ABSORPTIVE CAPACITY AND CONTEXTUAL FACTORS THAT INFLUENCE GREEN IT ASSIMILATION

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ABSTRACT

The first wave of research in Green IT has often focused on organisational adoption. As Green IT matures in organisations it is important to look beyond adoption and to investigate the assimilation of Green IT. To this end we draw from and compare two theories – contextual theory and absorptive capacity – and investigate which of the two theories better explains the level of Green IT assimilation in organisations. Results from an international survey of 148 large organisations show that both theories explain Green IT assimilation with a medium effect size and that while contextual theory has a slightly higher R2 value than absorptive capacity, the difference is not statistically significant. We then propose a parsimonious and integrated model of Green IT assimilation drawing on contextual and absorptive capacity theories and outline implications for practitioners. The integrated model is parsimonious and has a higher explanatory power implying that a combination of contextual and absorptive capacity factors influences why and how widely and deeply Green IT practices, technologies and values are embedded in the IT people, in the IT management and IT infrastructure of organisations.

Keywords: Green IT, IT Assimilation, Absorptive Capacity, Contextual Theory, Organisation Technology Environment Context.

INTRODUCTION

The worldwide use of information technology (IT) consumes vast amounts of electricity which led Gartner in its 2007-2010 technology analyses to feature Green IT, narrowly defined as data centre energy efficiency, as one of the top 10 strategic technologies. In Gartner's analysis, a strategic technology has "high potential for disruption to IT or the business and requires a major dollar investment" to avoid the risk of late adoption. Over the last few years, in addition to the increasing energy intensity, there is increased awareness about the environmental foot print of IT. The manufacturing of IT requires rare and toxic resources and raises environmental and ethical issues throughout the supply chain, while the electricity used to power IT is related to emissions, and the disposal of IT equipment generates e-waste that can have negative impacts on the natural environment (Murugesan 2008). As a result the conception and practice of Green IT has moved from the narrow focus on data centre energy efficiency to cover strategies, practices and technologies that improve the environmental footprint of the production, use and disposal of IT such as computers, servers, and associated subsystems (Dedrick 2010). Green IT also includes the beliefs, responsibilities and actions (both individually as well as within the organisational context) of IT professionals to prevent pollution, improve product stewardship and contribute to sustainable development (Molla et al. 2014).

A number of previous studies have contributed to the understanding and practice of Green IT, however defined. The energy informatics framework proposes research regarding sensor networks, flow networks, information systems and sensitised objects to reduce society's energy consumption (Watson et al. 2010). The carbon productivity framework addresses the role of IT in increasing carbon productivity (Dedrick 2010). The Belief–Action–Outcome framework offers questions to guide research on Green IT belief formation, action and outcome (Melville 2010). IT-enabled business transformation was developed to address key issues and questions about the role of IT in environmental sustainability (Elliot 2011). The multi-level framework for environmentally sustainable IT provides several theoretical propositions and suggestions for future research in the area of Green IT including environmental sustainability motivating forces, environmental sustainability initiatives, environmental orientation and environmental impacts (Jenkin et al. 2011). All are important to guide practice, inform policy, disseminate good practices and build a cumulative body of knowledge that is beginning to make an impact. For the IS discipline, continued Green IT research demonstrates IS scholarship and scholars' engagement with and contribution to the development of environmentally sustainable social and business practices. Our overall intention in this paper is therefore to build on and contribute to the Green IT body of knowledge by addressing three issues.

First, a number of the Green IT studies (Chen et al. 2010; Gholami et al. 2013; Mishra et al. 2014) focus on Green IT adoption. These studies explain either theoretically or empirically, or both, the variations in adoption and the relationships between adoption and use and other technological, organisational, environmental and institutional antecedent factors. The adoption of a new technology implies the initial success and tells little if that technology has moved beyond the initial trial and becomes embedded into the routines of organisations, that is, the extent to which it is assimilated. Technology assimilation as opposed to adoption refers to the acquisition, full utilisation, and institutionalisation of a technology (Zhu et al. 2006). Technology assimilation reflects to what extent a technology is utilised, both in terms of depth and breadth, and helps to unravel how organisations and other adopting entities leverage the advantages of a given technology (Zhu et al. 2006). In this paper, we focus on Green IT assimilation and extend previous Green IT adoption studies.

Second, existing studies offer two main perspectives on Green IT driven either by organisation, technology and environment contextual and institutional factors (Chen et al. 2010; Dao et al. 2011) and attitudinal and motivational factors (Mishra et al. 2014; Molla et al. 2012). While these perspectives provide useful insight, we argue that an absorptive capacity perspective might provide as good an explanation as the two perspectives but is largely missing from extant Green IT literature. Environmental sustainability, which is the ultimate goal of Green IT practice, is inherently linked to learning and innovation (Elliot 2013). Organisational learning capability is usually anchored to the concept of absorptive capacity which is defined as the ability to recognise the value of new and external information, assimilate and apply it (Zahra et al. 2002). Roberts et al. (2012) provide a comprehensive review of the ways in which IS researchers have conceptualised, analysed and measured absorptive capacity. Their review of 98 papers highlights that the absorptive capacity perspective has been used in analysing IT assimilation (such as enterprise systems) (Roberts et al. 2012). This study is the first to apply the absorptive capacity perspective to Green IT assimilation.

Third, in addition to adopting an absorptive capacity perspective, the study compares contextual and absorptive capacity perspective models and investigates which of the two perspectives provide a better explanation of Green IT assimilation. This has important implications for influencing managerial practice as well as advancing the theoretical foundation of Green IT scholarship. We are not aware of other Green IT research that attempted such an exercise.

The research questions we address are, therefore, *what influences Green IT assimilation?* and *which of the two theories – absorptive capacity vs. contextual, better explain variation in Green IT assimilation?*

The contributions to Green IT research include theory building that explains Green IT assimilation and the factors which influence this. Further, following a comparison of the utility of contextual and absorptive capacity theories in explaining Green IT assimilation, we propose an integrated model of Green IT assimilation. These efforts can be used in future studies. In terms of contributions to practice, by identifying the constructs that have most effect on Green IT assimilation, we provide insight for practitioners that might guide them in terms of where they might best focus their efforts and limited resources.

BACKGROUND LITERATURE

Four areas of literature are relevant – Green IT, IT assimilation; organisation, technology and environment (OTE) and absorptive capacity. These are discussed in the following section.

Green IT

Green IT aims to minimise the negative impact of IT operations on the environment through the sourcing, operations and end of life management of IT and IT-related products in an environmentally friendly way (Murugesan 2008). Green IT requires that environmental considerations be embedded in the technical IT infrastructure as well as in the IT human infrastructure and IT managerial capability (Molla et al. 2011). In terms of the technical IT infrastructure, Green IT focuses on improving energy efficiency in the powering and cooling of IT (Kumar et al. 2014), including the use of renewable energy to power the IT infrastructure (Chen et al. 2010), and on reducing greenhouse gas emissions through technologies such as server and storage virtualisation (Bose and Luo 2011) and data centre airflow and power management (Alaraifi et al. 2013). In terms of the IT human and IT managerial capability dimensions, the application and realisation of environmental sustainability-oriented practices in the sourcing, operation and disposal of the IT infrastructure, such as the analysis of the environmental track record of IT vendors as part of their procurement decisions (Molla et al. 2011) and electronic waste disposal (Pant 2014) is important. Further, defining clear governance models for the administration of Green IT, establishing policies that prescribe systematic frameworks to apply environmental criteria in IT-related activities (Molla et al. 2011) and developing environmental awareness of IT managers and professionals (Gholami et al. 2013) are key considerations within the IT human and IT management dimensions of the IT infrastructure.

Green IT is of increasing importance to organisations. Research has identified a range of drivers for Green IT including increasing energy costs (Alaraifi et al. 2013); coercive and mimetic pressures (Chen et al. 2010; Gholami et al. 2013); environmental legislation that addresses the disposal of electronic waste and energy efficiency (Bose et al. 2011); and public perceptions of corporate strategies and operations (Molla et al. 2012). As indicated earlier in the introduction, most of these Green IT studies tend to focus on adoption and not assimilation. In the following section we introduce the IT assimilation construct.

IT Assimilation

IS researchers have distinguished between diffusion, the process whereby technology spreads across a population, and assimilation, being the process by which progress from initial awareness of an innovation to formal adoption and full-scale deployment is made (Fichman and Kremer 1999). The IT assimilation construct has been defined in the IS literature in different ways. Massetti and Zmud (1996) provided one of the most widely used definitions of IT assimilation constituted of four facets: volume, diversity, breadth and depth. Volume represents the percentage of an organisation's processes that are handled through a system. Diversity refers to the variety of business functions that are performed routinely through a system. Breadth represents the extent to which an organisation has used a technology to conduct routine functions and depth refers to the degree of a system’s functionalities that

has been established in performing the business processes. Thus IT assimilation can also be defined as "the extent to which the use of technology diffuses across organizational projects or work processes and becomes routinized in the activities of those projects and processes" (Roberts et al. 2012, p. 636). IT assimilation is of much interest to researchers and practitioners alike. We now turn to two theories which highlight the factors which influence IT assimilation in organisations.

The Organisation Technology Environment (OTE) Framework

Tornatzky et al. (1990) developed the OTE framework from Rogers's (1995) diffusion of innovation theory by adding the environmental context as a third factor together with Roger's two factors of technology and organisation. This addition was important for addressing innovation use in a complex environment in which the external environment could provide both constraints and opportunities (Tornatzky et al. 1990). The OTE identifies three categories of contextual factors that influence the assimilation of technology: *the technological context* which refers to existing and new technology, *the organisational context* which refers to firms' measurable characteristics such as size, scope and resource availability, and *the environmental context* which refers to the external environment in which firms conduct their business (such as industry, market participants, and government) and extends to any factor or source that could directly or indirectly motivate and/or inhibit firms' operation or decision towards innovation (Tornatzky et al. 1990). The OTE provides a generic foundation that integrates the organisational, technological and environmental contexts to understand the factors that could affect the assimilation of technologies.

The OTE framework has been widely used in IS research to study the implementation and use of innovations such as object-oriented technology (Cho and Kim 2002), e-business (e.g. Zhu et al. 2006), ERP assimilation (Liang et al. 2007), and Green IT (e.g. Bose and Luo 2011). However, the factors that constitute the three contexts differ from one study to another. For example, Zhu et al. (2006) identify technology readiness, technology integration, firm size, global scope, managerial obstacles, competition intensity and the regulatory environment as important contextual explanations of e-business assimilation. Cho and Kim (2002) include expectation for market trend, maturity of technology, intensity of new technology education and satisfaction with existing technology. Liang et al. (2007) in their study of the determinants of ERP success have identified (a) under technological context, ERP attributes and expertise; (b) under organisational context, top management support, strategic alignment, managers' and users' involvement, reward systems and culture; and (c) under environmental context, institutional pressures and consultant effectiveness (Kouki et al. 2010; Liang et al. 2007).

In addition, researchers have introduced variables that are specific to their focus of study under the generic OTE framework. Examples include manufacturing context, manufacturing technologies, networking intensity (Raymond et al. 2005), trading partner pressure (Hsu et al. 2006), reward system, consultant effectiveness and vendor support (Kouki et al. 2010). This implies that by building on the OTE structure, researchers can develop the relevant factors that are specific to their research context and focus only on the most relevant factors. Further, researchers (Cho and Kim 2002) argue that some of the technological, organisational and environmental factors that appear to be more important indicators for the adoption stage could be less important or irrelevant to the post-adoption stage. Therefore, researchers should carefully select the important factors to their research context. As such, the OTE has a generic nature that makes it suitable to study different types of technology innovation and accommodates context-based constructs. Thus it is useful to be applied as one of the conceptual foundations for investigating Green IT assimilation. While OTE factors can provide the contextual factors that influence IT assimilation, they do not capture the dynamics of learning, thus a few researchers have followed the absorptive capacity perspective.

Absorptive Capacity

Absorptive Capacity was first introduced to an organisational context by Cohen and Levinthal (1990) and refers to the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends. Absorptive capacity is conceptualised by scholars in a variety of ways but most tend to model absorptive capacity as comprising either two, three or four underlying constructs. The most frequently cited work to date is the model provided by Zahra and George (2002). This model identifies that absorptive capacity comprises the four processes of acquisition, assimilation, transformation and exploitation and these processes are grouped into two higher order dimensions, namely, potential and realised absorptive capacity.

Potential absorptive capacity comprises acquisition, which refers to a firm's capability "to identify and acquire externally generated knowledge that is critical to its operations" (Zahra and George 2002, p.189) and assimilation, being the firm's "routines and processes that allow it to analyse, process, interpret and understand information obtained from external sources" (ibid, p. 189). Zahra and George (2002) argue that while potential absorptive capacity enables the firm to be receptive to acquiring and assimilating external knowledge it does not guarantee that a firm will leverage and exploit this knowledge, rather, this requires realised absorptive capacity. Realised absorptive capacity comprises transformation, which represents the firm's capability to "develop and refine the routines that facilitate combining existing knowledge and the newly acquired and assimilated knowledge" (ibid, p. 190) along with exploitation, which is the firm's ability to "refine, extend and leverage existing competencies or to create new competencies by incorporating transformed knowledge into its operations" (ibid, p. 190). Absorptive capacity has been used to investigate innovation and firm performance (e.g. Cohen and Levinthal 1990; Gluch et al. 2009), and importantly, IT assimilation (Saref et al. 2012; Roberts et al. 2012).

MODEL SPECIFICATION AND HYPOTHESIS DEVELOPMENT

Based on the review of the literature, in this section we introduce the two models and related hypotheses.

Model 1- Contextual-based Model of Green IT Assimilation

The contextual model is composed of three constructs: organisational, technological, environmental (Figure 1). Generally speaking, *organisational context* refers to descriptive measures such as slack resources, structural characteristics and the characteristics of leaders (such as their commitment) (Fichman 2000). Perceived availability and allocation of sufficient organisational resources has been argued to be an important factor for the adoption and assimilation of IT because if the firm does not perceive the benefits of technology can be achieved within the allotted resources, adoption, and therefore assimilation of IT, becomes futile (Kuan and Chau 2001). Structural characteristics include firm size and scope, the degree of centralisation, formalisation and the complexity of the managerial structure (Zhu et al. 2004). Top management support and managerial knowledge are often cited as key elements in facilitating the assimilation of IT. Top management influences the perceived importance of Green IT which in turn influences resource allocation and investment in Green IT (Mithas et al. 2010). The support of top management, especially support of long term strategies, will influence the formation and creation of policy and governance for Green IT (Molla et al. 2011) and provides a positive environment for the success of Green IT (Armstrong and Sambamurthy 1999). Environmental commitment of managers can for example, lead organisations to embrace Green IT strategy. Actions undertaken by senior management can introduce complementary structures to facilitate Green IT assimilation, and modify and reinforce the norms that value the use of Green IT. There is a greater likelihood of Green IT assimilation when positive top management mind-set has been communicated effectively to the users. Indeed the wider attitude of IT people, which encompasses their sentiment, values and norms toward climate change and eco-sustainability and IT's role in Green IT (Gholami et

al. 2013; Molla et al. 2011) is important to ensure Green IT practices and technologies are embedded across an organisation at an operational level. Thus we hypothesize

> HC1: Organisational context such as resource commitment, formal structure and top management commitment, positively influences Green IT assimilation

Within the context of OTE and drawing from prior studies (Zhu and Kraemer 2005) we consider the *technological context* to represent the IT assets including the IT people of organisations. It refers to organisation's IT size in terms of the number of IT staff, and the personal computer and server (both physical as well as virtual) fleets. The technology context shows the depth, breadth and sophistication of IT usage in an organisation. It can influence Green IT assimilation in three ways. First, firms with more IT resources may consider the environmental impact of those assets and may demonstrate greater commitment and managerial support to use of Green IT to minimize their footprint. Second, previous research indicates that the level of IT resources a firm accumulates is an indication of a positive attitude towards extending IT use (Hsu et al. 2006). Further, studies have also found that there is a significant relationship between technological resources and organisational innovativeness (Zhu et al. 2004). This leads us to the following

> HC2: A firm with more technological resources will have greater assimilation of Green IT

> HC3: A firm with more technological resources will develop favourable organisational context for Green IT assimilation

Environmental context refers to the institutional and market environment within which organisations operate. Market and regulatory forces, when present and mature, can create conducive conditions for widening and deepening Green IT implementations (Molla et al. 2012). Stakeholders such as suppliers, customers, industry associations and regulatory agencies have influenced the assimilation of technologies within data centre (Alaraifi et al. 2013) and Green IT policies (Chen et al. 2010). Market and non-market external pressures, in addition to directly affecting Green IT assimilation, can also influence managers to improve their environmental performance (Gholami et al. 2013). Therefore, as the institutional, industry and market dynamics for Green IT become favourable, organisations might commit resources, structure and support towards either exploring or exploiting various Green IT technologies and practices. On the basis of these, we formulate the following two hypotheses

> HC4: The environmental context for Green IT such as market, regulatory and institutional factors positively influences Green IT assimilation

> HC5: The environmental context for Green IT positively influences the organisational context for Green IT

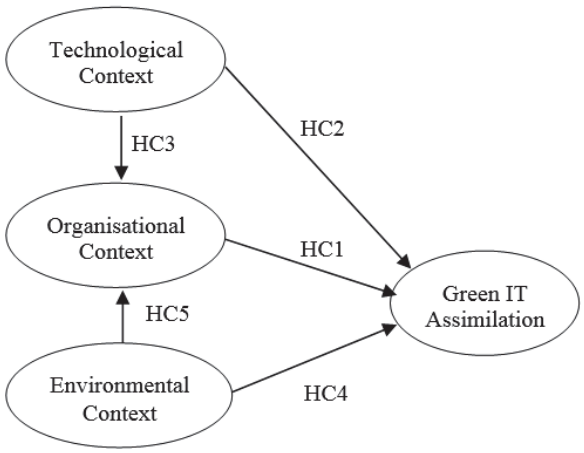

Figure 1: Context-Based Model of Green IT Assimilation

Model 2- Absorptive Capacity Based Model of Green IT Assimilation

Both the environmental sustainability and IS literature use absorptive capacity to understand the adoption of environmentally friendly technologies and IT assimilation respectively. In terms of environmental sustainability, Gluch et al. (2009) found that in the construction industry absorptive capacity explains green innovation and environmental performance. Absorptive capacity has been found to explain the undertaking of proactive environmental strategy (Delmas et al. 2011), environmental commitment of Canadian Small-Medium Enterprises (SMEs) (Roy et al. 2008), the diffusion of clean technology in the Spanish Pulp and Paper industry (del Río González 2005) and the development of clean technology and production (Vickers 1999).

In terms of IT assimilation, Roberts et al. (2012) provide a comprehensive review of the ways in which IS researchers have conceptualised, analysed and measured absorptive capacity. Their review of 98 papers highlights that one of the themes in the application of absorptive capacity in IS research is IT assimilation. IS researchers have consistently found that there is a positive relationship between absorptive capacity and IT assimilation as high absorptive capacity in a domain increases the capability of the organisation to assimilate complex innovations in that domain (Roberts et al. 2012; Sharma et al. 2012). IT education (e.g. new technology education and learning) and IT capabilities (e.g. investment in IT infrastructure), often triggered by external institutional pressures (Saraf et al. 2012), have been found to increase related knowledge and the diversity of knowledge held (i.e. absorptive capacity). This in turn improves IT assimilation.

In Zahra and George's (2002) initial model of absorptive capacity, potential and realised absorptive capacity were seen to have separate but complementary roles, with both being necessary to improve firm performance. That is, firms cannot transform and exploit knowledge (i.e. develop realised absorptive capacity) without first acquiring and assimilating knowledge (i.e. developing potential absorptive capacity). Zahra and George (2002) advocate that while potential absorptive capacity is necessary to improve firm performance it is not sufficient alone. More recent empirical studies (e.g. Saref et al. 2012) have found that both potential absorptive capacity (weak support) and realised absorptive capacity (strong support) have a direct influence on IS assimilation. Most studies report that potential absorptive capacity, either directly or indirectly, that is, through realised absorptive capacity, influences IS assimilation (Cooper and Molla. 2012; Gluch et al. 2009; Saraf et al. 2012; Sharma et al. 2012).Therefore our absorptive capacity model tests the relationships among potential Green IT

absorptive capacity, realised Green IT absorptive capacity and Green IT assimilation, with the following three hypotheses (Figure 2)

HA1: Potential Green IT absorptive capacity significantly contributes to Green IT assimilation

HA2: Realised Green IT absorptive capacity significantly contributes to Green IT assimilation

HA3: Potential Green IT absorptive capacity significantly contributes to realised Green IT absorptive capacity

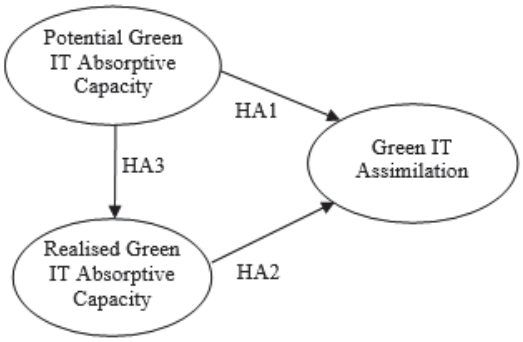

Figure 2: Absorptive capacity-based Model of Green IS Assimilation

RESEARCH METHOD

To collect the data, we first developed a measurement instrument to test the hypotheses and compare the research models. Green IT assimilation is measured based on five items adopted from the G-readiness instrument (Molla et al. 2011). Organisational context is measured based on Fichman and Carroll (1999) using three items covering top management support, formal organisational structure and resource commitment. Technology context was measured using three items that reflect the IT resources (hardware) and the size of the IT function (IT people). Three items are drawn from Molla et al. (2012) to capture the environmental context of regulatory, industry and market dynamics to benefit from Green IT.

The potential and realised absorptive capacity constructs were modelled and measured as second-order reflective-formative constructs as illustrated in Figure 3. The use of higher order constructs is appropriate to model multi-dimensional latent variables and to reduce the complexity of structural models (Hair et al. 2014). Potential Green IT absorptive capacity is measured as a reflective-formative second-order construct, with Green IT knowledge acquisition and assimilation as its underlying first order dimensions. Likewise, realised Green IT absorptive capacity is modeled as a reflective-formative second-order construct, with Green IT knowledge transformation and exploitation as its underlying first order dimensions. Items to operationalise the four first order constructs are adopted from Gluch et al. (2009) and Zahra et al. (2002). Here six items are used to capture the ability to acquire new knowledge on Green IT; four items to measure assimilation, that is, the routines and processes to interpret external knowledge; four items to assess the mechanisms for transforming and integrating new knowledge with existing knowledge, and four items to measure the routines and processes to exploit Green IT knowledge. See Appendix 1 for the list of questions and items.

Figure 3: The Measurement Model of Potential and Realised Green IT Absorptive Capacity

After the instrument was developed, a panel of three experts reviewed the items for content validity. IT managers from large Australian, New Zealand and US organisations were sampled to complete the survey. Respondents were asked to respond to questions on a five point Likert scale ranging from 1 = Very Low to 5 = Very High. The survey had 179 responses (109 Australian; 21 New Zealand, 14 U.S. and 35 missing) out of which 148 were usable. Eighty percent of the respondents were senior IT managers (such as CIOs) working in large organisations (71%) (more than 500 full time equivalent (FTE) employees) in the services (23%), manufacturing (20%), utilities and transport (12%) and education and government (20%) sub sectors. The IT departments of most of the respondents' (72%) organisations have more than 10 FTE staff.

ANALYSES AND RESULTS

The psychometric property (that is reliability and validity) of the instrument was tested using Partial Least Square in two steps. In the first step, the first order measurement models were tested for convergent and discriminant validity. The result (Appendix 1) shows that the measurement models are valid and reliable. In terms of convergent validity, all factor loadings are greater than 0.7 and the average variance extracted is greater than 0.5. The composite reliability and Cronbach alpha values are also greater than 0.7 providing evidence of internal consistency of the measures. Further, the square root of the AVE is larger than the off diagonal inter-construct correlation (see Table 1) and supports discriminant validity.

	1	2	3	4	5	6	7	8
1 Green IT Knowledge Acquisition	***0.77****							
2.Green IT Knowledge Assimilation	0.74	**0.87**						
3. Environmental Context	0.62	0.61	**0.90**					
4. Green IT Knowledge Exploitation	0.64	0.78	0.63	**0.94**				
5. Green IT Assimilation	0.64	0.69	0.67	0.70	**0.87**			
6. Organisational Context	0.60	0.59	0.66	0.65	0.72	**0.87**		
7. Technology Context	0.18	0.11	0.16	0.04	0.05	0.13	**0.92**	
8. Green IT Knowledge Transformation	0.68	0.80	0.58	0.86	0.72	0.60	0.07	**0.92**

** diagonal values in bold and italics are square root of the AVE*

Table 1: Discriminant Validity of the First Order Measurement Model

In the second step, the two second order constructs that is potential and realised Green IT absorptive capacity were validated following a repeated indicator approach as described in Hair et al. (2014, p231) and tested for collinearity of indicators. Since the t-values of the outer weights are significant, all VIF

values are <5.0 and the tolerance values are >0.20 (Hair et al. 2014, p. 125), there is no collinearity problem. This shows adequate measurement validity of the second order models.

		Outer weight (Outer loading)	t value	VIF	tolerance
Potential Green IT absorptive capacity	Green IT knowledge acquisition	0.56 (0.93)	23.20	2.30	0.44
	Green IT knowledge assimilation	0.52 (0.94)	33.77	3.62	0.28
Realised Green IT absorptive capacity	Green IT knowledge transformation	0.53 (0.96)	73.44	4.24	0.24
	Green IT knowledge exploitation	0.51 (0.97)	70.43	4.80	0.21

Table 2: Validation of the Second Order Measurement Models

After the instrument was validated the structural models were tested using Partial Least Square-Structural Equation Modeling (PLS-SEM). PLS-SEM was selected because of its relative robustness in working with smaller and larger samples; flexibility achieved by having few limiting assumptions regarding the model specifications and data; provision of parameter estimates that maximize the explained variance of dependent constructs (thus supporting prediction or theory building aims); and its ability to also be used for confirmatory theory testing and model comparison (Hair et al. 2014). To test the second order structural model, a two stage latent variable approach was used (Hair et al. 2014). Figures 4a and 4b show the result of the structural model tests.

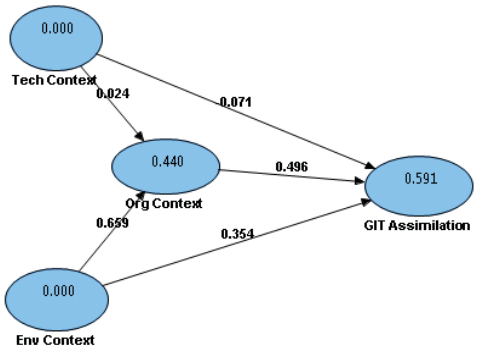

Figure 4a: Structural test of the contextual model

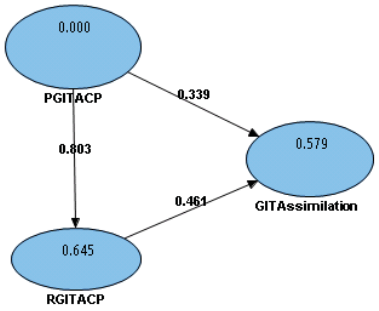

Figure 4b: Green IT absoptive capacity structural model

To estimate the significance of the path coefficients, 5000 sample bootstrapping was performed. Further, in order to estimate the predictive accuracy of the structural models, we also examine the Stone-Geisser's Q2 values. To compare the two models, following Hair et al.'s (2014) recommendations, we have used several tests, such as effect sizes, adjusted R2 and Q2 effect size. The results are summarized in Table 3.

Model	Hypothesis	Paths	Path Coefficient	t values	sig	R^2	R^2_{adj}	Q^2	f^2 Effect size	q^2 Effect size
Context	HC1	Organisational context -> Green IT assimilation	0.50	4.50	**	0.59	0.60	0.59	0.30	0.28
	HC2	Technology context -> Green IT assimilation	0.07	1.13	ns					
	HC4	Environmental context -> Green IT assimilation	0.35	2.88	*					
	HC3	Technology context -> Organsational context	0.02		ns	0.44				
	HC5	Environmental context -> Organisational context	0.66	9.88	**					
Absorptive Capacity	HA1	Potential Green IT absorptive capacity -> Green IT assimilation	0.34	2.50	*	0.58	0.59	0.57	0.26	0.23
	HA2	Realised Green IT absorptive capacity -> Green IT assimilation	0.46	2.9638	*					
	HA3	Potential Green IT absorptive capacity -> Realised Green IT absorptive capacity	0.80	24.9	**	0.65				

*Significant at 0.01; ** Significant at 0.001; ns Not Significant

Table 3 Structural Model Results and Comparison

DISCUSSION

As indicated in Table 3, six out of the eight paths in the two models are significant at a 0.01 confidence level and some at a 0.001 confidence level thus supporting six of the theoretical hypotheses. The contextual model explains 59% of the variance of Green IT assimilation whereas the absorptive capacity

model explains 58%. In addition, environmental and technology contexts explain 44% of the variance in organisational context, however the path coefficient of the technology context is statistically insignificant (Hypothesis C3). Potential Green IT absorptive capacity explains 65% of the variation in realised Green IT absorptive capacity. Further, two out of the three exogenous variables in the two models significantly influence Green IT assimilation such that the total effects of the exogenous variables, that is, potential Green IT absorptive capacity, and environmental context on Green IT assimilation are 0.40 (p= 0.01), and 0.31 (p=0.01) respectively. Further of all the variables included in the two models, potential Green IT absorptive capacity has a higher magnitude of total (direct and indirect) effect (but with medium effect size) whereas organisational context has a higher magnitude (Table 1) of direct effect (with medium effect size) on Green IT assimilation. However the size of the IT function doesn't seem to have any influence on Green IT assimilation (Hypothesis C2).

Both models explain more than 50% of the variance in Green IT assimilation. The model comparison test results show that the contextual model has a marginally larger adjusted R2 and Q2 values with a medium effect size whereas the absorptive capacity model has relatively lower adjusted R2 and Q2 values but still with medium effect size. This means, at least in the current sample, both learning based and organisational and contextual factors explain why and how widely and deeply Green IT practices, technologies and values are embedded in the IT people, in the IT management and IT infrastructure of organisations.

With regards to the contextual model, the support for Hypothesis C1 indicates that organisational context has a strong impact on Green IT assimilation (0.50). The support of senior managers has been found to impact on IT assimilation generally (Armstrong and Sambamurthy 1999) and this has been found to be transferrable to the context of Green IT assimilation. In Fischman and Carroll's (1999) review of factors having an impact on IT diffusion and assimilation, the communication environment was found to be important, as was structural characteristics of an organisation – although with mixed results. Some studies found that organisations with lower centralisation, formalisation and vertical differentiation are more likely to innovate, whereas others found that such firms will have difficulty reaching consensus about adopting innovations and less likely to sustain them. Our study suggests that there is a need for formal structures that enable the exchange of ideas to enhance Green IT assimilation. Further, the provision of sufficient resources will increase Green IT assimilation and this is consistent with wider research in IT assimilation whereby a firm's 'slack resources' and investment in, for example, training, (Fischman and Caroll 1999) affects IT assimilation.

The support for Hypothesis C4 shows that the environmental context has a medium effect on Green IT assimilation (0.35). Market demand for Green IT products, processes and services was found to have a positive effect on Green IT assimilation in our study, which is consistent with the work of Molla and Abareshi (2012) wherein market forces were identified as a motive of early adoption of Green IT practices. Institutional and industry dynamics were perceived to impact the ability of firms to assimilate Green IT. This finding, while consistent with studies that highlight institutional drivers as impacting on a firm's environmental performance (e.g. Zalani et al. 2012), is inconsistent with the finding of Melville and Salandha (2013) in their investigation of the antecedents for adoption of carbon management systems. This may be because their study operationalised external environmental factors in terms of global climate agreements whereas our survey did not tap into such agreements specifically. Through support for Hypothesis C5, our study indicates that the environmental context has a strong impact in terms of shaping the organisational context (0.66). This suggests that institutional theory (DiMaggio and Powell 1983) may shed further light on organisations' response to environmental factors as they pertain to Green IT.

With regards to Model 2, absorptive capacity, the support for Hypotheses A1 and A2 indicates that firms that are able to develop potential absorptive capacity and able to develop realised absorptive capacity, will be better able to assimilate Green IT. The results indicate that realised absorptive capacity

has a larger direct effect (0.46) on Green IT assimilation than does potential absorptive capacity (0.34). This is consistent with the theorization of absorptive capacity by Zahra and George (2002). The dominance of realised absorptive capacity in explaining Green IT assimilation, however, does not render potential absorptive capacity unimportant. Potential Green IT absorptive capacity has strong explanatory power for realised absorptive capacity (0.80), indicating that there must be sufficient understanding of Green IT issues in the first instance. Further, our findings show that potential absorptive capacity has a significant direct effect on Green IT assimilation and this is consistent with Saref et al. (2012) in their study on enterprise systems assimilation. Other scholars have noted the importance of this relationship between potential and realised absorptive capacity (Hypothesis A3), including in the IS domain, where information systems have been argued to mediate the relationship between potential and realised absorptive capacity. For example, Cepeda-Carrion et al. (2012) found that while IS capability is needed to enhance potential absorptive capacity to realised absorptive capacity, in turn, these two forms of capabilities, contribute to creating higher-order dynamic capabilities (Hu et al. 2012) and mediate the influence of IS capabilities (such as flexible IS infrastructure, IS integration and assimilation) on firm performance (Francalanci and Morabito 2008; Liu et al. 2013).

Overall our study indicates that Green IT assimilation is influenced by potential and realised absorptive capacity through different pathways and thus adds to other studies that have explored potential and realised absorptive capacity on IS assimilation.

THEORETICAL CONTRIBUTION: A PARSIMONIOUS AND INTEGRATED MODEL OF GREEN IT ASSIMILATION

This study was set out to address the questions of what influences Green IT assimilation and which of the two theories – absorptive capacity vs. contextual – better explain variation in Green IT assimilation. We have shown, via a contextual model, that market, institutional and industry dynamics of Green IT as well as top management, formal organisational structure and organisational resources influence Green IT assimilation. We have also shown, via a model of absorptive capacity, that the Green IT knowledge acquisition and assimilation (potential absorptive capacity) together with transformation and exploitation processes (realised absorptive capacity), equally influence Green IT assimilation. The results further demonstrate that both models explain more than 50% of the variation in the Green IT assimilation of the sample. The explanatory powers of the models are better than Chen et al.'s (2010) institutional theory based model, Molla and Abarehsi's (2012) motivational theory based model and Gholami et al.'s (2013) managerial perception and belief based model. This means researchers can use the models and hypotheses developed in this study in future studies.

In terms of which model has better utility to understand Green IT assimilation, both models have medium effect but the contextual model shows a marginally higher R2 value. This finding has two implications. First, if one is seeking to choose between the two models, our results favour the contextual model which might be further improved by improving the measures of the technological context variables. Nevertheless, as Green IT can be considered at the early stage of development, it remains to be seen if contextual factors continue to dominate the assimilation of Green IT or if this might change in the future as organisations move from reactive strategies and start integrating Green IT as part of building and renewing their overall IT capabilities. Second, in order to get a more comprehensive understanding of Green IT assimilation, a model that draws from both contextual and absorptive capacity theories and that integrates the external context as triggers of Green IT absorptive capacity and the organisational context as mediating mechanisms for building Green IT absorptive capacity can be considered. We believe that the integrated model will yield a better understanding and explanation. As a result, and as a theoretical contribution, we propose a parsimonious and integrated model of Green IT assimilation illustrated in Figure 5.

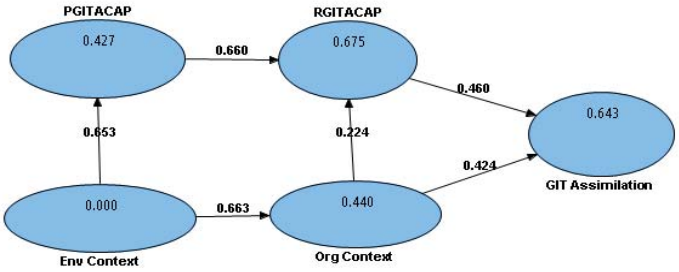

Figure 5: Integrated model of Green IT assimilation

The model explains 64% of the variation in Green IT assimilation, 68% of the variance in realised Green IT absorptive capacity and about 43% of variations in potential Green IT absorptive capacity, as well as 44% of organisational support and commitment for Green IT. All the paths are higher in magnitude and significant at 99% confidence interval. Its predictive accuracy, that is, Q^2 is 64% showing large predictive relevance of the model to investigate three questions: what factors explain Green IT assimilation?; how can organisations develop their potential and realised Green IT absorptive capacity?; and what influences organisational commitment and support for Green IT? The model is parsimonious because it provides higher explanatory power with fewer paths. The integrated model and the paths have also strong foundation in the OTE and absorptive capacity theories.

The general proposition of the integrated model is that the external environment context for Green IT contributes positively to both organisational support and commitment, as well as the ability to acquire and assimilate Green IT knowledge. Together these two contribute significantly to create a higher order and realized absorptive capacity by transforming and exploiting the acquired and assimilated knowledge. The higher order realised absorptive capacity and the continued management commitment, support and resource for Green IT lead to assimilation of Green IT. These general propositions have six individual hypotheses (the paths in Figure 5) that can be retested in future studies.

PRACTICAL CONTRIBUTION: GUIDING PRACTITIONERS TOWARDS GREEN IT ASSIMILATION

This study provides a number of insights for practitioners endeavouring to assimilate Green IT in their organisations.

First, our study provides insight into the environmental and organisational factors that influence Green IT assimilation. This understanding will become increasingly important to practitioners as organisations move beyond the initial stages of adoption and endeavour to fully assimilate Green IT (Fichman and Kremer 1999). Importantly, our study has identified the strong influence that organisational factors such as formal structures, provision of resources and top management support have on Green IT assimilation. This indicates that practitioners should pay careful attention to these issues.

Second, we have shown that organisations can benefit from adopting a learning perspective towards Green IT. This is because developing higher levels of potential and realised absorptive capacity can lead to higher levels of Green IT assimilation. Potential absorptive capacity in this context involves acquiring new knowledge from a diverse range of sources (e.g. from relationships with external stakeholders, participation in Green IT interest groups and undertaking formal Green IT training programs), and then assimilating the newly acquired knowledge through development of the routines and processes that enable an organisation to analyse, interpret and understand newly acquired knowledge. Realised absorptive capacity requires firms to ensure that IT staff understand Green IT

issues and concepts and enable staff to transform wider organisational routines and processes, and in turn, create new, refine, and exploit existing Green IT competencies. By unraveling the routines and processes organisations require for assimilating Green IT and by providing empirical evidence as to their influence, we provide insight for practitioners in terms of the capabilities they should learn to develop.

CONCLUSION AND FUTURE WORK

Our study provides the foundation for undertaking theory building and explanation of Green IT as well as for influencing IT-enabled actions for addressing environmental sustainability, which is an original contribution to the Green IT literature. In addition, the study adds to the empirical base of Green IT literature and can be considered as one of the few empirical studies to look beyond initial adoption of Green IT to understand its assimilation. Thus, researchers can use our findings to compare what factors are common to influence both the adoption and the assimilation of Green IT and what factors are unique to each construct domain.

The study has a number of limitations that offer avenues for future research. First, we have developed the models on the basis of a single sample and did not have a hold-out sample to re-test the model. Second, our study has focused on large organisations and future research might investigate how each model explains Green IT assimilation in a variety of organisations. Third the technology context as measured in this study has no direct effect in our model and researchers need to look into the measurement items as well as the possibility of moderating or controlling effect. The integrated model although theoretically sound, was driven from the data and requires further test in another sample and opens avenue for future research. Research comparing Green IS assimilation and wider IS assimilation in firms would be an interesting avenue for future research.

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APPENDIX 1: FIRST ORDER MEASUREMENT MODEL VALIDITY AND RELIABILITY

Factor	Item	Factor Loadings	CR	ά	AVE
Organisational Context	Please rate the extent to which each the following has facilitated Green IT:				
	O_fos Formal organisational structures	0.90	0.91	0.84	0.76
	O_res Provision of sufficient resource	0.88			
	O_tms Top management support	0.84			
Technology Contex	Please provide data for each of the following				
	T_ITstaff: Number of IT staff	.99	0.95	0.92	0.85
	T_PCs: Number of personal computers	.94			
	T_servers: Number of servers	.84			
Environmental Context	Please rate the extent to which each the following has influenced Green IT:				
	E_ind Industry dynamics	0.92	0.93	0.88	0.81
	E_inst Institutional dynamics	0.91			
	E_mkt Market demand	0.86			
Green IT Knowledge Acquisition	Please rate the capability of your IT department to acquire new knowledge on Green IT via:				
	ACQ1 Carrying out market research	0.71	0.90	0.86	0.59
	ACQ2 Sending IT staff to complete training courses	0.74			
	ACQ3 Participation in interest groups	0.83			
	ACQ4 Relationships with external stakeholders	0.82			
	ACQ5 Observation of approaches adopted by competitors	0.78			
	ACQ6 Compliance with environmental legislation	0.72			
Green IT Knowledge Assimilation	Please rate the capability of the routines and processes in your IT department to:				
	ASS1 Interpret and understand information on Green IT	0.86	0.93	0.89	0.76
	ASS2 Ensure newly acquired Green IT knowledge is understood by I staff	0.88			
	ASS3 Conduct a lifecycle analysis of its products/services to identif their environmental impact	0.83			
	ASS4 Develop a plan of action on how to achieve environmental goals	0.90			
Green IT Knowled Transformation	Please rate your IT department's capability to:				
	TFRM1 Develop effective routines to facilitate the combination of newly acquired or assimilated knowledge with existing Green IT knowledge	0.92	0.96	0.94	0.85
	TFRM2 Refine its routines to facilitate the combination of newly acquired or assimilated knowledge with existing Green IT knowledge	0.92			
	TFRM3 Develop Green IT performance goals (e.g. KPIs) to reflect understanding gained from newly acquired or assimilated knowledge	0.91			
	TFRM4 Refine Green IT performance goals (e.g. Key Performance Indicators) to reflect understanding gained from newly acquired or assimilated knowledge	0.93			
Green IT Knowledge Exploitation	Please rate the capability of your IT department's to develop and refine routines to:				
	XPLT1 Ensure that existing Green IT competencies are effectively leveraged in its operations	0.95	0.97	0.96	0.89
	XPLT2 Refine existing Green IT competencies	0.96			
	XPLT3 Extend existing Green IT competencies	0.95			
	XPLT4 Enable the creation of new Green IT competencies	0.91			
Green IT Assimilation	Please rate the extent to which your IT department has:				
	GR_att A positive Green IT attitude	0.79	0.94	0.92	0.75
	GR_gov Well-developed Green IT governance mechanisms	0.88			
	GR_pol Well-developed Green IT policy frameworks	0.87			
	GR_prc Well-developed Green IT practices	0.92			
	GR_tec Acquired and build an environmentally effective IT infrastructure	0.87			