05
I1*	< 0.05	77.74	< 0.05

\* significant at p = 5%

According to the hypotheses, these results suggested that the adoption of Green IT in higher education institutions in South Africa is significantly ( $p < 0.05$ ) affected by economic benefits, overall perception and beliefs of an institution, external pressures, government and professional bodies and by the perception of an institutions Green IT readiness. Green IT Drivers as a whole plays a significant role in affecting adoption of Green IT in higher education institutions in South Africa (Figure 8).

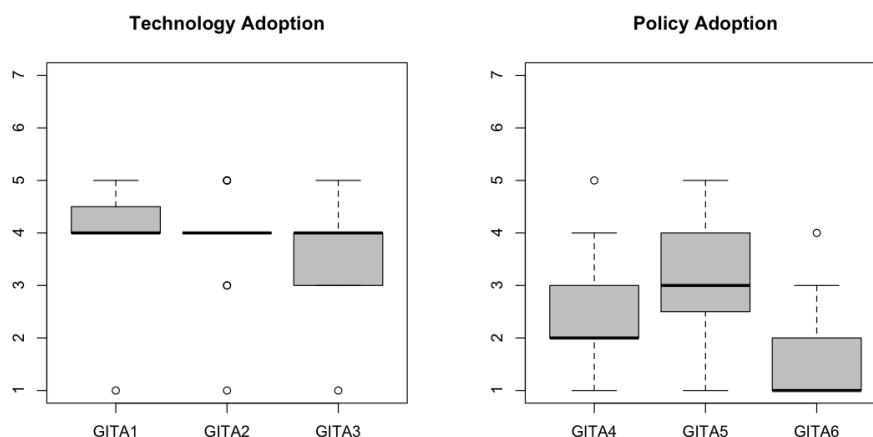


**Figure 9:** Proposed model indicating p-values for hypotheses testing using Fishers exact test

In contrast, the adoption of Green IT in higher education institutions in South Africa is not significantly ( $p > 0.05$ ) affected by the perception of an institution's value network Green IT readiness or by the perception of an institutions institutional Green IT readiness. Nonetheless, results indicate that Green IT Readiness overall affects the adoption of Green IT in higher education institutions in South Africa (Figure 9). Furthermore, the perception of Green IT readiness has a significant ( $p < 0.05$ ) effect on Green IT Drivers. Regardless of the small sample size, the results of the Chi-squared give nearly identical results to the Fishers Exact test, with the exception being that H2 is found to be not significant (Table 2).

#### 4.6 Further model refinement: distinguishing between Technology and Policy Adoption

The box plot for the Adoption constructs indicates that the first three items are fairly similar (GITA1-3) and the last three items are also similar (GITA4-6) (Figure 10). Previous research from which this construct was adopted, defined this split by dividing Adoption of Green IT into two separate entities, namely Green IT Technologies (GITTS) and Green IT Policy and Practice (GITPP) (Molla & Abareshi, 2011).



**Figure 10:** Box plot for Adoption Technology and Adoption Policy constructs.

In order to further explore the anomalies of the box plot (Figure 10), Green IT Adoption was split into two constructs, Green IT Technology Adoption and Green IT Policy Adoption. A Mann-Whitney U-test was run and results indicated that there was a significant difference ( $p < 0.05$ ) between Green IT Policy Adoption and Green IT Technology Adoption (McKnight & Najab, 2010). It is thus suggested that future research adopts a more refined model which separates Green Technology Adoption from Green IT Policy Adoption.

Our sample size is too small to build a definitive final model based on this refinement. The refined model was tested using a stepwise forward and backward selection process of explanatory variables to determine the best fitting model to explain the predicted variable. The best fitting model was chosen based on the lowest Akaike's Information Criterion (AIC) fitted using stepAIC function in R (Bozdogan, 1987).

Using our limited data set, Green Technology adoption was best explained (AIC coefficient = -12.47) using only the drivers, and in particular economic drivers ( $p = 0.05$ ) and regulatory drivers ( $p = 0.01$ ). However, Green Policy adoption was best explained (AIC coefficient = 22.89) using Organisational Green IT readiness ( $p = 0.003$ ) and Institutional Green IT readiness ( $p = 0.02$ ).

## **5. Conclusion, limitations and future research**

The adoption of Green IT in higher education institutions in South Africa has not been investigated to date and results from this study will contribute towards understanding what factors that influence this adoption. This will enable future movements towards implementing Green IT solution in higher education institutions in South Africa, thereby promoting the sustained practice and usage of IT infrastructure and support. As a result of small sample size, the results of this study should be viewed as an explorative study into some of the perceptions of IT staff and managers on the factors driving the adoption of Green IT in higher education institutions in South Africa.

The theoretical framework for this research is based on the GITAM model developed by Molla (2008). An empirical research instrument was developed and tested for reliability. In spite of the small sample size, some very strong correlations between factors were revealed, suggesting that a refinement of the antecedents in the GITAM model is needed (Figure 3). Strong, highly significant positive correlations within Green IT Readiness exist between the constructs Organizational Green IT Readiness, Value Network Green IT Readiness and Institutional Green IT Readiness. The significant positive correlation between Commitment and Resources, between Commitment and Suppliers and between Resources and Suppliers seem to suggest that institutions that are committed to Green IT, may have the necessary resources for Green IT and as well the necessary supplier relationships.

In addition to the strong correlative trends which were found, all but one of the hypotheses put forward were accepted. Results indicated that all constructs of the perception of Green IT Drivers have a statistically significant influence on the adoption of Green IT in higher education institutions in South Africa. The perception of an institution's value network Green IT readiness and the perception of an institutions institutional Green IT readiness did not appear to affect the adoption of Green IT. Therefore, suppliers, investors, competitors and government does not appear to play an important role in influencing the adoption of Green IT within higher education in South Africa. Unfortunately, currently the actual level of Green IT Adoption and Readiness within higher education institutions in South Africa appeared to be fairly low. In the absence of normative pressure, a significant acceleration of Green IT implementation beyond cost-driven rationales may require a legislative or financial incentive.

From our data, Green IT adoption appeared to split into two categories: Technology Adoption and Policy Adoption. Tentative results of model testing on these individual items appeared to have drastically different antecedents indicating that in future studies it may be beneficial to split the measurement of Green IT adoption for future studies.

These findings need to be confirmed through further studies with a larger sample size and possibly with more of a qualitative approach. Additionally, it will be interesting to have an international comparison to see which factors and relationships are dependent on country, regional and developing economy contexts. Hopefully comparisons can also be made with regions where Green IT adoption is higher as different drivers and

pressures may exhibit themselves at different levels of sustainability maturity. These studies would also lead to further empirical validation and possible refinement of the research instrument proposed here.

## References

- Bozdogan, H. (1987). Model selection and Akaike's information criterion (AIC): The general theory and its analytical extensions. *Psychometrika*, 52(3), 345–370.
- Butler, T. (2011) "Compliance with institutional imperatives on environmental sustainability: Building theory on the role of Green IS", *The Journal of Strategic Information Systems*, Vol. 20, No. 1, pp 6–26.
- Butler, T. (2012) *Institutional Change and Green IS: Towards Problem-Driven, Mechanism-Based Explanations*, Springer, New York.
- Chen, A., Boudreau, M.-C. & Watson, R.T. (2008) "Information systems and ecological sustainability", *Journal of Systems and Information Technology*, Vol. 10, No. 3, pp 186–201.
- Cooper, V. & Molla, A. (2010) "Conceptualizing Green IT Organizational Learning (GITOL)", *Green IT Working Paper series*, Vol. 1, No. 3, pp 1–12.
- Cronbach, L.J. (1951) "Coefficient alpha and the internal structure of tests", *Psychometrika*, Vol. 16, No. 3, pp 297–334.
- Gulliksen, H. (1945) "The relation of item difficulty and inter-item correlation to test variance and reliability", *Psychometrika*, Vol. 20, No. 4, pp 79–91.
- Guttman, L. (1945) "A basis for analyzing test-retest reliability", *Psychometrika*, Vol. 10, No. 4, pp 255–282.
- Hanne, F. (2011) "GREEN-IT: Why Developing Countries Should Care?", *International Journal of Computer Science*, Vol. 8, No. 4, pp 424–427.
- Harmon, R. & Auseklis, N. (2009) "Sustainable IT services: Assessing the impact of green computing practices", *PICMET 2009 Proceedings*, pp 1707–1717.
- Ijab, M.T. (2010) "Seeking the "Green" in "Green IS": A Spirit, Practice and Impact Perspective", *Pacific Asian Conference on Information Systems*, Vol. 46, pp 433–443.
- Jenkin, T. a., Webster, J. & McShane, L. (2011) "An agenda for "Green" information technology and systems research", *Information and Organization*, Vol. 21, No. 1, pp 17–40.
- Kadijevich, D. (2003) "Examining Mathematics Attitude", *Trends in International Mathematics and Science Study in*, Vol. 1, No. 1, pp 64–73.
- Kuder, G.F. & Richardson, M.W. (1937) "The theory of the estimation of test reliability", *Psychometrika*, Vol. 2, No. 3, pp 151.
- Lancaster, H. & Seneta, E. (1969) Chi-Square Distribution, *Encyclopedia of biostatistics*.
- McKnight, P., & Najab, J. (2010). Mann-Whitney U Test, *Corsini Encyclopedia of Psychology*.
- Molla, A. et al. (2008) "E-readiness to G-readiness: developing a green information technology readiness framework", *19th Australasian Conference on Information Systems*, pp 669–678.
- Molla, A. (2008) "GITAM : A Model for the Adoption of Green IT", *Australasian Conference on Information Systems*, pp 658–668.
- Molla, A. & Abareshi, A. (2011) "Green IT adoption: A motivational perspective", *Proceedings of the 15th Pacific Asia Conference on Information Systems (PACIS)*, pp 1–14.
- Molla, A. & Cooper, V. (2010) "Green IT Readiness: A Framework and preliminary proof of concept", *Australasian journal of information systems*, Vol. 16, No. 2, pp 5–23.
- Molla, A. & Licker, P.S. (2005) "eCommerce adoption in developing countries: a model and instrument", *Information & Management*, Vol. 42, No. 6, pp 877–899.
- Murugesan, S. (2008) "Harnessing Green IT: Principles and Practices", *IT Professional*, Vol. 10, No. 1, pp 24–33.
- Murugesan, S. & Gangadharan, G. (2012) *Harnessing green IT: Principles and practices*, John Wiley and Sons, Chichester.
- Nazari, G. & Karim, H. (2012) "Green IT adoption: The impact of IT on environment: A case study on Green IT adoption and underlying factors influencing it", *Proceedings of 17th Conference on Electrical Power Distribution Networks (EPDC)*, pp 1–7.
- Paruchuri, V. (2011) "Greener ICT: Feasibility of successful technologies from energy sector", *13th International Conference on Advanced Communication Technology (ICTACT)*, pp 1398–1403.
- Petzer, C., McGibbon, C. & Brown, I. (2011) "Adoption of Green IS in South Africa", *Proceedings of the South African Institute of Computer Scientists and Information Technologists Conference on Knowledge Innovation and Leadership in a Diverse Multidisciplinary Environment SAICSIT*, pp 330.
- Robbins, N. & Heiberger, R. (2011) "Plotting Likert and Other Rating Scales", *Proceedings of the 2011 Joint Statistical Meeting*, pp 1058–1066.
- Routledge, R. (1998) Fisher's exact test, *Encyclopedia of biostatistics*.
- Schmidt, N. & Erek, K. (2010) "Predictors of Green IT Adoption : Implications from an Empirical Investigation", *Americas Conference on Information Systems*, pp 1–11.
- Schmitt, N. (1996) "Uses and abuses of coefficient alpha.", *Psychological assessment*, Vol. 8, No. 4, pp 350–353.
- Sedgwick, P. (2012) "Pearson's correlation coefficient", *British Medical Journal*, Vol. 345.
- Unhelkar, B. (2011) *Handbook of Research on Green ICT: Technology, Business, and Social Perspectives*, IGI Global, Hershey.

## Appendix: Survey Instrument

The following key test items relating to the Green IT model were used in the survey questionnaire (answers on a 7-point Likert scale).

### DRIVERS

How important are the following factors in driving your institution towards implementing Green IT?

<b>ECONOMICAL</b>	ECO1	Cost of server energy consumption
	ECO2	Efficiency of powering the ICT infrastructure
	ECO3	Cost of desktop energy consumption
<b>ETHICAL</b>	ETH1	Your institution's sustainability strategy
	ETH2	Corporate Social Responsibility
	ETH3	Senior management commitment
<b>RESPONSE</b>	RES1	The actions of your institutions competitors
	RES2	Pressure or marketing from ICT vendors
	RES3	Market incentives
	RES4	Pressure from investors (students, stakeholders, organizations, etc.)
<b>REGULATORY</b>	REG1	Government energy efficiency regulations
	REG2	Encouragement from industry associations
	REG3	Greenhouse gas regulations
	REG4	Regulations on discarding e-waste

### READINESS

Please indicate to what extent you agree or disagree with the following statements?

<b>COMMITMENT</b>	COM1	Your institution has a clear vision on Green IT
	COM2	Your institution's vision of Green IT is widely communicated and understood throughout your institution
	COM3	Your institution's Green IT implementations are strategy-led
	COM4	Senior management supports your institution's Green IT initiatives and implementations
<b>AWARENESS</b>	AWA1	Your institution is aware of its competitors' Green IT implementations
	AWA2	Your institution recognizes the benefits enabled by Green IT
	AWA3	Your institution has thought about whether or not Green IT has impacts on the way business is to be conducted in its industry
	AWA4	Your institution has considered whether or not businesses in its industry that fail to adopt Green IT would be at a competitive disadvantage
<b>RESOURCES</b>	REC1	Your institution has sufficient experience with Green IT
	REC2	Your institution has sufficient staff to implement Green IT
	REC3	Your institution has sufficient technical resources for the monitoring of energy costs of IT (PC's, printers, notebooks, etc.)
	REC4	Your institution has sufficient technical resources for measuring the impact of Green IT
	REC5	Your institution has a designated budget for Green IT
<b>SUPPLIERS</b>	SUP1	Your institution's has sufficient support from the local IT industry to support the move to Green IT
	SUP2	Your institution's suppliers have sufficient experience with Green IT
	SUP3	Your institution's suppliers are able to supply the necessary technology in order to assist the move towards Green IT
<b>COMPETITORS</b>	COMP1	Your institution's competitors have sufficient experience with Green IT
	COMP2	Your institution's competitors have implemented Green IT solutions

	COMP3	Your institution's competitors attract investors based on their green credentials
	COMP4	Your institution's competitors have established Green IT policies
<b>INVESTORS</b>	INV1	Students base their decision to enroll in your institution based on its green credentials
	INV2	Your institution's investors choose to invest in your institution based on its green credentials
	INV3	Your employees choose to work for your institution based on your institutions green credentials
<b>GOVERNMENT</b>	GOV1	The government demonstrates strong commitment to promote Green IT
	GOV2	Your institution believes that there are effective laws to enforce Green IT Adoption.
	GOV3	The government encourages Green IT adoption

**ADOPTION**

To what extent has your organization implemented the following?

<b>ADOPTION</b>	GITA1	Server virtualization
	GITA2	Storage virtualization
	GITA3	Storage consolidation
	GITA4	Environment-friendly IT procurement policy
	GITA5	Policy on managing electronic waste
	GITA6	Measuring the environmental impact of IT