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Organizational Motivations for Green IT: Exploring Green IT Matrix and Motivation Models

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ORGANIZATIONAL MOTIVATIONS FOR GREEN IT: DEVELOPING AND EXPLORING A GREEN IT MATRIX AND MOTIVATION MODELS

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Abstract

The environmental impact of information and communications technologies (ICT) might be a two way street. On the one hand, each stage of the ICT lifecycle has a potential to contribute to the damage of the environment. On the other hand, ICT can provide some of the best tools not only in measuring and reporting greenhouse gas emissions, waste and water use within core enterprise and value chain processes but also in reducing them. The application of environmental criteria to ICT is commonly referred to as Green IT. It is attracting IT management's interest but has hardly been researched. This paper aims to explore the extent to which Green IT has penetrated business consciousness. The contributions of the paper reset on offering a snapshot of Green IT diffusion, on proposing and empirically exploring a Green IT Matrix and Motivation classifications and on testing some of the theoretical propositions regarding the influence of institutional forces and organizational motivations in the adoption of Green IT.

Keywords*: Green IT, Green Information System, Eco-Sustainability, Adoption, Motivation*

1 INTRODUCTION

The past decade has seen many businesses realise the long term effects of pollution and taking responsibility for their actions in ways that improve their environmental footprint. Nevertheless, the role of information and communications technology (ICT) in causing and resolving eco-sustainability issues (usually referred to as Green IT) is an under-researched area. In the last two rounds of PACIS conferences, Elliot (2007) and Elliot and Binney (2008) have called on IS researchers and practitioners to take the environmental sustainability of ICTs as an important research agenda. This current paper follows suit and addresses some of the Green IT issues.

Two major but somehow inter-related streams of Green IT thoughts can be identified. On the one hand, each stage of the IT resources lifecycle from manufacturing to usage and disposal can pose environmental damages (Elliot and Binney, 2008).On the other hand though, ICTs can be deployed to tackle the environmental footprint of a business. This role of ICTs can range from enabling a carbon foot print analysis, monitoring and reporting capability through using IT to reduce greenhouse gas emissions, waste and water use within core enterprise and value chain processes (Elliot and Binney, 2008; Chen et al, 2008).

The adoption of Green IT could be different from other IT adoption because of the importance of ethical and eco-sustainability considerations in the decision making process. IT adoption is usually motivated by the potential economic benefits of using a technology. In contrast, Green IT practices might be motivated out of concern for the planet even if economic benefits might not be tangible in the short term. Adoption of Green IT could also be different from other Green-initiative adoption because of Green IT practice's potential role in enabling businesses to achieve their Green targets. Further, as Green IT is an emerging research, it is yet to be established if previous theories that explain IT and non-IT green initiatives adoption can apply to Green IT.

This paper seeks to determine the extent to which Green IT has penetrated business consciousness and unravel the influence of the regulatory, normative and economic drivers and motivating factors. The paper takes an exploratory approach to answer the following questions:

- What are the dimensions of Green IT?
- To what extent have businesses implemented Green IT? Which aspects of Green IT are widely diffused and which are not?
- Which of the institutional and economic factors influence Green IT?
- Are these factors different for different adopter categories?

2 CONCEPTUAL BACKGROUND

The conceptual foundation of this paper is based on previous literature on Green IT (Molla, 2008; Molla et al, 2008; Elliot and Binney, 2008; Elliot, 2007; Chen et al, 2008) and institutional and organizational motivation theories (King et al 1994; DiMaggio and Powell, 1983; Rahim et al 2007).

2.1 ICTs and Sustainability

In the last few decades, the advance of ICT based business and social practices has transformed many, if not most, economies into e-economy and businesses into e-business. For economies, ICTs are increasingly playing critical roles in transforming and generating economic opportunities. On the other hand though, global warming and climate change coalescing with limited availability and rising cost of energy are posing serious challenges to the sustainability of the global digital economy.

Sustainability is "the ability of one or more entities, either individually or collectively, to exist and thrive (either unchanged or in evolved forms) for lengthy timeframes, in such a manner that the existence and flourishing of other collectivities of entities is permitted at related levels and in related systems" (Starik and Rands, 1995:909). It often refers to meeting the needs of present generations without compromising the ability of future generations to meet their needs (Hart, 1997). Environment (alias eco-sustainability/Green) is one of the three pillars of sustainability. The other two are community and economy. Eco-sustainability considerations have been applied to different industries and sectors with the objective of preventing pollution at the end of a product's use; minimizing the environmental footprint during use and using clean technologies to reduce polluting materials and develop environmentally friendly competencies (Hart, 1997). The potential of technology to create sustainable business and society is widely accepted (Olson, 2008; Gonzalez, 2005; Hart, 1997). It is in this wider context of the technology–sustainability linkage that the issue of Green IT has emerged as one of the top issues of concern.

2.2 The Domain Construct of Green IT

Green IT is neither a well defined concept nor a uniformly accepted set of practice. In the practitioner literature, Green IT has mostly been associated with technologies and initiatives to reduce the power, cooling and real estate costs associated with ICT operations (Accenture, 2008; Rasmussen, 2006). This aspect of Green IT is not new. The ICT industry has been undertaking initiatives to improve the energy performance of technologies for several decades. Elliot (2007) on the other hand defined Green IT as *"the design, production, operation, and disposal of ICT and ICT-enabled products and services in a manner that is not harmful and may be positively beneficial to the environment during the course of its whole-of-life"*. This definition covers the two major issues identified at the beginning of the paper- ICT as a problem and ICT as a solution. In addition, it recognizes the importance of a lifecycle approach in the Green IT consideration. However, it is not specific enough in terms of the "ICT" and the positive environmental benefits associated with Greening ICT.

In conceptualizing the domain construct of Green IT, we sought to promote a wider understanding of Green IT-one that captures the two themes (problem and solutions) of Green IT; one that covers the IT lifecycle; and one that includes not only the hard technologies but also the soft business policies and practices. From an eco-sustainability perspective, Green IT can be defined as the systematic application of environmental considerations (that is pollution prevention, product stewardship and use of clean technologies) to IT. However, the concept of IT is very broad and needs unbundling. Previous IT research distinguishes between the IT technical infrastructure and the IT human and managerial capability infrastructure. The IT technical infrastructure refers to "choices pertaining to applications, data and technology configurations" (Broadbent and Weill, 1997). The human infrastructure pertains to "the experiences, competencies, commitments, values and norms of the IT personnel delivering the IT products and services" (Byrd and Turner, 2000). The managerial capability comprises the management of all IT activities including strategic foresight concerning changes in the business, IT and wider environment.

The combination of the IT infrastructure (Byrd and Turner, 200o; Broadbent and Weill, 1997) and eco-sustainability (Hart 1997) perspectives together with Elliot's (2007) notion of IT lifecycle can lead to the following definition of Green IT:

> *Green IT is an organization's ability to systematically apply environmental sustainability criteria (such as pollution prevention, product stewardship, use of clean technologies) to the design, production, sourcing, use and disposal of the IT technical infrastructure as well as within the human and managerial components of the IT infrastructure.*

On the basis of this definition, the domain construct of Green IT can cover two dimensions. On the one hand, it reflects the amount to which a company factors in environmental considerations in IT from sourcing through operations to end-of-life. This dimension of Green IT will be referred here as *"Green IT Reach"*. On the other hand the maturity of environmental considerations, whether they're part of a coherent set of policies, they've been adopted into operational routines practices, or been built into concrete information systems and technologies represent another dimension. This second dimension can be called *"Green IT Richness.* The combination of *Green IT Reach and Richness* can yield into a matrix as depicted in Table 1.

		Green IT Rich Dimension – PPT		
		Policies	Practices	Technologies and systems
Green IT Reach Dimensions : SOE	Sourcing	The extent to which an organization has adopted an environmentally preferable IT purchasing policy and articulated clear Green guidelines for buying IT equipment and services.	The practice of analysing the Green track record of software and IT services providers, incorporating Green considerations in vendor evaluation and IT procurement decisions	Information systems that track, monitor and analyse the carbon footprint of suppliers such as supplier sustainability assessment tools.
	Operations	Encompasses the extent to which the services provided by the IT infrastructure support issues encapsulated in business sustainability. Some of the policy considerations include PC power management; policy on staff computer usage and Green data centres	Green IT operation practices refer to eco-considerations in operating the IT and network critical physical infrastructure in data centres and beyond and operational actions designed to improve the energy performance of corporate IT assets	New technologies and systems for (a) reducing the energy consumption of powering and cooling corporate IT assets (such as data centres) (b) optimizing the energy efficiency of IT assets (c) reducing IT induced greenhouse gas emissions (d) supplanting carbon emitting business practices and (e). Analysing a businesses total environmental footprint.
	End of IT life management	End of IT life management policy	Reuse (extend life), refurbish, recycle or dispose IT hardware	Information systems that track the life-cycle of corporate IT assets and analyse the cost-benefit of different disposal methods.

Table 1. The Green IT Reach-Richness Matrix

2.3 Organizational Motivation for Green IT

Motivational and institutional forces might influence the progress of an organization's Green IT adoption and will be discussed in this section. King et al (1994) identify two forms of institutional interventions (influence versus regulation) and two innovation drivers (demand pull versus supply push). Influence initiatives can change the behaviour of those under the institution's way. This can be achieved either without direct use of force; with the exercise of command or by providing resources. On the other hand, regulatory actions have the purpose of directly and at times indirectly affecting the behaviour of entities under their jurisdiction. This can be done through directives or actions that limit options and modify behaviours. Either way, influence and regulation can result in different but related outcomes depending on whether supply-push (production of innovative product or process) or demand-pull (willingness to use the product) forces drive the innovation (King et al, 1994).

Institutional forces can influence and/or regulate the behaviour of firms through mimetic, coercive and normative pressures (DiMaggio and Powell, 1983). In the context of ecological sustainability, Chen et al (2008) identified three eco-motivations- as *eco-efficiency, eco-equity and eco-effectiveness*. Eco-efficiency refers to a business's ability to deliver "competitively priced goods and services…while progressively reducing ecological impacts" (DeSimone and Popoff, in Chen et al, 2008: 190). Eco-equity focuses on "equal right of people to environmental resources" and a business's "social responsibility for the future generations" (Ibid: 192). Eco-effectiveness on the other hand, "aims to stop contamination and depletion…by directing individual and organizational attention to the underlying and fundamental factors of environmental problems …through a fundamental redesign of the system" (Ibid: 195).

On the basis of the above argument and depending on the prevailing balance of demand pull vs. supply push, organizational motivations for Greening IT can include an economic expectation of enhancing efficiency, a regulatory response of ensuring compliance and a normative objective of attaining legitimacy (Rahim et al ,2007; King et al 1994, DiMaggio and Powell, 1983).

3 RESEARCH METHOD

The research reported in this paper is part of an international study on the adoption of Green IT. The Data for this paper is based on the 109 respondents from Australia (95) and New Zealand (14). The survey instrument was prepared by considering the exploratory nature of the study and following Hair et al' (2006) guidelines on instrument development. It involved four steps which are briefly discussed next.

3.1 Step 1: Specify the Domain Constructs

The research deals with two major constructs- organisational motivation and Green IT adoption. The Green IT Matrix (Table 1) provides the domain constructs of Green IT. The organizational motivation construct is discussed below.

Efficiency Motive: Energy costs make a significant proportion of the total cost of running IT assets and infrastructure (Rasmussen, 2006). Reducing costs and improving the energy efficiency of corporate IT assets and infrastructure are most IT managers' top priorities. Accenture (2008) estimates that US's data centres and servers consume 1.5% of US's total electricity consumption and cost over USD 4.5 billion annually. In Australia, the ANZ Bank's initiative to ban screensavers has provided an estimated savings of approximately 4% reduction in its annual electricity bill. In cost terms, this translates to AU$500,000 per year (Milburn and Howarth, 2007). Efficiency motive can lead to practices in operating corporate IT assets in an energy efficient manner and the adoption of Green IT initiatives that yield cost reduction.

Regulatory Compliance Motive: Regulatory requirements and legislative actions are likely to force some businesses to accept a technology or practice even if they do not have a strong intention to do so (Olson, 2008; Gonzalez, 2005). For example, the Australian government, after ratifying the Kyoto Protocol late in 2007, has moved to draft new legislation to mandate standardised carbon reporting. From 1 July 2008, as per the National Greenhouse and Energy Reporting Act (NGERA), organizations that emit more than 125 kilo tonnes of greenhouse gas annually are expected to report their carbon emissions according to the NGERA standardised framework. Such regulatory requirements might force many businesses to engage in Green IT projects that ensure compliance. The prevalence of regulations can lead to the adoption of at least minimalist Green IT initiatives.

Legitimacy Motive: The pursuit of legitimacy within the wider social context is one of the motivating factors affecting organizational behaviour (DiMaggio and Powell, 1983). The emphasis is on actions that are induced because of the need to meet certain demands. Consumers are increasingly active in seeking information regarding the sustainability policies of businesses. Green labelling is now common, and a range of indicators such as the Good Reputation Index, The Green Ranking and Energy Smart labels make it easier for consumers to pick those companies which have genuine and demonstrable Green credentials. Organizations' response to greening IT can therefore be motivated by the need to achieve legitimacy within the wider environment.

3.2 Step 2: Generate Items

To capture the organizational motivation for Green IT, 13 items were generated. Green IT adoption is operationalized in view of the Green IT Reach and Richness matrix with a total of six policy, 17 practice and 20 technology related questions. Examples of these items are described in Molla (2008) and Molla et al (2008). After an initial pool of items was identified, a team of five researchers reviewed and edited the instrument for face validity.

3.3 Step 3 Data Collection

In addition to the two main constructs, data were collected about the profile of respondents and their organization such as size, industry classification, and scale of IT operations (such as installed server base, and number of personal computers). Except questions related to the demographic characteristics of sampled firms, all the items were measured using a seven point Likert type scale with only the extreme points anchored with labels. The adoption of Green IT were measured using a "not-at all (1)" to "great extent (7)" seven point scale. While policy related items were measured on the scale of "not at all developed (1)" to "fully developed (7)", motivation factors were measured using a 'strongly disagree (1)" to "strongly agree (7)".

The sampling frame was defined as organizations with more than 100 employees excluding those in the agriculture and mining sectors. Chief Information Officers or their equivalents were selected as respondents. The sampling criteria were then passed to IncNet Australia, a business database provider that provides names and e-mail addresses of IT managers. IncNet returned an initial list of 1305 contacts from Australia and 215 from New Zealand. Upon inspection of the data set, 354 of the Australian and 13 of the New Zealand contacts were outside the sample frame (mostly non-CIO contact and in some cases from industries excluded form the sample frame) and were therefore excluded. Invitation to participate in the survey was e-mailed together with the Web address of the questionnaire to 1153 CIOs in Australia and New Zealand. After two rounds of reminders a total of 109 responses were received. Quite a large number of respondents (12%) choose to be removed from the survey and a significant number (23%) of the addresses failed to deliver giving an effective overall response rate of 16%. Although the response can not be considered as representative, it offers preliminary insight.

4 ANALYSIS AND RESULTS

The data are analysed using descriptive and exploratory (such as principal component and cluster analysis) statistics. In the analysis below, a "7", unless indicated otherwise represents a most positive/favourable value whereas a "1" indicates a least positive/favourable response. Most of the respondents (80%) who completed the questionnaire were Chief Information Officers or IT (systems, infrastructure, information) Managers. Others held job titles such as Enterprise Architect, Software Development Manager, Office Manager, IT Coordinator, Directory of Sustainability and IT Group Leader. While 72% classify their organizational size as medium, 20% are large. Most respondents are from manufacturing (22%) and government (19%) sectors. The rest are distributed across education (9%), finance and insurance (7%), and ICT (7%). An equal six percent come from health and wholesaling sectors. Utility, transport and construction companies each represent 4%. Participating firms differ greatly in terms of their IT profile. One medium sized Manufacturing company has only one server, 13 personal computers, and annual IT spend less than AUD 10,000. However, a large Finance and Insurance firm has 1000 servers, 40,000 personal computers and spends about an AUD billion annually on IT operational budget. Overall it appears that the firms in the sample represent medium size both in terms of their business and IT operations.

4.1 Principal Component Analysis

Principal component analysis was used in order to identify underlying constructs and condense the items used to assess Green IT adoption and the motivations for doing so. The objective is to identify latent dimensions and summarize and reduce (for use in cluster analysis) the data (Hair et al, 2006). The factors were extracted using the principal component extraction technique. Using the Green IT richness dimension and the motivation theory as conceptual foundations, the items were put into the component analysis in four separate models. All the four models satisfy the minimum required sample size to item (observation) ratio of 5:1 (Hair et al, 2006:112). To facilitate interpretability, varimax rotation was followed.

The principal component analysis for organizational motivation produced four motivation dimensions explaining 70% of the variance. Taking the locus of motivation (internal vs. external) and the focus of the motivation (economic vs. regulatory/normative), the four factors can be mapped into a Green IT Motivation Grid (Figure 1). Further, based on Chen et al (2008), and Rahim et al (2007) the four factors are labelled as *eco-effectiveness, eco-responsiveness, eco-legitimacy and eco-efficiency*.

		Locus of motivation	
		Internal	*External*
Focus of Motivation	*Economic*	Eco-efficiency	Eco-responsive
	Regulatory/ Normative	Eco-effectiveness	Eco-legitimacy

Figure 1. The Green IT Motivation Grid

Cronbach's alpha was calculated to assess the reliability of the measures. The scores are well above the 0.5-0.6 threshold acceptable for early stage research (Hair et al, 20006). Table 2 presents the factor structure of the Green IT motivation construct.

Variable	Items	ID	Factor Loading	Inter-Item Correltaion	Cronbach Alpha	Mean	Stad Dev
Eco-effectiveness	Own corporate strategy	Q9F	0.77	0.71	0.85	5.12	1.24
	Environmental considerations	Q9G	0.93	0.78			
	Social acceptance as concerned entities of global and local communities	Q9J	0.74	0.68			
Eco-responsiveness	Competitor's actions	Q9C	0.73	0.64	0.77	3.39	1.29
	Pressure from IT vendors	Q9D	0.63	0.58			
	Clients'/consumers' pressure	Q9E	0.71	0.60			
Eco-legitimacy	Government incentives	Q9K	0.55	0.47	0.75	4.07	1.27
	Green IT uptake by more and more organisations	Q9L	0.67	0.66			
	Industry associations	Q9M	0.70	0.63			
Eco-efficiency	The cost of greening IT	Q9H	0.63	0.52	0.67	5.07	1.08
	IT cost reduction considerations	Q9I	0.77	0.5			

Table 2. Factor Structure of Motivations for Green IT

The principal component analysis for Green IT produced one Green IT Policy (GITP) factor composed of 7 items. The Green IT practice model returned four factors containing 15 items. The first component reflects the application of environmental consideration in IT sourcing decisions and is labelled as Green IT sourcing practice (GITSP). The second component refers to operational practices in reducing the energy consumption of the IT technical infrastructure and is labelled as Green IT energy efficiency practice (GITEFP). The third component captures the use of IT in monitoring energy consumption and environmental footprint and is labelled as Green IT measuring and monitoring practice (GITMMP). The fourth factor is about recycling and disposal and is labelled as Green IT end-of-IT-life practice (GITEOLP). The technology component model returned two factors with 17 items. The first factor contains technologies that reduce power consumptions in lighting, power delivery and cooling of data centres and is labelled as Green IT network critical physical infrastructure (GITNCPI). The second component consists of technologies that improve the environmental value of servers, storage and network devices and is labelled as Green IT technical infrastructure (GITI). All four models were valid because each model explain more than 60% of the variance and there was no single factor that account for more than 50% of the variance in a given model (Hair et al ,2006). The final factor structure of the Green IT construct is depicted in Table 3.

Variable	Items	Factor Loading	Inter Item correlation	Cronbach Alpha	Mean	Std.Dev.
GITP	Policy on the use of IT to reduce the business's carbon footprint	0.90	0.84	0.93	3.53	1.46
(Green IT Policy)	Green information technology policy	0.89	0.84			
	Environmentally friendly IT purchasing policy	0.88	0.83			
	Green data centres policy	0.88	0.82			
	Policy on employees use of IT in an energy efficient manner	0.87	0.81			
	End of IT life management	0.77	0.69			
GITSP	Preference of IT suppliers that have a green track record	0.83	0.83	0.85	3.88	1.58
(Green IT	Gives weight to environmental considerations in IT procurement	0.82	0.81			
Sourcing Practice)	Prefers hardware vendors that offer "take-back" options	0.77	0.62			
GITEFP	Operates existing IT systems in an energy efficient manner	0.83	0.73	0.79	4.20	1.24
(Green IT Energy	Switches off data centre lights and equipment when not needed	0.81	0.60			
Efficiency Practice)	Enforces PC power management	0.66	0.56			
	Uses electricity supplied by green energy providers	0.53	0.52			
GITMMP	Implements IT projects to monitor the enterprise's carbon footprint	0.79	0.65	0.84	2.89	1.28
(Green IT Monitoring	Analyses IT's energy bill separately from the overall corporate bill	0.78	0.70			
Practice)	Engages the service of a professional service provider on Green IT	0.69	0.63			
	Shorten IT refresh periods to access energy efficient equipment	0.61	0.58			
	Audits the power efficiency of existing IT systems and technologies	0.57	0.67			
GITEOLP	Disposes of IT in an environmentally friendly manner	0.79	0.57	0.73	5.14	1.27
(Green IT End of	Prints double-sided on paper	0.74	0.51			
Life Practice)	Recycles IT consumable equipment	0.64	0.57			
GITNCPI	Airside/waterside economizer	0.86	0.82	0.93	2.84	1.33
(Green IT Network	Liquid cooling for IT equipment	0.82	0.78			
Critical Physical	Hot aisle/cool aisle data centre layout	0.77	0.69			
Infrastructure)	Water cooled chillers with variable speed fans and pumps	0.77	0.71			
	High efficiency stand-by power systems	0.75	0.73			
	Free cooling in large scale data centres	0.73	0.75			
	Upgrades to more efficient transformers and UPS	0.72	0.70			
	DC powered IT equipment	0.69	0.66			
	Data centre airflow management	0.67	0.69			
	High voltage AC power	0.65	0.65			
	Install more energy efficient lights	0.56	0.58			
GITI	Storage virtualisation	0.83	0.73	0.86	4.00	1.34
(Green IT Technical	Server consolidation and virtualisation	0.79	0.64			
Infrastructure)	Rightsizing IT equipment	0.69	0.64			
	Storage tiering	0.69	0.71			
	Data de-duplication	0.64	0.68			
	Desktop virtualisation	0.56	0.48			

Table 3. Green IT Adoption Factor Structure

4.2 Correlation Analysis

There is significant and positive correlation among the Green IT variables (Table 4). The magnitude is stronger between Green IT policies and the other Green IT dimensions. The correlation among the motivation dimensions is not very strong excepting between eco-legitimacy and eco-response. There is significant correlation between eco-effectiveness and many of the Green IT variables. In particular, the association is strong association between the adoption of Green IT policy (GITP), end of life practice and a business's motivation to do the "right" thing.

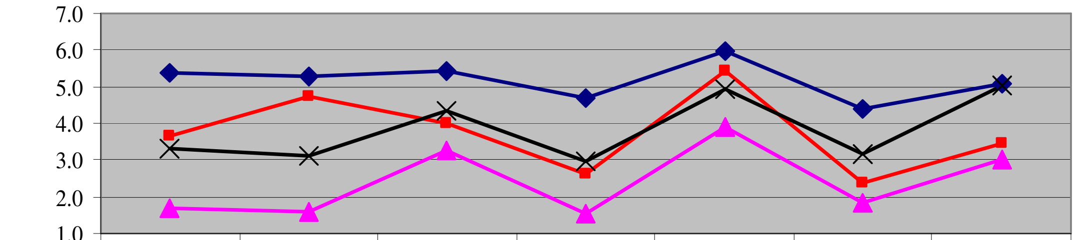
	GITP	GITSP	GITEFP	GITMMP	GITEOLP	GITNCPI	GITI	Eco-Efficiency	Eco-Effectiveness	Eco-Responsive	Eco-Legitimacy
GITP	1										
GITSP	**0.72	*1.00*									
GITEFP	*0.46*	*0.43*	*1.00*								
GITMMP	*0.73*	*0.55*	*0.53*	*1.00*							
GITEOLP	*0.52*	*0.57*	*0.52*	*0.37*	*1.00*						
GITNCPI	*0.62*	*0.41*	*0.49*	*0.71*	*0.29*	*1.00*					
GITI	*0.45*	*0.27*	*0.46*	*0.61*	*0.23*	*0.52*	*1.00*				
Eco-Efficiency	0.01	0.01	0.15	0.03	0.07	0.21	0.07	1.00			
Eco-Effectiveness	*0.53*	*0.55*	*0.32*	*0.38*	*0.55*	*0.28*	*0.30*	0.03	1.00		
Eco-Responsive	0.08	0.08	-0.02	***0.20***	0.03	0.15	0.08	0.17	*0.26*	1.00	
Eco-Legitimacy	0.18	***0.22***	***0.19***	0.11	0.17	***0.20***	0.13	*0.27*	*0.31*	*0.54*	1.00

** (*Italic fon* t). Correlation is significant at the 0.01 level (2-tailed).
* (**Bold italic Fon**t). Correlation is significant at the 0.05 level (2-tailed).

Table 4. Correlation Matrix

4.3 Cluster Analysis

In order to explore different adopter categories and answer one of the research questions, the variables identified from the principal component analysis are standardized and further analyzed using K-means cluster analysis. Cluster analysis helps to organize data into meaningful structures, classify it into homogenous groups and develop taxonomies (Hair et al, 2006). Two clustering variables (Green IT motivation and adoption) identified through the prinicpal component analysis were tested using two, three, four, five and six cluster solutions. The Green IT adoption variables and the four cluster solution produced a better classificatiosn of the cases. The Euclidean distances range from 7 to 2 and indicate that the claissfication is good and the groups are distinct from each other. The four clusters are plotted in Figure 2.



	GITP	GITSP	GITEFP	GITMMP	GITEOLP	GITNCPI	GITI
Cluster1	5.4	5.3	5.4	4.7	6.0	4.4	5.1
Cluster 2	3.6	4.7	4.0	2.6	5.4	2.4	3.4
Cluster 3	1.7	1.6	3.3	1.5	3.9	1.8	3.0
Cluster 4	3.3	3.1	4.3	3.0	5.0	3.2	5.0

Figure 2. Green IT Adopters Cluster Plot

5 DISCUSSION

This paper was set out to address four main research questions. This section discusses the findings of the research under each of the questions.

Although “Green IT” is becoming more common in discussion, there is still little common understanding of the domain constructs of Green IT. Using theoretical insights from the sustainability and IT infrastructure literature, a comprehensive conceptualization of Green IT has been proposed. Further, nine possible classifications of Green IT has been identified. The principal component analysis which has produced seven factors provides a preliminary empirical support to the classifications of Green IT and the Green IT Reach-Richness matrix.

5.1 Green IT Adoption and Diffusion

The current diffusion of Green IT among Australian and New Zealand organizations (Table 3 and Figure 1) indicates that disposal of IT in an environmentally friendly manner is the most relevant organizational concern about Green IT. It is therefore not surprising that there is significantly more attention paid to the end-of-IT-life management practice aspect of Green IT. On the other hand, technologies that can structurally reduce the power consumption of the network critical site infrastructure are not widely adopted.

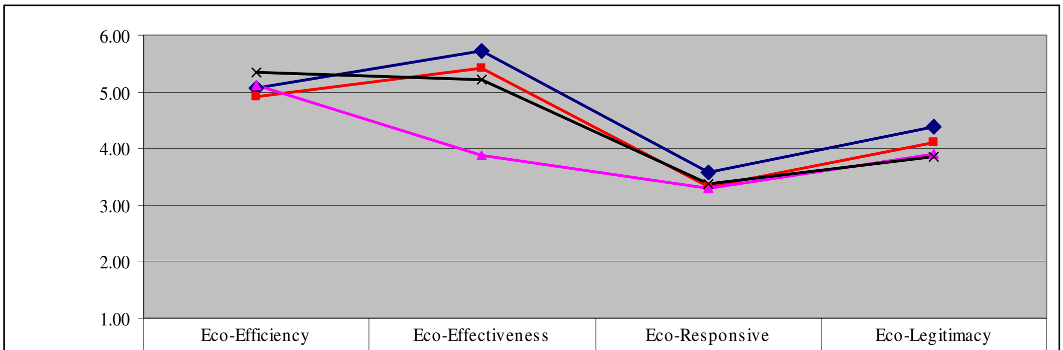
A number of actions to improve IT’s energy consumption are getting practiced both in and beyond data centres. In data centre practices, 87% switch off lights and equipment when not needed. Beyond data centres, the most common of all Green IT practices is to operate existing IT systems in an energy efficient manner (mean= 4.4; 19% great extent and 70% to some extent). However, as 54% of respondents (60% Australian, 50% New Zealand) do not know how much IT is contributing towards their organization's electricity bill, actual energy cost savings might not be known in most cases.

In terms of GITI, server consolidation and virtualisation (mean=5.1) is the most widely adopted technology. 64% and 47% of New Zealand and Australian organisations respectively have virtualised and consolidated their servers to a great extent. Other data centre focused technologies such as rightsizing IT equipment, storage tiering, storage virtualisation and data de-duplication are also getting increasing acceptance with more than 70% of respondents having implemented these technologies to some extent. End user focused technologies such as desktop virtualisation and print optimisation are not as widely diffused as data centre focused technologies. There is very low level of implementation of state of the art NCPI technologies.

Some organisations are adopting environmental considerations in IT procurement and IT vendor evaluation decisions. Thus, green IT sourcing practices are getting acceptance. The extent of development of Green IT policies among the respondents indicates that, overall, Green IT policies are at an embryonic stage. The relatively matured policy item is e-waste management (mean 4.16). On the other hand, the least matured policy frameworks are use of IT to reduce a business's carbon footprint and Green IT itself, however defined (mean 3.09). More than forty percent of respondents do not have a policy framework earmarked as "Green IT" (mean=3.092). Such a policy framework is well developed only in 7% of the cases and somewhat developed among the remaining. Further, the use of IT to measure and monitor power utilisation and greenhouse emission is very limited.

5.2 Adopter Categories and Motivations

Based on the level of Green IT adoption, four clusters were identified. The groups vary in terms of the reach and richness of Green IT. Cluster 1 (n=23) contains respondents which have showed relatively highest level of Green IT adoption. Cluster 2 (n=42) represents respondents who demonstrate niche practice in the areas of Green IT sourcing and end of IT life management. Cluster 3 (n= 23) is comprised of respondents with relatively low level of adoption. The last group (n=21) on the other hand contains respondents in the middle of the pack. The four clusters may be represented as *Green IT Leaders, Green IT Niche Seekers, Green IT Starters* and *Green IT Experimenters respectively.* The prevalence and pervasiveness of the Green IT motivation among the four clusters show some variation as depicted in Figure 3.



	Eco-Efficiency	Eco-Effectiveness	Eco-Responsive	Eco-Legitimacy
Cluster 1	5.07	5.72	3.58	4.39
Cluster 2	4.92	5.42	3.33	4.10
Cluster 3	5.11	3.88	3.30	3.91
Cluster 4	5.33	5.21	3.38	3.84

Figure 4. Motivations for Green IT

Of the four Green IT motivation factors, eco-efficiency and eco-effectiveness appear to be most relevant in organization's decision to Green IT. However, as there is no significant correlation between eco-efficiency and the seven Green IT variables, the effect of eco-efficiency has yet to emerge. The majority of respondents indicate that the main motivations for Greening IT are business strategies that emphasize not only environmental consideration but also cost savings whilst pursuing corporate responsibility as concerned entities of global and local communities for Greening IT. Market forces such as competitors', IT vendors' and client's pressure have not so far emerged as motivating Green IT uptake. Most of the existing Green regulations and legislations are non-binding. As a result, a significant number do not yet see government regulations or incentives as driving their Green IT strategy. Table 5 provides some of the salient features of the four clusters. While all respondents agree about the inhibitor of Green IT, they differ in what motivate Green IT. In addition, most seem to operate from the notion of IT as one of the causes of environmental damages.

	Cluster 1: *Green IT Leaders*	Cluster 2:*Green IT Niche Seekers*	Cluster 3: *Green IT Starters*	Cluster 4: *Green IT Experimenters*
Green IT Matrix position	High reach and richness	High Richness	Low reach and richness	High Reach
Motivation	Highest eco-effectiveness; high eco-efficiency; some eco-legitimacy and low eco-response	High eco-effectiveness and efficiency, some eco-legitimacy and low responsiveness	High eco-efficiency; some eco-effectiveness, low legitimacy and response	High eco-effectiveness and efficiency, some eco-legitimacy and low responsiveness
Sample	65% of Australian and 35% of New Zealand	88% Australian	89% Australian	100% Australian
The most relevant aspect of Green IT	Purchase more environmentally friendly IT and discard IT in eco-friendly way (91%)	Discarding IT in an environmental friendly way (75%)	Discarding IT in an environmental friendly way (34%)	Discarding IT in an environmental friendly way (70%)
The most important Green IT driver	Environmental consideration (100%)	Own corporate strategy (91%)	Government Incentive (73%)	IT cost reduction consideration (90%)
Major Green IT inhibitor	Cost of Green IT solutions (65%)	The cost of Green IT solutions (64%)	The cost of Green IT solutions (64%)	The cost of Green IT solutions (90%)
IT scale	39% have more than 150 servers; 48% have more than 1000 PCs	58% < 49 servers; 52% < 200 PC	78% less than 49 servers; 78% less than 500 PC	57% <50 servers; >150; 66< 500 PC
Profile	39% large and 42 manufacturing and government sectors	78% medium ; 29% government	73% medium and 9% small; 39% manufacturing	90% medium; 14% finance and insurance and 14% manufacturing

Table 5. Salient Features of Clusters

6 SUMMARY AND CONCLUSION

This study proposed and empirically derived a Green IT-Reach-Richness Matrix to classify Green IT strategies and initiatives. The Green IT matrix would allow assessing both the breadth and depth of Green IT adoption. Whereas high Green IT Reach can be associated with the adoption of Green IT covering the sourcing, operation and end-of-life IT management, low Green IT Reach can be associated with initiatives that focus on one dimension of the life cycle only. Firms' response to environmental sustainability varies. While some might just have environmental policies for public consumption, others Green-wash their strategies through recycling practices. Still others might approach Greening IT through either selective or comprehensive strategy. *Green IT Richness* therefore refers to the extent of maturity of Green IT polices, practices and technologies. The four adopter categories derived in this study can indicate different strategic trajectories in Greening IT as depicted in Figure 5. In terms of current diffusion of Green IT, overall, the adoption pattern can be characterized by low Reach.

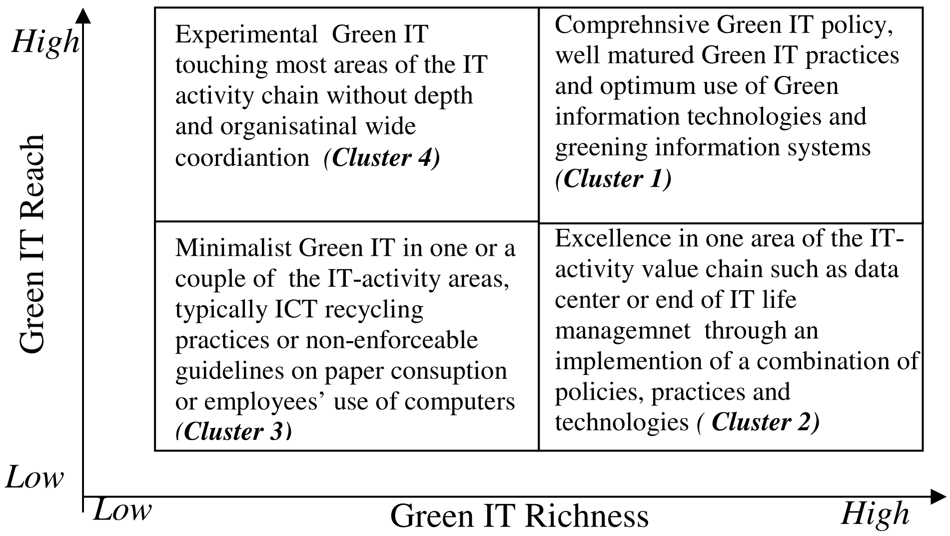


Figure 5: Strategic Options in Green IT

The study also identified a Green IT Motivation Grid. *C*urrent drivers of Green IT are internally located and are focused on environmental considerations that help a business to brand itself as a concerned entity of global and local communities. Olson (2008) argues that Green initiatives take longer period to break-even. He further postulates that rather than hard dollar gains, softer benefits such as employee morale and good corporate citizenship motivate adoption. Further, Gonzalez's (2005) study of the adoption of environmental technologies identified better corporate image and the pressure of regulation as the main reasons for adoption. Somewhat contrary to these previous studies, our findings appear to suggest that current drivers of Green IT adoption have more to do with eco-efficiency and effectiveness and less with regulatory compliance. This perhaps explains why server virtualisation and consolidation tops the list of current adoption of Green IT technologies. In this sense, previous theories of technology adoption that emphasize the relative advantage of a technology might explain Green IT adoption. This implies that as corporate IT budget continues to shrink, IT managers may turn to Green IT only if Green solutions are affordable and yield tangible savings.

Businesses' use of Green strategies can set the Green norms of competition and motivate others to follow suit (Porter and Kramer, 2006). A number of vendors are marketing their products as Green solutions. Indeed, IT vendors have been at the forefront of setting the Green IT agenda. Previous studies of innovation adoption (Damanpour and Schneider 2006) also recognise the influence of market forces in facilitating adoption either through the effects of network externalities or through creating a critical mass of users. Our finding does not appear to support these theses as eco-responsiveness does not appear to have any significant influence on Green IT uptake. From previous innovation literature (Swanson, 1994), the factors that facilitate innovation in its early phase could be the reverse of those facilitating later phases. As Green IT can be considered at the early stage of development, it remains to be seen if economic concerns continue to dominate as the primary reasons for Greening IT or if other (such as regulatory) considerations start to play in. Most of the existing Green regulations and legislations are non-binding but this might change in the future.

Finally, the study has a number of limitations due to both small response rate and its exploratory nature. Therefore, the findings can only be considered at best preliminary and require further data before any generalisation can be attempted. The specific characteristics of a business such as sector, size and corporate citizenship might have some influence on Green IT adoption. The data limitations did not allow us to fully test the effect of these variables. There is also a need to empirically test the content and construct validity of the dimensions of Green IT Motivation Grid, Green IT Richness-Reach Matrix and Green IT Adopter categories. For example, for a stable principal component analysis, an item to response ratio of 1:10 is ideal. The current study satisfies only the minimum 1:5 ratio. Future studies shall also develop and test either an antecedent or causal model of Green IT adoption. This paper has provided a foundation upon which other studies might build their framework.

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