8-2011

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Recommended Citation

Molla, Alemayehu; Cooper, Vanessa; and Pittayachawan, Siddhi (2011) "The Green IT Readiness (G-Readiness) of Organizations: An Exploratory Analysis of a Construct and Instrument," *Communications of the Association for Information Systems*: Vol. 29 , Article 4.
DOI: 10.17705/1CAIS.02904

Available at: <https://aisel.aisnet.org/cais/vol29/iss1/4>

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Communications of the Association for Information Systems

The Green IT Readiness (G-Readiness) of Organizations: An Exploratory Analysis of a Construct and Instrument

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Abstract:

The realization that legacy information technology (IT) systems have environmental footprint has elevated the sustainability of IT (Green IT) as a significant IT management issue. However, there is a lack of empirical research to explain Green IT capabilities of organizations and the maturity of those capabilities. This article reports a Green IT Readiness framework to capture the input, transformational and output capabilities that organizations need to nurture in sustainable management of IT. It identifies five components of G-readiness and provides an exploratory framework and a research-ready instrument. The instrument is validated based on data collected from a cross-sectional and cross-country survey of IT managers.

Keywords: Green IT, Green IS, capability, readiness, G-readiness, eco-sustainability

Volume 29, Article 4, pp. 67-96, August 2011

I. INTRODUCTION

The impact of IT on and its role in ecological sustainability, under the headline of Green IT, has emerged as one of the key IT management issues [Dedrick, 2010]. A number of organizations are expected to jump on the Green IT bandwagon pushing the Green IT services market to an estimated US \$4.5 billion by 2013 [Mines, 2008]. Thus, while currently leading-edge executives are focusing on Green IT issues; Green IT initiatives will become mainstream and will move from niche projects to a part of core business practice. This portends two challenges for enterprise IT management. First, IT managers are required to minimize IT related energy use, emissions, inefficiency, and waste. Second (and perhaps most importantly), IT managers are expected to provide IT solutions that enable businesses to measure, monitor, report, and improve their environmental footprint within their core enterprise and supply chain processes. These challenges are faced on top of the overarching need to deliver return on IT investments. Thus, in the future, the strategic role of IT will depend not only on delivering economic value, but also on a capability to maintain a sustainable IT operation and on IT's support for the sustainability transformation of organizations.

The importance of Green IT is strongly recognized through practitioner reports [CFO, 2009; Gartner, 2008] and Information Systems research [Dedrick, 2010]. Nevertheless, the capability that organizations need to build in managing and using IT in the context of environmental sustainability has yet to be researched. To date, no empirically validated framework that guides practitioners and researchers to explain the capability that firms need to build in order to Green their IT and the extent to which they have progressed along the Green IT path has emerged. Indeed, IS research is criticized for failing to provide meaningful assistance to "those organizations unsure about how, where, and when to respond to imperatives for their [IT] applications and practices to become Green" [Elliot and Binney, 2008, p. 1] and for being slow to recognize the problem of climate change and take action [Watson et al., 2010]. While the opportunities and potentials of Green IT might be attractive, a measure of the Green IT readiness (G-readiness) of organizations has not been provided in extant literature. Without such a measurement, organizations will be unable to determine their current performance in relation to Green IT initiatives, and this will subsequently impede their ability to improve these capabilities. In addition, reliable measurements are necessary for developing a cumulative empirical research tradition [Recker and Rosemann, 2010].

The aim of this article is to aid the process of theorization of Green IT by addressing the questions of "What capability do firms need to build into their IT organization in Greening IT?" and "How can the dimensions of this capability be assessed?" The study defines the Green IT readiness, G-Readiness in short, to explicate the capabilities businesses need to nurture in the sustainable management of their IT infrastructure and in IT department's role to promote enterprise-wide sustainability. It makes an original contribution to advance the sustainable management of IT through theorization, model construction, and measurement development.

The remaining part of the article is organized as follows. Section II reviews the conceptual foundations of the G-readiness construct drawing from the sustainability, IT infrastructure, and e-readiness literature. Next, the development of the G-readiness construct is presented including instrument development and preliminary validation. Third, the implications of the model are discussed. Finally, conclusions are drawn and limitations of the study are identified with suggestions for future research.

II. CONCEPTUAL BACKGROUND

The conceptual foundation of the G-readiness framework is drawn from the theories of sustainability, the natural-resource-based view, the resource-based view of IT and E-readiness. Each of these areas is reviewed next.

Sustainability and Green

Sustainability is an often used but less understood concept. The Brundtland Commission defines sustainability as "development that meets the needs of the present world, without compromising the ability of future generations to meet their own needs" [Brundtland, 1987, p. 8]. The commission treats development not as a "state of harmony," but as a "process of change." Thus, for development to be sustainable, the decision of individuals, organizations, and institutions about resource consumption, technological innovation, and institutional orientation have to be consistent with future as well as present needs [Robèrt et al., 2002]. For organizations, this implies balancing the pursuit of economic interest with responsibility toward the wider society and the natural environment. Thus, a prominent way of defining the sustainability construct is through its triadic nature that encompasses *economical, social, and*

environmental dimensions [Elkington, 1994]. This balancing of economic profitability with social responsibility and environmental obligations is commonly referred to as the “Triple Bottom Line” [Elkington, 1998].

In this article, we focus on environmental sustainability for IT, as until recently this issue has received little attention from IS researchers. Importantly, however, in narrowing our scope to environmental sustainability, we do recognize that economical, social, and environmental sustainability are closely intertwined and in practice difficult to separate. As such, although environmental sustainability is primarily concerned with commitment toward the natural environment, research shows that organizations’ investment to improve their environmental performance yields operational and market benefits. For example, two-thirds of the executives in Toyota, GE, Timberland, and Starbucks see eco-sustainability as a revenue driver [Unruh and Ettenson, 2010]. Sen et al. [2006] indicate that a growing proportion of customers and investors consider the environmental awareness of a business in their decision to conduct business and buy share respectively. Rao and Holt [2005] also found a positive relationship between green supply chain management practices and market performance and competitiveness.

In relation to environmental sustainability, a number of concepts are often used interchangeably. These include *Green*, *eco-sustainable*, and *environmentally friendly*. A full review of these concepts is out of the scope of this article. Nevertheless, Hart [1997] refers to “ecologically sustainable” and Baumann et al. [2002] use *Green* to describe firms, products, and production processes that use less energy, that recycle materials, that reduce waste and pollution, and that preserve natural resources. Yet, *Green*, when viewed from the socio-historical perspective, refers to the “pro-environmental” movement that symbolizes a general reaction toward the fracture in the Western social formation; its economy, security systems, social structures, and traditions [Galtung, 1986].

Hart [1995, 1997] proposes a natural-resource-based theory that defines the greenness of organizations as competencies of pollution prevention at the end of a product’s use, product stewardship to minimize the environmental footprint during use and adoption of clean technologies to reduce the use of polluting materials and develop environmentally friendly competencies. Pollution prevention focuses on the control and prevention of polluting emissions and effluents during organizational production and operations processes. Pollution control means cleaning up waste once it has been created, and this can be achieved via the use of pollution-control equipment, whereas pollution prevention means minimizing or preventing pollution before it occurs, and this can be achieved via improved management, material substitution, recycling, or process innovation [Hart, 1997; Hart and Milstein, 2006]. Product stewardship requires environmental impacts to be considered throughout the entire lifecycle of the organization, including raw-material sourcing, product design, and development processes [Hart, 1997; Hart and Milstein, 2006]. Clean technology requires investment in technologies of the future. Such technologies can cause significant changes in the production process with a view to reducing the level of environmental impact along a product’s lifecycle from design to consumption [Hart, 1997].

Thus, a business is considered as green if it has made an enduring commitment to integrate environmental sustainability principles of pollution prevention, product stewardship, and use of clean technologies into all of its business decisions and operations [Schendler, 2002]. Green businesses also supply products or services that control and prevent pollution, that improve product stewardship, and that are clean (such as renewable) and replace the demand for non-green products and services. Thus a green business could be one that is set up on “green basis” or one that has transformed to become green [Walley and Taylor, 2005].

The processes for organizational transformation to become greener are complex. Legislation, stakeholder pressures, economic opportunities, and competition all play significant roles [Bansal and Roth, 2000]. Generally, an organization’s sustainability transformation has been linked to organizational- and individual-level factors [Hostager et al., 1998]. Whereas the organization can signal the desire for ecological innovation through the development of policies and the provision of supervisory support from management [Ramus and Steger, 2000] and incentives [Hostager et al., 1998], it is individuals with the capacity (skills and capability) and intrinsic motivation (values and concern) required to be environmental innovators [Ramus and Steger, 2000]. Individual champions who are able to successfully identify, frame, present, and sell environmental issues are important in the eco-sustainability transformation of organizations [Andersson and Bateman, 2000].

Organizational sustainability transformation also requires adopting a lifecycle approach to organizational processes and products. A lifecycle approach implies that adverse impacts of products and services on the environment have to be considered from raw-material sourcing through product design and development processes to distribution and end-of-life management [Heiskanen, 2000]. A lifecycle approach has been employed to examine various industries and products and can equally be applied to IT [Melville, 2010]. Such an approach can enable an organization to understand trade-offs at each stage in order to better manage its sustainability performance. Further, organizations that combine a lifecycle approach within a wider performance framework, such as the triple bottom line [Elkington, 1998], are able to better measure their economic, social, and environmental performance [Elliot, 2007].

Table 1 summarizes the key concepts and definitions extracted from the sustainability literature in light of its relevance to the Green IT Readiness construct.

Table 1: Summary of Key Sustainability Concepts		
Concept	Definition	Relevance to G-readiness
Sustainability	Meeting the needs of the present world, without compromising the ability of future generation to meet their own needs.	Provides the conceptual foundation on the role of IT in sustainable development and position the G-readiness construct within the IT and sustainable development equation.
Triple Bottom Line	The consideration of economical, social, and environmental dimensions in measuring organizational sustainability.	The concept of triple bottom line and the triadic nature of economical, social, and environmental performance imply that even if G-readiness is primarily concerned with the eco-sustainability of IT, it will have impact on the economical and societal value of IT.
Natural-Resource-Based Theory	Defines eco-sustainability as a firm's relationship with the natural environment in relation to three strategies: pollution prevention, product stewardship, and clean technologies.	The concepts of pollution prevention, product stewardship, and use of clean technologies can be applied in defining what it means to green IT and to use IT to green the rest of the enterprise.
Sustainability Transformation	Explains sustainability transformation and why and how organizations become greener.	Factors such as sustainability champions, governance, and policy-setting assist our understanding of why and how organizations become greener.
Lifecycle approach	Considering environmental impacts from raw-material sourcing through product design and development processes to distribution and end-of life management.	This means an organization's view of greening IT needs to be expanded to reflect the entire IT lifecycle from creation, through sourcing, to disposing.

IT Infrastructure

IT, both as a source of problem and solution, is increasingly becoming linked to eco-sustainability [Fuchs, 2008]. Each stage of the IT lifecycle from manufacturing to usage and disposal has deleterious environmental impact [Murugesan, 2008]. Therefore, both IT hardware manufacturers and firms using IT need to apply principles of pollution prevention, product stewardship, and use of clean technologies in managing IT. IT can also be deployed to prevent pollution, improve product stewardship, and facilitate sustainable development [Melville et al., 2010]. In this article, consistent with our organizational focus, we draw from the IT infrastructure and capability perspective to conceptualize IT.

The IT infrastructure and capability perspective, which draws from the resource-based theory, is a relevant framework in defining the "IT" in Green IT. The IT literature typically defines the IT infrastructure in terms of the basic technology assets, with some definitions extending this to include resource planning and management factors that affect the design and capabilities of infrastructure [Byrd and Turner, 2000]. IT infrastructure is also conceptualized as a pyramid of three layers: *IT and communications technologies* (e.g., physical servers and network devices); *shared services* (e.g., enterprise-wide databases and electronic data interchange (EDI)); and *business applications* that utilize the shared infrastructure (e.g., sales analysis, purchasing) [Broadbent and Weil, 1997]. Importantly, people with knowledge, skills, and experience bind the technology components into reliable, shared IT infrastructure services [Broadbent and Weil, 1997]. Human, technological, and relationship resources affect IT departments' functional capabilities which in turn affects the capability of IT to support the core competencies of an organization [Ravichandran and Letwongsatien, 2005]. Thus, previous IT research distinguishes between *the technical IT infrastructure* and the *IT human and managerial capability infrastructure* posit.

The technical IT infrastructure encompasses the physical IT and communications resources of an organization, along with the shared services and business applications. It encompasses an organization's network, storage, data, and application assets as well as the network critical physical infrastructures [Byrd and Turner, 2000; Rasmussen, 2006]. The *IT 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, p. 169]. The *managerial capability* comprises the management of all IT activities including strategic foresight concerning changes in the business, IT and wider environment [Ravichandran and Letwongsatien, 2005].

The greening of the IT infrastructure implies, therefore, that eco-sustainability considerations need to be incorporated within the IT technical and human infrastructure and IT managerial capability dimensions of the IT

infrastructure across the entire IT lifecycle. Table 2 summarizes the key concepts extracted from the IT infrastructure and capability perspective in light of their relevance to the G-readiness construct.

Table 2: Summary of Concepts from the IT Infrastructure and Capability Perspective

Concept	Definition	Relevance to G-readiness
IT Technical Infrastructure	The physical IT and communications resources of an organization, along with the shared services and business applications.	Provides a basis for defining the IT technical assets of an organization that can be transformed to a greener IT.
IT Human Infrastructure	The experiences, competencies, commitments, values, and norms of the IT personnel delivering the IT products and services.	Provides a basis for identifying and defining the necessary environmentally-based behaviors of IT people in the transformation to a greener IT.
IT Managerial Capability	The management of all IT activities including strategic foresight concerning changes in the business, IT and wider environment.	Provides a basis for identifying and defining the IT managerial capability needed to transform toward a greener IT.

The speed with which environmental sustainability impacts IT infrastructure requires a construct that not only accounts for factors enabling the spread and usage of Green IT, but also explicitly considers the roles played by key enterprise stakeholders. This leads to a question: How do enterprises succeed in greening their IT? We argue that as much as e-readiness has been and still continues to be a critical attribute to succeed in the digital economy, G-readiness could be a critical capability to succeed in the low-carbon digital economy. The following section offers a review of the readiness (e-readiness) concept.

E-Readiness and Capability

Although the construct of “readiness” can be traced in organizational change, Information Systems, business process reengineering (BPR) and innovation literature, it has become popular in the e-commerce and e-government literature. Several researchers have used the “readiness” or “e-readiness” construct in empirical studies [e.g., Tanet. et al., 2007; Molla and Licker, 2005]. At a global scale, since 2001, the World Economic Forum publishes its annual report on the “Network Readiness” of countries [Dutta and Mia, 2010]. Two dimensions of the e-readiness construct can be identified in the literature. The first refers to readiness as a precursor condition (or set of conditions) for the implementation of initiative such as a change, IS or innovation [e.g., Guha et al., 1997]. The second refers to readiness as a capability of a business that needs constant building, rebuilding and upgrading [e.g. Clark and Cavanaugh, 1997; Dutta and Mia, 2010]. This current article promotes the construct of readiness as a capability.

Organizational capabilities are explained in the context of the resource-based view of the firm [Barney, 1996; Wade and Hulland, 2004]. The resource-based view of the firm considers firms to be heterogeneous bundles of resources whose characteristics can predict organizational success [Barney, 1996]. An organization’s capability differentiates it from its competitors and can affect organizational performance. Capabilities could be tangible or intangible firm-specific processes and assets that represent firms’ ability at coordinating and deploying resources [Bhatt and Grover, 2005]. It can include functional skills and cultural perceptions to manage change and innovation. Capabilities emerge over time through complex interactions among tangible and intangible resources. Overall though, capabilities could be input, transformational and output-based [Lado et al., 1992]. Input capabilities refer to firms’ physical, capital, and human resources. In particular, human resource capabilities include the training, experience, judgment, and insights of managers and workers. Transformational capabilities transform inputs into outputs, and include innovation to generate new processes, products, and services, as well as organizational culture, learning, and adaptation. Output capabilities refer to firms’ tangible products and services and intangible output.

Extending these views to Green IT, capabilities represent the tangible and intangible assets, resources, and processes by which firms deploy eco-sustainability considerations in building and managing their IT infrastructure. Thus, a firm’s capability to Green its IT can be understood by looking at the permeation of eco-sustainability considerations in a company’s IT department input, transformational and output capabilities. An IT department’s input capabilities include IT human resources. While transformational capabilities cover the routines and processes that IT management follow to deliver its services, output capabilities refer to the IT products, systems and practices that are delivered to the wider organization.

When a capability perspective of readiness is adopted, it is clear that the development and distribution of capabilities are not uniform across firms and are highly firm-specific. Capabilities require constant building, rebuilding, and upgrading; hence different firms are likely to be found at different states of maturity. Consequently the readiness of an organization could be considered an assessment of a level of maturity at a particular point in time. Maturity can be considered to be a result of adopting a lifecycle approach whereby a firm develops through the levels over time

until it reaches “perfection” at the highest level [Klimko, 2001]. A variety of frameworks to assess an organization’s maturity are available, the most famous being the Capability Maturity Model [Humphrey, 1988]. The CMM approach is an internationally recognized framework that has been applied in Software Engineering, IT management, IT business alignment, outsourcing vendors, and e-business and e-government to reveal and map achievements in key performance areas. Understanding the level of maturity of an organization can be beneficial by providing a framework to prioritize actions to improve performance.

Table 3: Summary of Concepts from E-Readiness and Capability Perspective

Concept	Definition	Relevance to G-readiness
E-readiness	Refers to critical human, technological and managerial capacities required to transform to e-business and to execute in the e-economy successfully.	Provides a solid framework to understand organizations’ capacity to transform towards a greener IT and help to identify some of the important variables necessary for such transformation.
Organizational Capabilities	Capabilities represent firms’ ability at acquiring, coordinating, and deploying resources. Capabilities can be input-, transformation-, and output-based.	Offers a theoretical foundation to anchor G-readiness as the permeation of eco-sustainability principles in a company’s IT input, transformation and output capabilities.
Maturity	A framework that maps a firm’s development through various stages over time until it reaches the highest level of perfection.	The G-readiness of an organization at any one time can be considered to be an assessment of the level of maturity with respect to Greening IT.

The combination of the eco-sustainability, IT infrastructure, and e-readiness perspectives offer useful insights in conceptualizing G-readiness. As more organizations become concerned with Green IT, there is a need to understand their capability for implementing and sustaining Green IT strategies and policies.

III. DEVELOPMENT OF THE G-READINESS FRAMEWORK

Green IT and G-readiness are the main constructs of interest in this research. In order to develop the G-readiness framework and ensure the accuracy and validity of its measuring instrument, this study follows structured procedures outlined in previous research [Churchill, 1979; Straub et al., 2004]. The first stage involves defining the domain construct of Green IT and G-readiness. Stage two operationalizes the constructs by generating measuring items to ensure content validity. In stage three, sample design and data collection issues are covered. Stage four contains data analysis to test the validity and reliability of the developed model and instrument.

Domain of the G-Readiness Construct

Defining a construct’s theoretical meaning and conceptual domain are necessary steps in developing a construct and an accurate and valid instrument to operationalize it. Clear domain definition is also an essential procedure in ensuring the content validity of an instrument.

Green IT means many things to different people. In the practitioner literature, Green IT has mostly been associated with technologies and initiatives to reduce the power consumption of IT [Accenture, 2008]. This aspect of Green IT is not new. The IT industry has been undertaking initiatives to improve the energy performance of technologies for several decades. For some IT managers and IT vendors, Green IT is also about data center energy efficiency. Therefore, narrowly defined, Green IT implies technologies and initiatives to reduce the power, cooling, and real estate costs associated with data center operations [Info-Tech, 2007b; Mines, 2008]. However, Green IT should be seen more than data centers and encompasses an enterprise’s overall IT activities. Elliot [2007: 107], therefore, defines Green IT as *“the design, production, operation, and disposal of [IT] and [IT]-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 challenges of IT—IT as a problem and IT 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 “IT” and the positive environmental benefits associated with Greening IT.

This current article conceptualizes Green IT from the IT infrastructure and capability perspective taking an IT lifecycle approach. This implies that eco-sustainability considerations need to be incorporated within the IT technical and human infrastructure and IT managerial capability dimensions of the IT infrastructure. In addition, the insight from the green supply chain literature [Rao and Holt, 2005] indicates that the boundary of Green IT conceptualization can range from green production, through green purchasing and internal operations to end of IT life management. Thus, Green IT is defined as:

Green IT is a systematic application of ecological-sustainability criteria (such as pollution prevention, product stewardship, use of clean technologies) to the creation, sourcing, use and disposal of the IT technical infrastructure as well as within the IT human and managerial practices.

Thus defined, Green IT includes hard technologies as well as soft systems and business practices spanning the IT lifecycle from sourcing through building and use to disposal. Environmental considerations can be embedded in the mindset of decision makers, IT systems, policy frameworks, and operational routines, as well as in IT human infrastructure and managerial considerations and practices.

Firms are likely to vary in their Green IT input, transformational, and output capabilities. We use the concept of Green IT Readiness (in short G-readiness) to capture this construct. On the basis of the definition of Green IT and the e-readiness and capability framework discussed in Section II, G-readiness can refer to the maturity of environmental considerations, whether they're part of a coherent set of IT management policies, they've been adopted into the IT human and managerial operational practices, or been built into concrete Information Systems. Thus:

G-readiness is defined as an organization's capability in Greening IT (that is applying environmental criteria to its IT technical infrastructure as well as within its IT human and management practices across the key areas of IT creation, sourcing, operations, and disposal) in order to reduce IT, business process, and supply chain related emissions, waste and water use; improve energy efficiency; and generate green economic rent.

G-readiness demonstrates the comparative levels of Green IT development among businesses and serves as one of the benchmarks for measuring an enterprise's progress to participate in the global low-carbon e-economy. Thus G-readiness is a measurement of the Green IT capabilities of an organization.

Content Analysis of G-Readiness

Strategies for G-readiness Operationalization

The operationalization of the G-readiness construct follows two exploratory strategies. First, we use the IT infrastructure and capability perspective and the input, transformational, and output dimensions of capabilities to analyze existing Green IT practitioner and academic publications. There were three reasons for restricting the content areas of G-readiness to the capabilities derived from the resource-based theory. First, given that resource-based theory is an important theory in explaining firm performance and the role of IT in firm performance, it offers a clear foundation to the theoretical domain of G-readiness. A strong and clear theoretical meaning and conceptual domain are essential for developing a reliable and valid instrument [Straub et al., 2004]. Second, human, technological and managerial resources impact on the functional capabilities of IT departments which, in turn, impacts the capability of IT to support the core competencies of an organization [Ravichandran and Letwongsatien, 2005]. Thus a focus on these capabilities provides much scope to develop our understanding of the role of IT in enterprise-wide green transformation. Third, a capabilities perspective is consistent with the natural-resource-based theory [Hart, 1995] which views green competencies (such as G-readiness) as sources of value that can contribute to sustained competitive advantages, thus showing the triadic nature of the triple bottom line.

The decision to examine both practitioner and academic publications is mainly because at the time of the survey the literature on Green IT was scant with little empirical work focusing on input, transformational, and output capabilities. The analysis was conducted in three stages: identification of articles, coding and identification of indicators, and assessment. To identify relevant publications, we initially searched for the terms "Green Information Technology," "Green data centers," "Making IT green," "reducing energy consumption of ICT infrastructure" in Ebscohost, Proquest, Emerald, Google Scholar, Google and Amazon databases. Subsequently, seven practitioner publications are sourced from Green IT reports released during 2007–2009 by four of the major technology research and service firms, namely Gartner, Accenture, Forrester, and Infoedge. These four firms are inarguably the leaders in the Green IT space. The academic publications are identified mostly from proceedings of IS conferences held during 2007–2009. In the second stage, using the theoretical categories as seed codes, two researchers independently read each article and identified relevant indicators. In the third stage, the codes produced are evaluated as a group and differences resolved through discussion leading to a number of points discussed below and indicators (see Table 4).

First, as a basic input capability, greening IT requires changing the mindset of IT personnel. Second, there are a number of technologies such as virtualization that are considered to be Green. Third, recommendations to Green IT also cover softer practices such as IT energy utilization audit, PC power management, eco-friendly IT disposal, and data center energy and airflow management. Fourth, differences exist in the institutionalization of Green IT policies and between the eco-sustainability intention of a business as captured in policy documents and the actualization of those intentions. Fifth, although the importance of managing Green IT is well recognized, current practices vary

significantly. While some allocate specific budget for and give the responsibility to Green IT to IT managers, others consider Green IT as part of enterprise-wide sustainability initiatives.

Table 4: Content Analysis of Green IT Publications

Capability Category	Indicators	Green IT Publications*												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Green IT Input Capability	Sustainability intelligence	X				X				X			X	
	Attitudes and beliefs toward climate change		X		X		X	X	X					X
	Awareness				X		X		x					
Green IT Transformational Capability	Green governance process and roles		X		X	X							X	
	Assess, measure, monitor		X		X					X		X	X	
	E-waste policy			X										
	Environmental strategy		X	X					X	X				
	CIO commitment		X		X	X	X		X	X		X		
	IT procurement policy				X		X			X	X			
	Budget commitment		X			X	X	X						
Green IT Output Capability	Green data center	X	X		X		X			X	X			
	Infrastructure virtualization, consolidation	X	X		X		X			X	X			
	Energy efficiency in end user IT		X		X		X	X	X	X	X	X		
	Green enabling tools, technologies and systems		X	X	X	X	X		X	X		X		X
	End of IT life management			X			X		X	X			X	
	Retiring energy inefficient systems	X	X				X							
	Energy audit		X				X	X						
IT vendor green track record assessment							X	X			X	X		
* Legend:		4 Elliot and Binney [2008]			8 Jenkin and Mc-Shane [2009]			11 Nunn [2007]						
1 Accenture [2008]		5 Gartner [2008]						12 Schmidt et al. [2009]						
2 CFO [2009]		6 Info~Tech [2007a,b]			9 Mines [2008]			13 York et al. [2009]						
3 Elliot [2007]		7 Info~Tech [2008]			10 Murugesan [2008]									

The second strategy led to a desk-based research utilizing secondary data source (such as Company Websites, Internet, Newspaper articles) of seven conveniently selected companies—SAP, IBM, Deloitte, ANZ, Australia Post, BHP, Telstra. This search strategy was not intended to evaluate the capabilities of these organizations in Greening IT, but rather, to get examples and anecdotal evidences of what organizations are doing in Greening their IT infrastructure and if there are any commonly encountered barriers. Although such a strategy is not a substitute to an in-depth case study and cannot be claimed to be adequate, it nonetheless offers some practical insight into the nature of the study phenomenon given the constraints of access and resources for conducting in-depth case studies. Using the five key lessons identified from the literature search as a template, a research assistant working for thirty hours has conducted the desk-research. Further details of the desk-research and its findings are reported in Molla and Cooper [2010]. This strategy has provided indications regarding the extent to which Green IT is top of mind in these organizations and how environmental considerations are being incorporated in IT sourcing decisions, end-user IT usage, e-waste management, and product development.

Definition of the G-Readiness Components

The above two strategies and the conceptual foundation discussed in the earlier section of this article led to the identification of five components of G-readiness, that is, *attitude, policy, practice, technology, and governance*. The attitude dimension of G-readiness is an element of the IT human infrastructure and can be argued to represent the Green IT input capability. The policy and governance components are elements of the IT managerial capability and represent the transformational capability. The technology and practice components are elements of the IT technical infrastructure and represent the output capability. Combining the definition of G-readiness provided earlier in this article with these five components yields:

G-readiness is an organization's Green IT capability as demonstrated through the combination of green IT attitude, policy, practice, technology, and governance in order to reduce IT, business process, and supply chain related emissions, waste and water use; improve energy efficiency; and generate green economic rent.

Thus G-readiness is a second-order construct composed of first-order constructs of Green IT Attitude, Green IT Policy, Green IT Practices, Green IT Technologies, and Green IT Governance. Table 5 reflects the definitions of the constructs identified and their theoretical domain; it is followed by a discussion of each of the dimensions.

Table 5: Construct Definitions

Construct	Definition	Conceptual Domain
Green IT	Green IT is a systematic application of ecological-sustainability criteria (such as pollution prevention, product stewardship, use of clean technologies) to the creation, sourcing, use, and disposal of the IT technical infrastructure, as well as within the human and managerial components of the IT infrastructure.	<ul style="list-style-type: none"> • Natural resource-based view (NRBV) theory [Hart, 1995] • Lifecycle approach [Heiskanen, 2000] • IT Infrastructure and Capability [Byrd and Turner, 2000]
Green IT Readiness	G-readiness is an organization's Green IT capability as demonstrated through the combination of green attitude, policy, practice, technology, and governance in order to reduce IT, business process, and supply-chain-related emissions, waste, and water use; improve energy efficiency, and generate Green economic rent.	<ul style="list-style-type: none"> • Capabilities perspective of RBV [Lado et al., 1992] • NRBV [Hart, 1995] • E-readiness [Dutta and Mia, 2010; Molla and Licker, 2005]
Green IT Attitude	Refers to an organization's IT people sentiment, values, and norms toward climate change and eco-sustainability and IT's role.	<ul style="list-style-type: none"> • Input Capability [Lado et al., 1992] • IT human capability [Byrd and Turner, 2000]
Green IT Policy	Refers to the environmental criteria and frameworks an organization puts in place to guide the sourcing, use, and disposal of the IT technical infrastructure and the activities of IT people.	<ul style="list-style-type: none"> • Transformational capability [Lado et al., 1992]
Green IT Governance	Refers to the operating model that defines the administration of Green IT initiatives, the allocation of budget, and other resources and the metrics for assessing impacts.	<ul style="list-style-type: none"> • IT managerial capability [Ravichandran and Letwongsatien, 2005]
Green IT Practice	Pertains to the actual application and realization of eco-sustainability considerations in IT infrastructure sourcing, operation, and disposal.	<ul style="list-style-type: none"> • Output capability (Soft) [Lado et al., 1992]. • (Soft) IT technical infrastructure [Byrd and Turner, 2000]
Green IT Technologies	Refers to Information Technologies and Systems for reducing the energy consumption of powering and cooling corporate IT assets, optimizing the energy efficiency of the IT technical infrastructure, reducing IT induced greenhouse gas emissions, supplanting carbon emitting business practices, and analyzing a business's total environmental footprint.	<ul style="list-style-type: none"> • Output capability (Hard) [Lado et al., 1992] • (Hard) IT technical infrastructure [Byrd and Turner, 2000]

Green IT Attitude: An attitude represents an enduring positive or negative feeling about some object or issue [Eagly and Chaiken, 1993]. Attitudes are learned dispositions and are often the result of experiences. On the issue of climate change, two major attitudes can be found. Most submit that the climate is changing at an alarming rate and human (including business) activities are the main causes of the change [Stern, 2008]. On the other hand, others are skeptical about the causes and impacts of climate change [Royal Society, 2007]. This group maintains that the climate is always changing, and its impact is not as severe as most would have liked us to believe. Correspondingly, organizations are likely to adopt very different attitudes at the corporate level for dealing with eco-sustainability, and these differing attitudes will impact their expectations of Green IT [CFO, 2009; York et al., 2009; Info-Tech, 2008]. *Green IT attitude* is defined, therefore, as an organization's IT people sentiment toward climate change and eco-sustainability. It measures the extent to which both IT and business are aware and concerned about the impact of IT on eco-sustainability. The power of individuals in creating leverage for organizational actions toward environmental issues has been shown to rely on their ability to champion such issues [Andersson and Bateman, 2000], their values about responsible actions as sustainability-aware employees [Collins et al., 2007], their motivation to follow organizational or supervisor encouragement [Ramus and Steger, 2000], and their perception of environmental norms as guiding principles for their actions [Cordano and Frieze, 2000]. For example, ANZ's Top management attitude toward Green IT is highlighted from statements in its Carbon Disclosure Project.¹ The sentiment to environmental concerns from the use of IT is further strengthened by the involvement of top management through the initiatives of ANZ CIO, whose intention was to remove a total of 400 servers from the bank's infrastructure by the end of 2009 to reduce both electricity cost and carbon emissions.

¹ http://www.anz.com/Documents/AU/Aboutanz/ANZ_CDP5_Response_FINAL.pdf

Green IT Policy encompasses the frameworks an organization puts in place to apply environmental criteria in its IT-related activities. It defines the extent to which Green issues are encapsulated in organizational procedures guiding the sourcing, use, and disposal of the IT technical infrastructure and the activities of IT people [Gartner, 2008; Info-Tech, 2007a,b; Jenkin and McShane, 2009]. The maturity of Green IT policy reflects whether environmental considerations are systematically permeating the IT activity value chain and are repeatable or they are disorganized and based on uncoordinated efforts. Policy captures an organization's intent to Green IT. However, not all policies are expected to be smoothly implemented, nor are all practices expected to be policy led.

Green IT Governance is the operating model that defines the administration of Green IT initiatives and is closely related to the policy construct. Roles, responsibilities, accountability, and control for Green IT initiatives need to be clearly established. Businesses should determine whether the responsibility for Green IT initiatives should be assigned to CIOs or to environmental managers [CFO, 2009; Elliot and Binney, 2008; Gartner, 2008]. In ANZ and Deloitte, IT leads Green IT initiatives, while in others, IT's role is restricted to providing either tools or insights [Gartner, 2008]. SAP on the other hand has an internal campaign, called *sGreen*, with the goal of launching green environmental program that defines global roles and responsibilities. Deloitte's Green IT operating model is based on a three-step process of planning sustainability measures, implementing, and tracking the measures and addressing green organizational change.² Governance also includes allocation of budget and other resources to Green IT initiatives and defining metrics for assessing the impacts of Green IT initiatives. Indeed, governance capability will require standard administrative processes for developing Green IT initiatives to be put in place.

Green IT Practice pertains to the actual application and realization of eco-sustainability considerations in IT infrastructure sourcing, operation, and disposal. Organizations are likely to vary in the actual practice of analyzing the Green track record of IT hardware, software, and services providers [CFO, 2009; Elliot and Binney, 2008; Info-Tech, 2007a,b]. They are also likely to vary in their practice in operating the IT and network critical physical infrastructure in data centers and beyond data centers throughout the organization in an eco-friendly manner [Accenture, 2008; CFO, 2009]. For example, some are enforcing advanced Configuration and Power Interface (ACPI) to slow down processors [Info-Tech, 2007a]. ANZ has banned screen savers and is retiring energy inefficient systems. In 2005, IBM USA's Tele-work program involved over 20,000 employees, saving more than five million gallons of fuel and avoiding more than 50,000 tons of CO₂ emissions. A number of companies either recycle their IT hardware at the end of its life or dispose it in an environmentally friendly way [CFO, 2009]. For instance, Deloitte's Green IT practices involve "replacing traditional computers with thin laptops, embracing LEED (Leadership in Energy and Environmental Design) for new data centers, and introducing application centralization and platform standardization."³

The *G-readiness technological* dimension refers to technologies and Information Systems for (a) reducing the energy consumption of powering and cooling corporate IT assets (such as data centers) (b) optimizing the energy efficiency of the IT technical infrastructure (c) reducing IT induced greenhouse gas emissions (d) supplanting carbon emitting business practices and (e) analyzing a business's total environmental footprint [Accenture, 2008; York et al., 2009; Jenkin and McShane, 2009; Elliot and Binney, 2008]. For example, SAP's Recycling Administration Application can help organizations meet regulatory reporting and documentation requirements, manage the recycling declaration and payment processes more efficiently, and reduce risk and cost of environmental reporting. The SAP Environmental Compliance application is designed to help "organizations ensure compliance with environmental laws and policies and reduce associated costs, efforts, and risks on plant and corporate level. It streamlines all environmental processes by seamless integration with operations control data, production control systems, and components from SAP software for environment, health and safety, enterprise asset management, materials management, the SAP Manufacturing Integration and Intelligence (SAP MII) application, business intelligence and knowledge management."⁴

Generation and Evaluation of Measurement Items

Using the Green IT dimensions discussed in the previous section, the definition of the constructs (Table 5), the content analysis of the Green IT practitioner, and academic literature reported in Table 4, two researchers working independently generated an initial pool of 103 items. They then met to discuss and defend their items and created a joint list of eighty-three items. After the joint pool of items was identified, an expert panel of five researchers, including the original two plus three additional researchers (two full professors and one assistant professor) who are researching Green IT and who have experience in survey design, reviewed the relevance of each of the items in relation to the variables they are supposed to measure. This assessment was done in two meetings, each ninety

² <http://www.deloitte.com/dtt/article/0,1002,sid%253D171726%2526cid%253D191008,00.html>

³ <http://www.computerworld.com.au/index.php/id:251353255:fp:4:fpid:2359>

⁴ www.sap.com

minutes long, of the panel where items were revised, decisions made, and differences resolved through open and consensual discussion. This has resulted in the reduction of the items from eighty-three to seventy and edit of the instrument to capture the essence of the domain constructs of the G-readiness dimensions.

After this discussion, the resulting questionnaire was then submitted for ethics approval to a Collage Ethics Committee. Based on feedback from the College Ethics' Committee, three items were dropped. Before deleting the three items, the impact of the deletion on the face validity of the construct was considered [Churchill, 1979]. As such, deleted items were either redundant or asked questions that were deemed outside the scope of the project and were not critical to the content domains of the constructs. The deleted items include:

- "We use eco-labeled IT equipment that may include aspects energy efficiency."
- "We have an IT sustainability road map integrated into business strategy."
- "We have corporate guidance on sustainable use of IT assets."

The evaluation process resulted in the sixty-six items found in Appendix A with original sources of references.

Sample Design and Data Collection

The empirical part of the research was conducted in order to collect the data and evaluate the reliability and construct, convergent, factorial, nomological, and predictive validity [Straub et al., 2004] of the measurement instrument. Data for the study were collected through a survey of organizations. To define the sampling frame for the study, we targeted organizations in Australia, New Zealand, and the United States with more than 100 employees, but we excluded those in the agriculture and mining sectors. These two sectors were excluded because our reading of the practitioner and academic literature led us to believe that, for organizations to be concerned about greening IT, they need to have some level of IT-use sophistication. The agribusiness and mining sectors generally demonstrate low intensity of IT utilization [Molla et al, 2010; European Commission, 2008]. Another criterion was to target Chief Information Officers or their equivalent. The decision to survey organizations from the three countries was motivated because of the need to cover broader geographic areas; the researchers' location (Australasian region); to follow the IS research norm (that is, most, if not all, IS surveys are from the United States) and in order to increase the applicability of the G-readiness construct. Virtually all commercial database providers contacted for the purpose of the study do not have a product that covers the three countries. As a result, two providers were selected. The sampling criteria were then passed to the two commercial database providers. Australian and New Zealand sample were drawn from a database rented from IncNet Australia whereas United States samples were drawn from the Top Computer Executives database. IncNet was chosen because to the best of our knowledge it is the only business database that provides names and e-mail addresses of IT managers. The Top Computer Executives database is widely used in previous IS research.

IncNet provided an initial list of 1305 contacts from Australia and 215 from New Zealand. Upon inspection of the data set, 354 of the Australian and thirteen of the New Zealand contacts were outside the sample frame (mostly non-CIO contact and in some cases industries excluded from the sample frame) and, therefore, were excluded. 1000 records were rented from the Top Computer Executives database. The database providers assured 80 percent delivery.

After initial screening of the rented databases, a total of 2153 CIOs or their equivalent (951 Australian, 202 New Zealand, and 1000 U.S.) were invited to complete the online survey. The survey questionnaire, in addition to the five G-readiness constructs, had items to capture the profile of respondents (job title) and the participating firms such as size (self-reported as small, medium, or large), industry classification, and scale of IT operations (such as installed server base, number of personal computers, and total number of IT staff, and extent of outsourced IT). The initial invitation was followed with three rounds of reminders. A total of 784 contacts bounced back because of delivery failure, out of office, or invitees' declining to complete the survey. A total of 146 responses were received. Three were unusable, hence removed from the analysis, leaving 143 usable responses (95 Australian; 14 New Zealand, and 34 U.S.). The response rate is comparable to response rates of other studies targeting senior executives [Bhatt and Grover, 2005; Fink and Neuman, 2007].

Most of the respondents (83 percent) were CIOs or IT (systems, infrastructure, and information) managers. Other job titles included Enterprise Architect, Software Development Manager, Office Manager, IT Coordinator, Directory of Sustainability, and IT Group Leader. While 69 percent classify their organizational size as medium and 24 percent as large, the remaining are small. In terms of industry distribution, most respondents were from manufacturing (21 percent), government (16 percent), and services (13 percent) sectors. Participating firms differ in terms of their IT profile. Forty-one percent of all respondents operate IT shops with less than fifty servers, 20 percent between fifty and 150 and 34 percent more than 150 servers. Other demographic characteristics are given in Table 6.

Table 6: Demographic Profile

Industry classification	Percentage	Organizational size	Percentage
Others	2%	Small	13%
Utilities and Transport	6%	Medium	64%
Trading	7%	Large	22%
ICT	8%	Total	100%
Finance and Insurance	8%		
Education	8%	Server size	Percentage
Health	10%	Less than 50	41%
Services	13%	50-150	20%
Government	16%	More than 150	34%
Manufacturing	21%	Missing	5%
Total	100%	Total	100%

To estimate the presence and extent of non-respondent bias, following an established norm in the literature [Lewis-Beck et al., 2004; Armstrong and Overton, 1977], early respondents are compared with late respondents, especially those that responded after reminders were sent out. This test, which is also referred to as extrapolation [Armstrong and Overton, 1977], is based on the assumption that the late respondents are likely to have characteristics similar to those of the non-respondents. There is no literature that discusses how to select the characteristics that are to be used for comparing early and late respondents. Therefore, the first twenty-one respondents are compared with the last twenty-one respondents on all items. Since Shapiro–Wilk test rejected the data to be normally distributed ($p < 0.05$), the Mann–Whitney U test is used to validate nonresponse bias. The result indicates that there is no difference among early and late respondents except in one item (31), which is a question directed to concerns about clients' environmental footprint. This implies that even if nonresponse bias exist, it is not statistically significant.

Instrument Assessment

A variety of techniques can be used to evaluate the measurement properties of a construct. The most common ones, which are assessed in this current study, are unidimensionality, convergent validity, discriminant validity, factorial validity, nomological validity, and predictive validity [Straub et al., 2004]. To assess unidimensionality and convergent validity, we first explored and identified the substrata of each construct with exploratory factor analysis (EFA). Confirmatory factor analysis (CFA) is used to conduct all validity tests.

For the EFA, maximum likelihood estimation with oblimin rotation was used. The objective of the EFA was to identify domain substrata and not to reduce the number of items. Kaiser's criterion (i.e., eigenvalue > 1) was used to evaluate the number of factors. However, using eigenvalue > 1 is known to usually overestimate, and sometimes underestimate, the number of factors [Zwick and Velicer, 1986]. Therefore, we used parallel analysis (PA) developed by O'Connor [2000] to estimate the maximum number of domain substrata that can be extracted. Parallel analysis is a Monte Carlo study that is based on researchers' interest to extract factors that account for more variance than those that can be "obtained from distributions of random numbers" [Montanelli and Humphreys, 1976, p. 341]. The method requires random generating data sets that parallel the actual data set and calculate eigenvalues. The calculated eigenvalues are then compared against those obtained from the EFA analysis of the actual data to estimate the maximum possible number of factors that can be extracted [O'Connor, 2000]. To undertake the parallel analysis, we run O'Connor's [2000, p. 400] SPSS script, randomly generated 1,000 data sets, and used the 95th percentile of eigenvalues calculated from the random data as the comparison baseline. A factor is retainable if its eigenvalue from the actual data is greater than the one calculated from the random data. The PA estimates the maximum (upper limit) number of substrata that can be extracted but the decision of how many of the estimated factors to retain depends, not only on eigenvalue comparison, but also on theoretical interpretability. The factorability of the data is tested through the Kaiser–Meyer–Olkin measure of sampling adequacy (KMOMSA) and Bartlett's test of sphericity. Generally data are factorable if the KMOMSA is between 0.5 and 0.1 and the Bartlett's Test of Sphericity is significant below 0.05. Sample size adequacy satisfies the subject to variable ratio of 5:1–10:1 [Hair et al., 2006].

For the CFA, LISREL 8.8 for structural equation modeling is used as analytical program. Since the data are captured at an ordinal level (i.e., a Likert scale), polychoric correlation, and weighted least-squares (WLS) are used to produce a correlation matrix [Jöreskog and Sörbom, 2001]. A critical consideration in using the confirmatory approach is sample size. Although there is no ideal sample size, around 200 is usually considered as "good" [Byrd and Turner, 2000]. Since the sample size in the current study is less than 200, the number of parameters to be estimated is reduced by constraining the measurement model from a congeneric model (i.e., each item measures a hypothetical factor with different accuracy and its measurement error is different) into a parallel model (i.e., all items

measure a hypothetical factor with the same accuracy and their measurement errors are the same) [Graham, 2006]. This approach improves the accuracy of parameter estimation and statistical power [MacCallu et al., 1996].

Unidimensionality and Convergent Validity Assessment (EFA)

Each of the items in Appendix A represents their corresponding components of G-readiness. In addition, the items are hypothesized to measure the associated factor, and the system of factors form the G-readiness construct. To identify the domain substrata, the five components of G-readiness are examined in separate EFA analyses. Appendix B provides the results of the five EFA models together with their corresponding Cronbach's α and parallel analyses. The EFA results show that Green IT Attitude and Technology are two-factor solutions; Green IT Policy and Governance each a one-factor solution, and Green IT Practice a three-factor solution. All Cronbach's α values are greater than 0.7, indicating reliability of extracted domain substrata. The parallel analyses confirm the maximum number of factors that can be extracted from each construct.

Unidimensionality and Convergent Validity Assessment (CFA)

Based on the factor structure of the EFA, we proceeded to test the unidimensionality of each factor. Straub et al. [2004] recommended the use of CFA to evaluate unidimensionality of a factor. This was achieved by using goodness-of-fit indices and a modification index (MI). If error terms are independent from one another, a factor is unidimensional; conversely, if error terms are correlated, a factor is multidimensional because a factor in an original model does not adequately account for common variance among items [Gerbing and Anderson, 1984].

Convergent validity assesses if a set of items represent the same latent variable. Chi-Square (χ^2) is used to test the convergent validity (unidimensionality) of each factor. When χ^2 reject a factor at $p < 0.05$, then it is assumed that the factor is multidimensional. Subsequently, modification index (MI) is used to further explore common factors among the items. Items that do not adequately share common variances with other groups of items were removed. This is to ensure that the set of retained items hold convergent validity. The analyses identified thirty-nine items in thirteen factors (Table 7). Further, it indicated that the initial G-readiness components are higher order and multidimensional and, therefore, are treated according to the procedure outlined above.

The final results show that all factors hold convergent validity. The Comparative Fit Index (CFI) is above the recommended cut-off 0.96 for unidimensionality and The Root Mean Square Error Approximation (RMSEA) is below 0.06 [Hair et al., 2006]. We used both Cronbach's α and coefficient H to determine construct reliability. Cronbach's α assumes a measurement model to be "essentially τ -equivalent" [Hancock and Mueller, 2001]. Essentially τ -equivalent models demonstrate equal true score (i.e., factor loading), but different precision (i.e., intercept or mean value) and error variance across items [Graham, 2006]. In contrast, congeneric models have different true score, precision and error variance across items [Graham, 2006]. From the CFA results, it is evident that not all measures have an equal factor loading or precision or error variance. This implies that our measures are a mix of congeneric and essentially τ -equivalent. When data violate the assumption of essentially τ -equivalence and the measures are congeneric, Cronbach's alpha underestimates the construct reliability [Cortina, 1993; Hancock and Mueller, 2001]. To overcome this limitation, Hancock and Mueller [2001] suggested a SEM approach, known as "coefficient H ." Coefficient H is flexible enough to accommodate congeneric measures and overcomes the dampening effect of items that load into a construct but that either do not or marginally contribute to the construct's meaning or interpretation on construct reliability. The idea behind coefficient H is that the construct reliability of congeneric measures should not be less than the reliability of the best item in a construct. To calculate the coefficient H , Hancock and Mueller's [2001, p. 202] formula is used:

$$H = \frac{1}{1 + \frac{1}{\sum_{i=1}^p \frac{\lambda^2}{1 - \lambda^2}}}$$

Table 7 shows that the Cronbach's α of all factors excepting POL1 and PRA3 satisfy the stringent reliability criterion of $\alpha > 0.70$. POL1 and PRA3 satisfy the lower limit Cronbach's $\alpha > 0.60$ for exploratory research [Hair et al., 2006: 137] and, therefore, are retained. Coefficient H is higher than Cronbach's α , especially for the congeneric measures.

Discriminant Validity Assessment (CFA)

Discriminant validity tests if the latent variables are different from one another and the components of G-readiness are indeed distinct, albeit related [Straub et al., 2004]. To assess discriminant validity, pairs of factors generated after convergent validity are correlated and the resulting correlations are tested to see if they are significantly

Table 7: Results of Convergent Validity Test

Component	Factor	Items	Factor Loading (λ)	χ^2	df	p	RMSEA	SRMR	NNFI	CFI	H	α
Attitude	ATT1	3A 3F 3I	0.71 0.71 0.71	5.87	4	0.21	0.057	0.055	0.99	0.98	0.75	0.74
	ATT2	3C 3D 3E	0.94 0.94 0.94	0.55	4	0.97	0.000	0.011	1.01	1.00	0.96	0.94
Policy	POL1	4A 4D	0.71 0.71	0.00	1	1.00	0.000	0.000	1.00	1.00	0.67	0.67
	POL2	4E 4F 4G 4J	0.89 0.89 0.89 0.89	5.71	8	0.68	0.000	0.031	1.00	1.00	0.94	0.92
Practice	PRA1	5A 5B	0.92 0.92	0.00	1	1.00	0.000	0.000	1.00	1.00	0.92	0.90
	PRA2	5D 5E 5I 5K	0.79 0.79 0.79 0.79	8.19	8	0.42	0.013	0.047	1.00	1.00	0.87	0.84
	PRA3	5N 5Q	0.70 0.70	0.00	1	1.00	0.000	0.000	1.00	1.00	0.66	0.63
Technology	TEC1	6A 6D 6E	0.59 0.85 0.85	2.57	2	0.28	0.045	0.031	0.99	1.00	0.85	0.78
	TEC2	6H 6K	0.86 0.86	0.00	1	1.00	0.000	0.000	1.00	1.00	0.85	0.80
	TEC3	6J 6M 6R	0.80 0.80 0.80	3.86	4	0.42	0.000	0.038	1.00	1.00	0.84	0.79
	TEC4	6L 6O 6P 6S 6T	0.71 0.71 0.71 0.71 0.71	5.62	13	0.96	0.000	0.037	1.02	1.00	0.84	0.80
Governance	GOV1	7B 7D	0.89 0.89	0.00	1	1.00	0.000	0.000	1.00	1.00	0.88	0.84
	GOV2	7E 7F 7G 7H	0.86 0.86 0.86 0.86	4.33	8	0.83	0.000	0.036	1.01	1.00	0.92	0.89

different from unity. Evidence of discriminant validity is obtained by comparing estimates from an unconstrained model that sets the correlation free against a constrained model that sets the correlation to one. Chi-Square (χ^2) test is then run to assess the difference between the two tests. This test was performed on all pairs of factors. The result is summarized in Appendix C and shows strong discriminant validity for all pairs of factors except three pairs (ATT1 and ATT2; POL1 and POL2, and PRA1 and PRA3). The three pairs of factors are combined (Table 8). Therefore, factor ATT is the result from combining factor ATT1 and ATT2, factor POL is the result from combining factor POL1 and POL2, and factor PRA1 is the result from combining factor PRA1 (old) and PRA3.

During the process of assessing the discriminant validity, item loadings between the set of factors are also examined. Items that cross-load on more than one factor are excluded from further analysis. In addition, when a factor is modified, both convergent and discriminant validation tests are repeated [Hair et al., 2006]. At the end of this process, four items are dropped (3A, 3I, 5I, 5N) leaving thirty-five items, ten factors solution (Table 8). Furthermore, all factors demonstrate high reliability ($\alpha > 0.70$ and $H > 0.70$).

Table 8: Measurement Properties of G-Readiness After Convergent and Discriminant Validation

Component	Factor	Items	Factor	χ^2	df	p	RMSEA	SRMR	NNFI	CFI	H	α
Attitude	ATT	3C	0.90	13.83	8	0.09	0.072	0.053	0.99	0.99	0.94	0.93
		3D	0.90									
		3E	0.90									
		3F	0.90									
Policy	POL	4A	0.61	15.18	17	0.58	0.000	0.058	1.00	1.00	0.94	0.90
		4D	0.61									
		4E	0.89									
		4F	0.89									
		4G	0.89									
Practice	PRA1	5A	0.92	0.02	2	0.99	0.000	0.003	1.02	1.00	0.92	0.84
		5B	0.92									
		5Q	0.60									
	PRA2	5D	0.81	1.69	4	0.79	0.000	0.024	1.01	1.00	0.85	0.81
		5E	0.81									
		5K	0.81									
Technology	TEC1	6A	0.59	2.57	2	0.28	0.045	0.031	0.99	1.00	0.85	0.78
		6D	0.85									
		6E	0.85									
	TEC2	6H	0.86	0.00	1	1.00	0.000	0.000	1.00	1.00	0.85	0.80
		6K	0.86									
	TEC3	6J	0.80	3.86	4	0.42	0.000	0.038	1.00	1.00	0.84	0.79
		6M	0.80									
		6R	0.80									
	TEC4	6L	0.71	5.62	13	0.96	0.000	0.037	1.02	1.00	0.84	0.80
		6O	0.71									
		6P	0.71									
		6S	0.71									
Governance	GOV1	7B	0.89	0.00	1	1.00	0.000	0.000	1.00	1.00	0.88	0.84
		7D	0.89									
	GOV2	7E	0.86	4.33	8	0.83	0.000	0.036	1.01	1.00	0.92	0.89
		7F	0.86									
		7G	0.86									
		7H	0.86									

Factorial Validity Assessment

Factorial validity is a test of whether or not a set of latent variables represent an underlying pattern in the data [Straub et al., 2004]. This was achieved by performing a measurement model with CFA, which includes all the factors that hold both convergent and discriminant validity. Items that could not be accurately estimated were dropped from the model since their estimated parameters would not provide any useful insight about G-readiness precisely. As a result of this process, a total of five items (3F, 4D, 4J, 6R, 7H) are dropped from the model. Table 9 summarizes the final measurement model which is 10 factors and 31 items solution. Both Cronbach's α and coefficient H show that all factors are highly reliable (> 0.70). Goodness-of-fit indices illustrate that the measurement model fits the data well $\chi^2(425) = 455.32$, $p = 0.15$. It also indicates that the values of the estimated parameters are valid and replicable in another sample (PCFI > 0.85) and are not results of a chance [Carlson and Mulaik, 1993].

Nomological Validity Assessment

Nomological validity verifies if the latent variables demonstrate relationships as per the theoretical framework [Straub et al., 2004]. Correlation coefficients between the factors in the measurement model are evaluated to test for nomological validity. From the result in Table 10, it is evident that the instrument holds nomological validity since all factors positively correlate with one another ($p < 0.05$). Several pairs of the factors produce high values of correlation coefficients, which mean that these factors measure the same underlying construct- G-Readiness. In addition, Table 10 summarizes average variance extracted (AVE) and the squared correlation coefficient. AVE > 0.50 means the factors and the items are reliable. These results further support that all of the factors hold discriminant validity except PRA2, TEC2, TEC3, and TEC4. High correlation between factors TEC2, TEC3 and TEC4 are expected because there is a second-order construct. However, high correlation between constructs practice, policy, and technology is due to the inter-correlation nature in the phenomenon.

Table 9: Final Measurement Properties of G-Readiness						
Component	Factor	Items	λ	H	α	Goodness-of-fit Indices
Attitude	ATT	3C	0.94	0.96	0.94	$\chi^2=455.32$ $df=425$ $p=0.15$ RMSEA=0.022 SRMR=0.060 NNFI=1.00 CFI=1.00 PCFI=0.91
		3D	0.94			
		3E	0.94			
Policy	POL	4D	0.68	0.93	0.85	
		4F	0.90			
		4G	0.90			
		4J	0.90			
Practice	PRA1	5A	0.92	0.92	0.84	
		5B	0.92			
		5Q	0.61			
	PRA2	5D	0.81	0.85	0.81	
		5E	0.81			
		5K	0.81			
Technology	TEC1	6A	0.60	0.84	0.78	
		6D	0.84			
		6E	0.84			
	TEC2	6H	0.86	0.85	0.80	
		6K	0.86			
	TEC3	6J	0.84	0.83	0.74	
		6M	0.84			
	TEC4	6L	0.71	0.84	0.80	
		6O	0.71			
		6P	0.71			
		6S	0.71			
		6T	0.71			
Governance	GOV1	7B	0.89	0.88	0.84	
		7D	0.89			
	GOV2	7E	0.86	0.92	0.89	
		7F	0.86			
		7G	0.86			
		7H	0.86			

Predictive Validity Assessment

To further test whether the factors in the measurement model actually reflect G-readiness, a second and third order convergent validity are tested using factor scores in two steps. First, since the components Practice (PRA), Technology (TEC) and Governance (GOV) are multidimensional, to assess if their corresponding factors (PRA1 and PRA2, TEC1-4, GOV1 and GOV2) indeed share the same domain construct and measure the components, a second order convergent validity is tested. The result in Table 11 demonstrates sufficient validity to proceed to step 2.

Table 10: Correlation-AVE Matrix of the Factors in the Measurement Model										
Factor	ATT	POL	PRA1	PRA2	TEC1	TEC2	TEC3	TEC4	GOV1	GOV2
ATT	0.88	0.29	0.29	0.56	0.15	0.40	0.19	0.31	0.26	0.35
POL	0.54	0.72	0.49	0.67	0.27	0.35	0.40	0.32	0.55	0.67
PRA1	0.54	0.70	0.69	0.44	0.12	0.24	0.14	0.27	0.48	0.46
PRA2	0.75	0.82	0.66	0.66	0.52	0.69	0.49	0.71	0.53	0.67
TEC1	0.39	0.52	0.34	0.72	0.59	0.36	0.31	0.52	0.15	0.42
TEC2	0.63	0.59	0.49	0.83	0.60	0.74	0.74	0.83	0.22	0.37
TEC3	0.44	0.63	0.37	0.70	0.56	0.86	0.71	0.67	0.20	0.37
TEC4	0.56	0.57	0.52	0.84	0.72	0.91	0.82	0.50	0.27	0.46
GOV1	0.51	0.74	0.69	0.73	0.39	0.47	0.45	0.52	0.79	0.71
GOV2	0.59	0.82	0.68	0.82	0.65	0.61	0.61	0.68	0.84	0.74

Note: The numbers in normal font re correlation coefficients. The numbers in italic are squared correlation coefficients. The numbers in bold are average variance extracted (AVE) or p_{vc} .

Table 11: Convergent Validity of the Second-Order Factors

Component	Factors	Factor Loading (λ)	χ^2	df	p	RMSEA	SRMR	NNFI	CFI	H	A
Practice (PRA)	PRA1	0.75	0.00	1	1.00	0.000	0.000	1.00	1.00	0.72	0.71
	PRA2	0.75									
Technology (TEC)	TEC1	0.78	2.27	8	0.97	0.000	0.075	1.01	1.00	0.86	0.85
	TEC2	0.78									
	TEC3	0.78									
	TEC4	0.78									
Governance (GOV)	GOV1	0.85	0.00	1	1.00	0.000	0.000	1.00	1.00	0.84	0.83
	GOV2	0.85									

In step 2, another convergent validity for the higher order factor G-readiness is conducted using the five components (ATT, POL, PRA, TEC, GOV). Based on the results shown in Table 12, it is clear that the five constructs measure G-readiness with high reliability ($H > 0.90$)

Table 12: Convergent Validity of the G-Readiness Construct

Component	Factor	Items	Factor Loading	χ^2	df	p	RMSEA	SRMR	NNFI	CFI	H	A
G-readiness	GRI	ATT	0.68	13.43	11	0.27	0.039	0.044	1.00	1.00	0.91	0.89
		POL	0.86									
		PRA	0.86									
		TEC	0.68									
		GOV	0.86									

Further evidence of predictive validity and the soundness of the G-readiness construct are obtained by calculating polyserial correlation (i.e., a correlation coefficient used between an ordinal variable and an interval variable). For this purpose, a G-readiness Index (GRI) based on the factor scores of each of the G-readiness components using the formula $GRI = (0.11 \cdot (ATT + TEC) + 0.3 \cdot (POL + PRA + GOV)) / 1.12$ was calculated. The GRI is then correlated with item 7J, which is a global measure of readiness as “Our organization demonstrates adequate readiness for Green IT.” The result signifies that the developed G-readiness construct has high predictive validity— $r = 0.829$ at $p < 0.001$.

IV. DISCUSSION

Green IT is a relatively recent research field. The advance of Green IT research field, like other research fields, requires theorization, model construction, and measurement development. This is because “theory construction and a cumulative tradition, the ultimate objectives of a research field, are inseparable from measurement” [Byrd and Turner, 2000, p. 192]. For any field of study to progress in theorization, clear definition of a construct is an essential first step. Indeed “defining a construct using rigor is an important aspect of theory building as lack of rigor often leads to competing and fuzzy conceptualizations” [Pankaj et al., 2009, p. 22].

This article, drawing from the IT infrastructure and capability, readiness and eco-sustainability theories, develops the G-readiness construct. The theories provide rigorous foundations to the conceptualization of Green IT and the G-readiness. In addition, they help to conceptualize the impact of IT not only as causing environmental problems (such as IT technical infrastructure’s energy consumption) but also as solving them through the use of IT in automating, informing and transforming business processes [Chen et al., 2008] and through the actions and leadership role of the IT management and human infrastructure. The definitions of Green IT and G-readiness satisfy the guidelines for a good definition as they clearly state the “genus (the type of thing defined) and differentia (what distinguishes it from others of the same genus)” [Pankaj et al., 2009, p. 22]. The definitions further have conceptual clarity and offer details of specific variables, elements, or components (for example those covering the IT lifecycle and the G-readiness dimensions)—additional qualities of a good definition [Byrd and Turner, 2000; Pankaj et al., 2009].

Our theoretical hypothesis is that G-readiness is comprised of the five components of Green IT Attitude, Policy, Practice, Technology, and Governance. The analysis shows that some of these components have substrata. The final solution is comprised of a higher level G-readiness construct, five components, and eight sub components (see Figure 1). Such a structure would allow the investigation of G-readiness at different levels of abstraction and granularity.

Figure 1. The G-Readiness Model

- *Green IT Attitude* (ATT) is comprised of items that reflect energy efficiency concerns in managing the IT technical infrastructure. These items tap into managerial attitude and beliefs regarding IT energy utilization. Because of the nature of current energy sources that use fossil fuel, there is strong correlation between energy use and greenhouse gas emissions. Thus, organizational action on reducing energy consumed by IT infrastructure relates to pollution prevention strategy. However, as sources of energy become cleaner, this association might decline, but the significance and cost of energy consumption remains top of mind. Green IT attitude captures these dynamics.
- The *Green IT Policy* (POL) items reflect the maturity of policy frameworks involving IT procurement, data centers, and IT's enterprise enablement, that is, policies covering the entire lifecycle of IT. These items tap the product stewardship (4FJ) and clean technologies (4D) strategies in Greening IT and the pollution prevention (4G) strategy in using IT to reduce overall emissions.
- *Green IT Practice* embraces two domain substrata covering the product stewardship and pollution prevention strategies. Subsequently, the first is referred here as procurement (PRA1) with items that indicate an organization's action to procure IT in an environmentally friendly way. The second is referred as energy audit and monitoring (PRA2) with items that indicate energy consumption audit and monitoring aspects that relate to pollution prevention.
- The *Technology* dimension contains four substrata covering the IT technical infrastructure capability. The first is referred to as IT technical infrastructure (TEC1). The items in this category represent technologies that transform the IT infrastructure into a sustainable platform and tap into the clean technologies domain. The other three technology domain substrata are named as data center air flow management (TEC2), data center cooling systems (TEC3), and power-delivery systems (TEC4). The items in these three categories represent organizational action to improve the energy efficiency of data centers cooling and power delivery platforms and reduce the environmental footprint and tap into the pollution prevention strategy.

- *Green IT Governance* has two substrata covering the IT managerial capability. The first is referred here as strategic foresight (GOV1) and the second resource and metrics (GOV2). The items cover management commitment, resource allocation, project management and benefit tracking of Green IT initiatives designed to prevent pollution, improve product stewardship, and implement clean technologies.

Theoretical Implications

The G-readiness construct represents an original contribution to the Information Systems literature. The G-readiness construct and its five domains together with the instrument will be useful in Green IT and Green IS research. Table 13 shows where and how researchers can use the G-readiness instrument in addressing some of the Green IT and Green IS research areas.

Table 13: Utility of the G-Readiness Instrument to Green IT and IS Research

Research Areas	Use of G-readiness
The role of IT in carbon productivity [Dedrick, 2010]	Green IT readiness is a factor in the first order effects of IT. A study examining the role of IT on carbon productivity should take in to account the G-readiness items to identify to what extent organizations are reducing their IT energy consumption.
Factors influencing Green IT adoption and assimilation [Dedrick, 2010]	IS researchers that study the factors influencing adoption of Green IT using institutional theory and technology adoption and assimilation models can consider the G-readiness constructs of policy, practice and technology in defining the dependent variable (i.e., Green IT), its diversity and intensity and add to their list of antecedent variables the G-readiness constructs of attitude and governance.
Role of IS to integrate supply and demand data to increase energy efficiency [Watson et al., 2010]	Studies using the energy informatics framework to understand the contribution of IS to energy efficiency at an organizational level should consider the G-readiness technology items in account to factor in or out energy inefficiencies embedded in the IT infrastructure of an organization that hosts Information Systems.
The association between IS and organizational and sustainability performance [Melville, 2010]	IS research draws from RBV to explain firm performance taking a range of IT capabilities and competencies. Researchers can consider the G-readiness construct as a new form of IT capability within the nomological network of influences that explain the association between IS and organizational and sustainability performance.
Intention to use and usage of IS for environmental sustainability [Melville, 2010]	Green IT readiness can be envisaged as a factor in the organization adoption of Green IS (such as collaborative technology to replace travel). A study examining such an adoption process should take the organizational readiness in account where the G-readiness instrument may be very helpful.

Practical Implications

The model will allow IT managers to approach Green IT not only from the IT technical infrastructure but also the human and managerial perspectives. In addition, the model, rather than viewing Green IT from one domain of the IT activity chain, is based on a lifecycle approach covering IT sourcing, operation, and disposal. The G-readiness model offers a common platform for practitioners to assess and benchmark their Green IT initiatives and progress. The G-readiness model offers a common platform for practitioners to assess and benchmark their Green IT initiatives and progress. Assessment of a current state is an essential step in any strategy development. The G-readiness model offers practitioners both a framework and an assessment tool to strategize for Green IT. The instrument serves as a means for firms to benchmark themselves against other firms and in particular against firms in the same industry.

A simple operational application of the model for practitioners is to assess G-readiness to identify areas that need improvement. Such an assessment is inherently subjective. If it is done by a group of managers for a single organization, it first requires developing a shared understanding of the G-readiness items. For example, by using a tally sheet, managers (either individually or as a group) can evaluate their performance across the thirty-two items on the scale of 1 (low) to 7 (high). The item scores can be averaged to produce subcomponent values. The subcomponent score can then be averaged to produce a score for the five basic components of G-readiness. Aggregating the five components will yield a G-readiness score out of a maximum of 35. On the basis of this simple algorithm, evaluation of the 143 respondents shows that their G-readiness score is 19.30 which can be interpreted as average. Figure 2 provides further details of the G-readiness at a component level for respondents in each of the three countries.

The findings in Figure 2 highlight the maturity of Green IT attitude over policy and governance. Employees' perception and attitude is as equal, if not more, important as management's commitment and resource allocation in the transformation to a sustainable IT operation. Thus, organizations can take advantage of their employees' values and concern about the environment to identify Green IT opportunities and encourage green innovations. This can be achieved through establishing and using enterprise social networks to link members of the firm with each other and with external sources of information. Green IT social networks can also yield additional benefits in diffusing Green IT concepts and practices across an enterprise. Nevertheless, the maturity of Green IT policies and governance are necessary for ensuring that Green IT initiatives within an enterprise are systematic and repeatable and for tracking and communicating Green IT benefits.

Figure 2. G-Readiness Maturity of Sampled Organizations

Limitations

We recognize the following limitations of the study. First, the field of Green IT and the organizational competencies to transform toward Green IT are evolving. We used both academic and practitioner literature and a desk-based research to identify items to operationalize the G-readiness construct. However, we haven't conducted in-depth case studies based on interviews to pool additional items. Although the procedure we have followed is adequate to ensure content validity, it leaves room for further improvement, especially one that is based on in-depth case studies to pool any potential items that are missed from the current study. Second, because we have used co-variance-based structural equation modeling, in order to get a fit model, we have to drop a number of items. Other alternative analytical methods, such as partial least square, where goodness-of-fit is not a major requirement, might result in a different set of final items. Third, due to data limitation, there was no holdout sample to evaluate the test-retest reliability and external validity and confirm the derived model. Thus, the model can be considered only as preliminary and needs further confirmation. Fourth, since factorial validity was the primary technique used in testing the construct validity, common method bias might not be completely ruled out. The decision to exclude Mining and Agriculture is another limitation of this article. Notwithstanding the above limitations, which offer opportunities for further refinement of the model, the current study has provided an original framework upon which other researchers can base their studies.

V. CONCLUSIONS AND FUTURE RESEARCH

Businesses are under increasing pressure from customers, competitors, regulators, and community groups to implement sustainable business practices. Balancing economic and environmental performance to be green and competitive, therefore, is a key strategic issue. The current study has made an original contribution in defining the G-readiness construct and model and developing the components that constitute it. It also provides a research-ready instrument whose properties are sufficiently validated. The rigorous procedure followed in validating the model

indicates that the five dimensions fit well with the first order construct of G-readiness. The model can be used by other researchers to establish cause-and-effect relationship models. It can also be used by practitioners as a decision tool to locate, measure, and manage their Green IT capability and identify strategies to improve it. Further using the model it will be possible to calculate G-readiness indices at different levels of abstraction and detail.

Future tests and refinements of the proposed model will be extremely useful to advance knowledge on Green IT. First, the field of Green IT and the organizational competency toward eco-sustainability are likely to evolve. Therefore, revising the items for operationalizing the G-readiness become important. Second, research using a larger sample size can test if the results obtained in the current study are replicable. Third, future study based on a single country or a single sector can enhance this study. Because of the increasing importance of the role of IT in eco-sustainability, researchers should continue investigating the preliminary model developed here. This can be achieved by refining the measures and factors proposed in this model, by testing the relationship among the different G-readiness factors, and by exploring the relationship between the G-readiness factors and other antecedent and/or consequent variables of interest.

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APPENDIX A: INITIAL INSTRUMENT

Table A-1: Initial Item Measures for G-Readiness's Attitude Construct
Seven point scale anchored by 1= Strongly Disagree and 7= Strongly Agree

Item	References
3A Our organization is concerned about emerging regulations in greenhouse gas emissions.	Info~Tech [2008]; York et al. [2009]
3B Our organization is concerned about our IT's energy consumption.	Info~Tech [2008]; Jenkin and McShane [2009]
3C Our organization is concerned about the energy consumption of cooling and lighting our data centers.	Info~Tech [2008]; Info~Tech [2007b]; Accenture [2008]
3D Our organization is concerned about the efficiency of powering our IT infrastructure (storage, servers, network).	Accenture [2008]
3E Our organization is concerned about IT's contribution to greenhouse gas emissions.	Info~Tech [2008]; Info~Tech [2007b]
3F Our organization is concerned about our business's overall environmental footprint.	CFO [2009]; Elliot and Binney [2008]
3G Our organization is concerned about our IT suppliers' environmental footprint.	Self-development
3H Our organization is concerned about our clients' environmental footprint.	Self- development
3I Our organization is concerned about the environmental impact in discarding IT at the end of its life.	Elliot and Binney [2008]; Jenkin and McShane [2009]

Table A-2: Initial Item Measures for G-Readiness's Policy Construct
Seven point scale anchored by 1= Not at all developed and 7= Extremely well developed

Item	References
4A Corporate social responsibility policy	CFO [2009]; Hart [1997]
4B Green supply chain management policy	Murugesan [2008]
4C Environmental sustainability policy	CFO [2009]; Hart [1997]
4D Shifting to green sources of energy	Self-development
4E Environmentally friendly IT purchasing policy	Murugesan [2008]
4F Green data centers policy	Info~Tech [2007b]
4G Policy on the use of IT to reduce the business's carbon footprint	CFO [2009]
4H Policy on employees use of IT in an energy efficient manner	Info~Tech [2007a]
4I End of IT life management	Murugesan [2008]
4J Green information technology policy	Self-development

Table A-3: Initial Item Measures for G-Readiness's Practice Construct
Seven point scale anchored by 1= Not at all practiced and 7= Practiced to a great extent

Item	References
5A Preference of IT suppliers that have a green track record	CFO [2009]; Info~Tech [2007a,b]
5B Gives weight to environmental considerations in IT procurement	Accenture [2008]; Velte et al. [2008]
5C Shortens IT equipment refresh periods to gain access to more energy efficient equipment	Info~Tech [2008]; CFO [2009]; Accenture [2008]
5D Considers environmental factors in the design of the site infrastructure (lighting, power delivery, cooling systems) and IT infrastructure (servers, storage and network) of data centers	Accenture [2008]; Elliot and Binney [2008]; CFO [2009]; Velte et al. [2008]
5E Audits the power efficiency of existing IT systems and technologies	Info~Tech [2008]; CFO [2008]; Gartner [2008]
5F Switches off data center lights and equipment when not needed	CFO [2009]; Info~Tech [2007a]; Velte et al. [2008]
5G Operates existing IT systems in an energy efficient manner	Info~Tech [2008]; Mines [2008]
5H Enforces PC power management	Info~Tech [2007a, 2008]; CFO [2009]
5I Implements IT projects to monitor the enterprise's carbon footprint	Elliot and Binney [2008]; Gartner [2008]
5J Prints double-sided on paper	CFO [2009];
5K Analyses IT's energy bill separately from the overall corporate bill	Info~Tech [2008]; CFO [2009]
5L Relocation of its data center near clean sources of energy	Self-development

Table A-3: Initial Item Measures for G-Readiness's Practice Construct – Continued
Seven point scale anchored by 1= Not at all practiced and 7= Practiced to a great extent

Item	Reference
5M Recycles consumable equipment (e.g., batteries, ink cartridges, and paper)	CFO [2009]; Schmidt et al. [2009]; Velte et al. [2008]
5N Disposes of IT equipment in an environmentally friendly manner	Elliot and Binney [2008]; Velte et al. [2008]
5O Uses electricity supplied by green energy providers	Self-development
5P Engages the service of a professional service provider regarding Green IT	Gartner [2008]
5Q Prefers hardware vendors that offer end of IT life "take-back" options	CFO [2009]
Seven point scale anchored by 1= Not at all practiced and 7= Practiced to a great extent	

Table A-4: Initial Item Measures for G-Readiness's Technology Construct
Seven point scale anchored by 1=Not at all and 7=Great Extent)

Item	References
6A Server consolidation and virtualisation	Info~Tech [2007c]; Mines [2008]; Elliot and Binney [2008]
6B Desktop virtualisation	Mines (2008); Accenture [2008]
6C Storage virtualisation	CFO [2009]
6D Data de-duplication	Self-development
6E Storage tiering	Accenture [2008]
6F Print optimisatio	Info~Tech [2007c]
6G Rightsizing IT equipment	Info~Tech [2007b]
6H Data center airflow management	Info~Tech [2007c]
6I Free cooling in large scale data centers	Info~Tech [2007b]
6J Water cooled chillers with variable speed fans and pumps	Accenture [2008]
6K Hot aisle/cool aisle data center layout	Info~Tech [2007c]
6L Upgrades to more efficient transformers and UPS	Accenture [2008]
6M Airside/waterside economizer	Info~Tech [2007c]
6N Liquid cooling for IT equipment	Info~Tech [2007c]
6O Install more energy efficient lights	Self-development
6P High voltage AC power	Accenture [2008]
6Q DC powered IT equipment	Info~Tech [2007c]
6R High efficiency stand-by power systems	Accenture [2008]
6S Retire energy inefficient systems	Accenture [2008]; Info~Tech [2007b]
6T Computers that have functions to monitor workloads and to shut down components when unused	Mines [2008]; Nunn [2007]

Table A-5: Initial Item Measures for the G-Readiness's Governance Construct
Seven point scale anchored by 1= Strongly Disagree and 7=Strongly Agree

Item	References
7A Our business has set CO2 targets to reduce our corporate carbon footprint.	CFO [2009]
7B We have defined a role for coordinating our business's green initiatives.	CFO [2009]; Gartner [2008]
7C Top management discuss Green IT issues as a priority.	Self-development
7D Responsibilities are clearly defined within each Green IT initiative.	Self-development
7E Our CIO (or equivalent) plays a leading role in all green (IT and non-IT) initiatives.	Gartner [2008]
7F We have earmarked a budget and other resources for Green IT.	CFO [2009]; Info~Tech [2007c]
7G We have established metrics for assessing the impact of Green IT initiatives.	CFO [2009]; Accenture [2008]
7H Our organization has mechanisms for monitoring IT suppliers' green performance.	Self- development
7I IT is responsible for its own electricity costs.	CFO [2009]; Info~Tech [2008]
Global Measure	
7J Our organization demonstrates adequate readiness for Green IT	Self-development

APPENDIX B: EFA AND PARALLEL ANALYSIS RESULTS

	Factor	
	1	2
Q3E	0.968	
Q3D	0.922	
Q3C	0.883	
Q3J	0.509	
Q3F	0.507	0.506
Q3I		0.825
Q3G		0.820
Q3H		0.680
Q3A		0.649
Q3B		0.508
α	.923	.840

KMOMSA = .877; Bartlett's test of sphericity (BTOS): $\chi^2(45) = 1112.145$ at $p = .000$; Sample Size Adequacy Ratio (SSAR): 15:1

Figure B-1. Green IT Attitude

	Factor
	1
Q4G	0.888
Q4F	0.866
Q4J	0.846
Q4E	0.845
Q4H	0.828
Q4B	0.746
Q4D	0.659
Q4I	0.625
Q4A	0.567
α	.927

KMOMSA = .905; BTOS: $\chi^2(36) = 944.427$ at $p = .000$; SSAR=14:1

Figure B-2. Green IT Policy

	Factor
	1
Q7D	0.873
Q7G	0.822
Q7C	0.813
Q7E	0.792
Q7F	0.767
Q7B	0.756
Q7H	0.749
Q7A	0.648
Q7I	0.504
α	.914

KMOMSA = .916; BTOS: $\chi^2(36) = 835.819$ at $p = .000$; SSAR: 15:1

Figure B-3. Green IT Governance

	Factor		
	1	2	3
Q5B	0.928		
Q5A	0.871		
Q5N	0.563		
Q5Q	0.504		
Q5M	0.385		
Q5J	0.277		
Q5O	0.256		
Q5F		0.791	
Q5G		0.697	
Q5H		0.553	
Q5I			0.801
Q5K			0.709
Q5L			0.683
Q5C			0.639
Q5P			0.630
Q5E			0.609
Q5D			0.406
α	.829	.795	.874

KMOMSA = .873; BTOS: $\chi^2(136) = 1255.754$ at $p = .000$; SSAR:8:1

Figure B-4. Green IT Practice

	Component	
	1	2
Q6R	0.821	
Q6M	0.797	
Q6J	0.797	
Q6N	0.793	
Q6K	0.733	
Q6L	0.727	
Q6I	0.672	
Q6H	0.668	
Q6P	0.645	
Q6O	0.600	
Q6Q	0.594	
Q6S	0.465	
Q6T	0.436	
Q6C		0.785
Q6D		0.712
Q6E		0.710
Q6A		0.670
Q6G		0.667
Q6F		0.535
Q6B		0.522
α	.926	.856

KMOMSA = .913; BTOS: $\chi^2(190) = 1603.231$ at $p = .000$; SSAR:7:1

Figure B-5. Green IT Technology

APPENDIX C: RESULTS OF DISCRIMINANT VALIDITY TESTS

Table C-1: Results of Discriminant Validity Tests

Pair		χ^2			df	p
		Constrained	Unconstrained	Difference		
ATT1	ATT2	17.24	14.37	2.87	1	0.09
POL1	POL2	15.18	12.11	3.07	1	0.08
PRA1	PRA3	7.5	4.47	3.03	1	0.08
ATT	POL	218.4	20.11	198.29	1	0.00
ATT	PRA1	54.61	5.59	49.02	1	0.00
ATT	PRA2	37.89	8.98	28.91	1	0.00
ATT	TEC1	43.4	4.74	38.66	1	0.00
ATT	TEC2	17.76	2.3	15.46	1	0.00
ATT	TEC3	57.69	8.57	49.12	1	0.00
ATT	TEC4	125.54	16.57	108.97	1	0.00
ATT	GOV1	27.05	4.76	22.29	1	0.00
ATT	GOV2	199.96	10.19	189.77	1	0.00
POL	PRA1	82.47	22.5	59.97	1	0.00
POL	PRA2	62.66	35.8	26.86	1	0.00
POL	TEC1	98.93	40.82	58.11	1	0.00
POL	TEC2	53.12	22.04	31.08	1	0.00
POL	TEC3	87.24	23.48	63.76	1	0.00
POL	TEC4	182.34	38.95	143.39	1	0.00
POL	GOV1	68.43	30.98	37.45	1	0.00
POL	GOV2	110.37	31.28	79.09	1	0.00
PRA1	PRA2	82.59	13.22	69.37	1	0.00
PRA1	TEC1	95.93	10.87	85.06	1	0.00
PRA1	TEC2	46.45	4.53	41.92	1	0.00
PRA1	TEC3	135.4	15.04	120.36	1	0.00
PRA1	TEC4	129.77	18.17	111.6	1	0.00
PRA1	GOV1	37.36	4.19	33.17	1	0.00
PRA1	GOV2	73.46	19.8	53.66	1	0.00
PRA2	TEC1	49.68	12.96	36.72	1	0.00
PRA2	TEC2	23.71	6.65	17.06	1	0.00
PRA2	TEC3	51.47	18.38	33.09	1	0.00
PRA2	TEC4	49.99	31.68	18.31	1	0.00
PRA2	GOV1	41.71	8.6	33.11	1	0.00
PRA2	GOV2	40.91	16.18	24.73	1	0.00
TEC1	TEC2	52.17	6.56	45.61	1	0.00
TEC1	TEC3	75.39	15.88	59.51	1	0.00
TEC1	TEC4	61.77	21.23	40.54	1	0.00
TEC1	GOV1	88.09	10.53	77.56	1	0.00
TEC1	GOV2	58.13	20.13	38	1	0.00
TEC2	TEC3	15.41	9.1	6.31	1	0.01
TEC2	TEC4	19.7	14.25	5.45	1	0.02
TEC2	GOV1	55.89	2.8	53.09	1	0.00
TEC2	GOV2	38.13	10.02	28.11	1	0.00
TEC3	TEC4	44.09	36.63	7.46	1	0.01
TEC3	GOV1	64.12	7.66	56.46	1	0.00
TEC3	GOV2	79.59	23.85	55.74	1	0.00
TEC4	GOV1	69.62	17.52	52.1	1	0.00
TEC4	GOV2	103.28	20.67	82.61	1	0.00
GOV1	GOV2	25.32	11.45	13.87	1	0.00

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Communications of the Association for Information Systems

ISSN: 1529-3181

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