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An agenda for 'Green' information technology and systems research

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ABSTRACT

Green information technologies and systems refer to initiatives and programs that directly or indirectly address environmental sustainability in organizations. Although practitioners have begun to focus on 'Green IT', there is little research in this area. To set the stage for this research, we develop a multilevel research framework to guide future research. To do so, we review the existing green information technology and systems literature, and also draw more broadly from research that addresses environmental sustainability in the management, environmental psychology, and social marketing domains. From this review, we identify important research gaps and present a set of propositions to guide future research.

"The cost of energy isn't likely to fall. Do you have a greener IT strategy?"

(Mahoney & Raskino, 2010, p. 3)

1. Introduction

There is a growing awareness of the necessity to reverse the process of environmental degradation and move toward sustainable business practices (GLRI, 2005). However, in spite of a burgeoning list of ecological problems, many people, including the leaders of our most influential organizations, often think of environmental problems as detached from their everyday business lives and behavior patterns. For instance, as organizations leverage their productivity with an ever increasing rate of information technology and system (IT/S) use, they often become part of the larger problem of environmental sustainability. The use of IT/S is exploding, growing two times faster than the Gross World Product (Siegler

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& Gaughan, 2008), and consuming large fractions of business' energy costs. In most cases, more than half of this energy is wasted by inefficient technologies, poorly designed systems, or uninformed behaviors.

IT/S can have a detrimental influence on the environmental footprint of organizations (Siegler & Gaughan, 2008): ITs have short product life spans (e.g., laptops, 3–4 years; networks, 5–7 years); their manufacture and disposal have resulted in toxic hotspots; and a large portion of organizations' electricity costs (and concomitant greenhouse gas emissions) is due to IT energy use (e.g., office buildings, 26%; data centers, 95%). Spending on IT has important implications for the environment. For example, in 2008 Gartner predicted that 80% of data centers will be running at their maximum available power and cooling levels by 2010 (Uhlman, 2008). Despite a decrease in server acquisition and increase in virtualization in 2009, power and cooling levels remained a top issue in 2009. Gartner predicts an increase in server acquisitions in 2010 and 2011, which will further exacerbate the issue (Kumar, 2010). IT is quickly surpassing air transportation in terms of its carbon footprint (Dembo, 2008). However, environmental issues underlying IT/S often have no clearly defined ownership in organizations (Siegler & Gaughan, 2008) and the IT/S function is often not considered by organizations in their assessment of their environmental footprints (Huang, 2008).

In contrast to harmful effects on the environment, 'Green' IT/S can have positive impacts, with the potential to reduce global emissions by 15% (The Climate Group, 2008). Green IT/S refers to information technology and system initiatives and programs that address environmental sustainability (e.g., Siegler & Gaughan, 2008). The effects of Green IT/S, which have the potential to be substantial, can be either direct – by reducing negative IT impacts on the environment – or indirect – using IS to support other business initiatives in reducing their negative environmental impacts. The IT and IS components of Green IT/S have been distinguished based on their focus and impact on the environment. 'Green IT', which addresses energy consumption and waste associated with the use of hardware and software, tends to have a direct and positive impact. Examples include improving the energy efficiency of hardware and data centers, consolidating servers using virtualization software, and reducing waste associated with obsolete equipment (Watson, Boudreau, Chen, & Huber, 2008). 'Green IS', on the other hand, refers to the development and use of information systems to support or enable environmental sustainability initiatives and, thus, tends to have an indirect and positive impact. Examples include: collaborative group software and telepresence systems to enable remote meetings and reduce the negative environmental impacts associated with travel; environmental information systems to track and monitor environmental variables such as waste, emissions, toxicity, water consumption, and carbon footprints; and supply chain systems to optimize product routing and transportation, thus reducing the amount of energy consumed moving products (Watson et al., 2008)[1].

The IT industry has recognized the issue and identified a variety of consulting opportunities (Feldman, 2008; Gonsalves, 2008; IBM, 2009; IDC, 2008; LaMonica, 2008; Siegler & Gaughan, 2008; West, 2008), such as IBM's Green Sigma consulting practice (Hoover, 2008). Nevertheless, there remain gaps in actual practices. In addition, there is very little research in this area (Chen, Boudreau, & Watson, 2008; Elliot & Binney, 2008). Therefore, to advance the research agenda for Green IT/S and move towards closing the gaps in practice, we aim to develop a comprehensive research framework that places the fragmented Green IT/S literature in conversation with the more well-established environmental sustainability literatures in management, environmental psychology, and social marketing. Specifically, we draw on past environmental research on individuals and organizations to develop themes to guide future Green IT/S research. The result is a multilevel research framework that enables us to both develop propositions and identify important future research areas. By integrating diverse streams of research on sustainability, the goal of this framework is to i) develop a richer understanding of how Green IT/S relates to sustainability in organizations, ii) demonstrate how the framework stands to advance the Green IT/S research agenda, and iii) identify critical research gaps.

This paper is organized as follows: we begin with a literature review and description of our research framework. Although the review highlights the Green IT/S literature, the framework goes beyond Green IT/S by drawing on well-established theories from other areas. Doing so places Green IT/S into the broader context of corporate environmental sustainability. Based on this review, we develop theoretical propositions that address several challenges and gaps related to the individual and organizational levels of analysis. We conclude with a discussion of future research opportunities.

[1] In this paper, we use the term IT/S to refer to technologies and systems collectively; often, they are not separated in practice.

2. Literature review

Environmental sustainability has been defined as "development that meets the needs and aspirations of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, p. 43), and is therefore linked to ongoing economic growth and development. Although several articles discuss organizations' environmental impacts, the precise meaning of this construct often remains unclear and ill-defined (Glasson, Therivel, & Chadwick, 1994). Perhaps one of the primary reasons for this ambiguity is that perceptions of environmental impact "differ depending on one's view of the environment and the components of the environment that one values" (Riha, Levitan, & Hutson, 1996, p.1). Given the potential discrepancy in meaning, it is critical to note that we adopt a definition of environmental impact that focuses solely on issues related to the natural environment, rather than the triple-bottom line that also includes financial and social impacts. Specifically, we define environmental impact as the degree to which an organization's business processes, activities and operations positively or negatively affect the natural environment. It represents the consequences of the firm's actions in relation to the quality and cleanliness of our air, water and soil and, more generally, to the short-term and long-term health of our ecosystems.

In order to understand the state of Green IT/S research, an in-depth literature review was conducted in the summer of 2009. Expanding upon Elliot and Binney's (2008) paper, in which eight leading MIS journals[2] were examined, we searched for Green IT/S scholarly articles in the ABI-Inform database, Business Source Complete database, and through research contacts. We also located several relevant conference proceedings from 2007 onwards as well as working papers.[3] This strategy allowed us to cast a wider net to see where Green IT/S research was being published, if not in the top MIS journals. It is important to note that our review of the Green IT/S literature was not restricted to MIS journals. Rather, we conducted a broad search for articles containing a Green IT/S artifact, regardless of the journals' primary domain. Thus, when we discuss Green IT/S research, we are referring to a broad set of outlets rather than a narrow subset of MIS journals. The following keywords were used in our search: green, information technolog*, information system*, environment*, sustain*.

The main acceptance criterion for inclusion of an academic paper in this review was the discussion of environmental sustainability and information technology or systems in an organizational setting. Therefore, articles that addressed environmental sustainability in the home (e.g., Chetty, Bernheim Brush, Meyers, & Johns, 2009), society (e.g., Fuchs, 2008), or more generally (e.g., DiSalvo, Boehner, Knouf, & Sengers, 2009) were not included. Like Elliot and Binney (2008), we found no articles on Green IT/S in the leading MIS journals. However, we did find 20 scholarly articles in other peer-reviewed journals and 18 conference and working papers, which are summarized in the Supplementary Table. The articles are almost evenly split between conceptual and empirical and only about half are based on strong theoretical grounding. Further, most of the papers focus on the organizational level of analysis.

The description of Green IT/S varies across these papers, from those narrowly focused on the particular system studied (e.g., a CO_2 calculator in Smart, Armstrong, & Vanclay, 2007) to more general definitions encompassing both IS and IT (e.g., Hasan & Kazlauskas, 2009). Most descriptions focus on information systems rather than on both systems and technologies. However, we adopt Watson et al.'s (2008) definition presented earlier that encompasses both systems and technologies because we believe it provides a more complete view of the potential opportunities and impacts. After the Green IT/S articles were gathered, two of the authors reviewed and coded them (see Supplementary Table). Coding was an emergent and iterative process, involving discussions between authors to refine the classification of articles and reach consensus; any differences were discussed and resolved. Given the low number of scholarly Green IT/S articles, we also drew on past environmental research on individuals and organizations from management, environmental psychology, and social marketing to help develop the codes. Specifically, we conducted a comprehensive

[2] Elliot and Binney (2008) reviewed the following journals: *European Journal of Information Systems, Information Systems Journal, Information Systems Research, Journal of the Association for Information Systems, Journal of Information Technology, Journal of Management Information Systems, Journal of Strategic Information Systems, Management Information Systems Quarterly*.

[3] Specifically, we reviewed papers from conferences such as AOM, AMCIS, ECIS, and PACIS. Although the focus of the review was on scholarly papers, we also reviewed book chapters and articles from non-scholarly sources (such as news, business magazine articles, and websites), because research is limited in this area.

literature review of these three supporting literatures to flesh out the concepts identified in the Green IT/S articles. Further, we analyzed articles within and across concepts to help identify research gaps.

In order to guide our research, a multilevel research framework was developed by integrating the concepts that were reflected in both the supporting and the Green IT/S literatures. It is made up of four main components (see Fig. 1): environmental sustainability motivating forces, environmental sustainability initiatives, environmental orientation, and environmental impacts. While three of these components seem best treated at the organizational level, the environmental orientation component can be applied at multiple levels of analysis, including individual and organizational. Multilevel models have been noted as offering unique theoretical and practical advantages (Starik & Rands, 1995) in that they "identify the individual-level characteristics, behaviors, attitudes, and perceptions that underlie and shape organization-level characteristics and outcomes" by "integrating the micro domain's focus on individuals and groups with the macro domain's focus on organizations, environment, and strategy" (Klein, Tosi, & Cannella, 1999, p. 243). By broadening the theoretical focus, this multilevel model moves towards capturing the intricacies and complexities associated with corporate environmental initiatives and, more specifically, those related to Green IT/S.

The following sections describe each component of the framework, outline the existing literature, and highlight research gaps that provide opportunities for Green IT/S research. Further, our discussion of environmental orientation provides a more in-depth examination of how this research can be conducted at multiple levels of analysis. Later, we delve more deeply into the theoretical rationale for this framework by developing propositions to help guide Green IT/S research.

2.1. A framework for Green IT/S research

Before examining the framework, it is instructive to consider how frequently the Green IT/S artifact has been studied in order to demonstrate the paucity of empirical research in this area, particularly research that focuses on the Green IT/S artifact. Almost one-half of the Green IT/S papers empirically focused on the actual Green IT/S artifact – the design, development, and implementation of either hardware or software – to either decrease negative environmental impacts or to support environmental sustainability initiatives more generally (see Supplementary Table). For example, some articles examine how the software development lifecycle can be modified to facilitate environmentally sustainable software development (Huang, 2008) or the potential negative environmental impacts of systems that are either not designed properly or not used as designed (Haigh & Griffiths, 2008). Further, a number of other studies examine environmental reporting, measurement, and accounting systems (e.g., Brown, Dillard, & Marshall, 2005; Goodman, 2000; Isenmann, Bey, & Welter, 2007; Moller & Schaltegger, 2005; Rikhardsson, 1998; Shaft, Sharfman, & Swahn, 2001), knowledge management systems for environmental sustainability initiatives (e.g., Jain, George, & Webster, 2008; Manning, 2007), or the concept of designing for the environment (DfE) – that is, taking the environment into consideration when designing products and services (e.g., Lenox, King, & Ehrenfeld, 2000; Yang, Moore, Wong, Pu, & Chong, 2007). Most of the research focuses on Green IS, rather than on IT. In contrast, the practitioner literature is more concerned with describing technologies, such as Green supercomputers (e.g., Schaffhauser, 2008) and Green data centers (e.g., West, 2008).

We now turn to the components of the Green IT/S framework, drawing our rationale for this framework mainly from the supporting management literature, and illustrating how existing Green IT/S research fits into this framework.

2.1.1. Environmental sustainability motivating forces

It is well-established in the management literature on organizational sustainability that numerous motivating forces influence an organization's environmental strategy. For instance, ecological forces (e.g., rate of resource renewal, regenerative capacity of resources), organizational forces (e.g., strong leadership, employee stewardship), political–economic forces (e.g., laws and regulations), and socio-cultural forces (e.g., institutions, norms) all have the capacity to motivate or constrain environmental strategies (Bansal, 2002; Bansal & Roth, 2000; Starik & Rands, 1995).

The review of Green IT/S literature identified just four articles that empirically assess motivating forces (see Supplementary Table). Interestingly, these articles also examine an additional motivating force, technological forces, which is particularly relevant to issues of Green IT/S. Based on both the broader

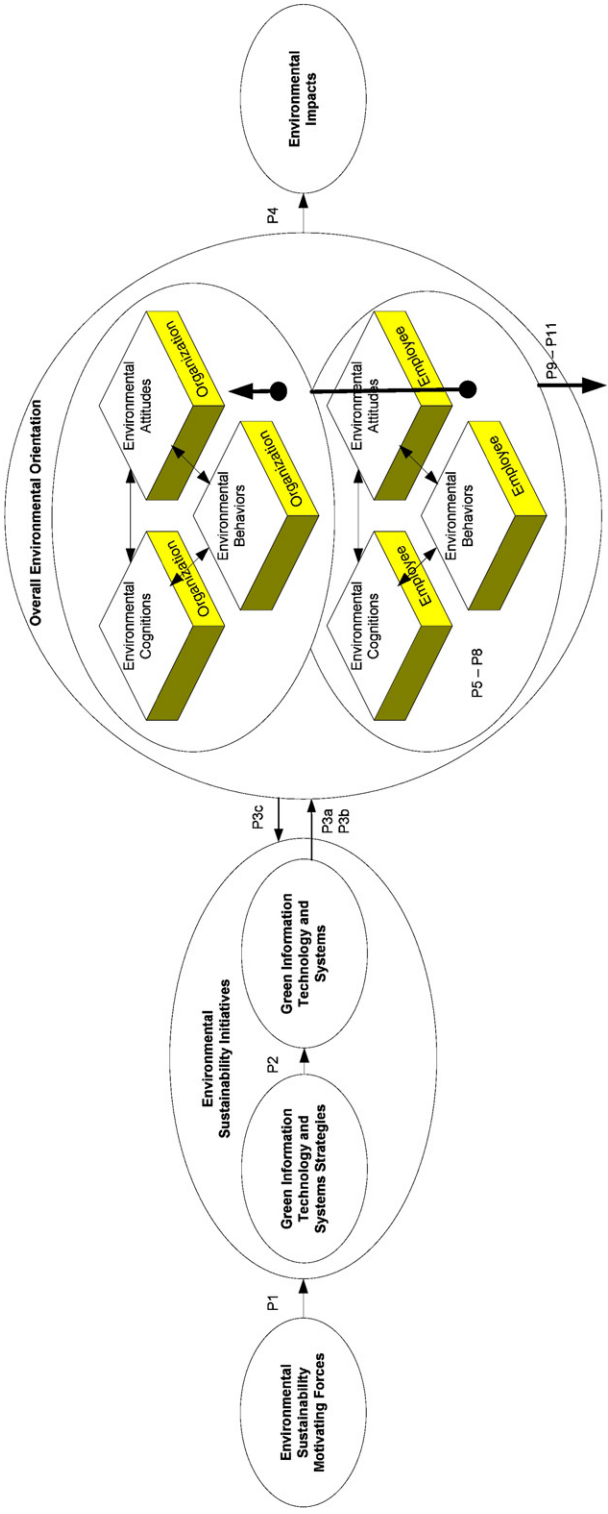

Fig. 1. Multilevel Framework for Environmentally Sustainable IT/S Research.

literature on organizational sustainability and the more nascent research on Green IT/S, we therefore identified five motivating forces that influence environmental sustainability strategies: organizational, regulatory-market, socio-cultural, ecological, and technological.

These forces describe the external and internal factors influencing the organization's actions. Organizational forces are those internal to the organization and reflect leadership, internal stakeholders (including employees), capabilities, structures, policies, and financial considerations. Although few empirical Green IT/S articles described organizational forces, those that did discussed organizational capabilities and financial considerations (Elliot & Binney, 2008), organizational structure (Lenox et al., 2000), and leadership and culture (Goodman, 2000). Additionally, conceptual work in this area has suggested that internal stakeholders (Setterstrom, 2008) and leadership (Manning, 2007) play critical roles in shaping an organization's environmental sustainability activities.

The other four forces encompass the external factors. Regulatory-market forces are represented by external standards, regulations and laws, as well as market pressures. Many of the Green IT/S articles discuss all types of regulatory-market pressures (e.g., Chen et al., 2008; Elliot & Binney, 2008; Setterstrom, 2008). To a lesser degree, this literature identifies socio-cultural forces, which reflect the environmental values, beliefs and trends in society. These forces recognize the influence of media (e.g., see San Miguel, 2009) and organizations' needs for social legitimacy. Public pressure can play a large role in moving organizations towards more sustainable business practices, including Green IT/S related ones (e.g., Elliot, 2007). While much of this work has been conceptual, Elliot and Binney's (2008) case study identifies a number of external factors, both regulatory (e.g., government regulations and mandates) and socio-cultural (e.g., environmental sustainability as part of the social contract) forces, that influence environmental sustainability strategies.

The ecological and technological forces describe the external resources – natural and artificial – available to the organization and how they affect the organization's decision to act in an environmentally sustainable way. Ecological forces represent the amount and rate of depletion of natural resources. Notably, while these forces do not appear to have been explicitly discussed in the Green IT/S literature, they do seem implied (e.g., Chen et al., 2008). Technological forces describe the technologies available that facilitate environmentally sustainable business practices, for example, energy efficient chips. Several articles discussing technological forces were found in the Green IT/S literature. These articles, primarily conceptual, tend to focus on the design and use of IT/S (e.g., Isenmann et al., 2007; Yang et al., 2007), as well as the systems development process (e.g., Haigh & Griffiths, 2008; Huang, 2008). While technological forces are critical for the types of Green IT/S strategies and activities available to organizations, the broader literature suggests that other forces have a much stronger influence on the organization's behavior.

Any number of these five motivating forces can combine in varying degrees to drive an organization to adopt particular environmental initiatives. The types of environmental initiatives are discussed next.

2.1.2. *Environmental sustainability initiatives: strategies and technologies/systems*

A significant portion of the existing management research on environmental sustainability looks at environmental strategies, or the organization's espoused stance towards the environment. For instance, one area examines ecological sustainable development and associated strategies (e.g., Berry & Rondinelli, 1998; Branzei, Vertinsky, & Zietsma, 2000; Egri & Herman, 2000; Shrivastava, 1995; Starik & Rands, 1995). Another area uses theories such as institutional theory, the resource-based view (RBV), and the natural resource-based view to examine how firms respond to internal and external pressures regarding environmentally sustainable strategies and the influence of firm capabilities (e.g., Aravind & Christmann, 2008; Berrone, Gelabert, Fosfuri, & Gomez-Mejia, 2008). In short, few gaps exist in management and there are several well-established frameworks.

For Green IT/S, environmental initiatives are composed of both strategies and the resulting technologies and systems. Green IT/S strategies are derived from environmental strategies, and thus represent the IT/S-specific elements of the overall environmental strategy,[4] or "the extent to which green and sustainability guidelines are developed across an organization and permeate the IT value chain" (Molla, Pittayachawan, & Corbitt, 2009b, p. 7). These strategies are then translated into actual Green IT/S – information technology

[4] IT/S strategies should align with organizational strategies; as there is a substantial body of research concerning this relationship (e.g., Bergeron et al., 2004; Chan & Reich, 2007; Chan et al., 1997), we do not develop the rationale for it in this paper.

and systems designed, developed, and implemented to support the organization's Green IT/S strategies. That is, these espoused strategies are instantiated, implemented and "realized" as Green IT/S. Table 1 provides examples of these espoused strategies and actual Green IT/S, which we describe in more detail next.

In contrast to the wide body of management literature on environmental strategies, we identified just seven Green IT/S articles that assess environmental strategies specific to IT/S (see Supplementary Table). This literature, which is largely conceptual, tends to draw on established management theories and findings. It focuses primarily on examining the benefits of developing Green IT/S practices (e.g., Setterstrom, 2008) as well as the environmental implications of IT and IS for organizations in general (Elliot, 2007; Haigh & Griffiths, 2008; Sarkis & Zhu, 2008).

Considering both the management and Green IT/S literatures, we identified four types of environmental sustainability strategies that are relevant for research on Green IT/S. These strategies range in terms of the degree to which they impact the environment and the amount of change that they require. Each of these strategies subsumes the lower types, resulting in a strategy hierarchy. Although some argue that environmental strategies range on a continuum (e.g., Murillo-Luna, Garcés-Ayerbe, & Rivera-Torres, 2007), most researchers examine strategies as distinct types. Although Types 1 to 3 have been previously examined in the management and Green IT/S literatures (Brown et al., 2005; Dyllick & Hockerts, 2002; Hart, 1995), we propose a new strategy, Type 0, which we believe also occurs in organizations.

A Type 0 environmental strategy involves portraying an image of caring about the environment by publicly announcing environmental policies (espoused strategy), yet not implementing or carrying out

Table 1
Green IT/S strategy types and Green IT/S examples.

		Examples	
Strategy type	Description	Green IT/S strategy	Green IT/S
Type 0: Image-oriented only	Involves portraying an image of caring about the environment by publicly announcing environmental policies (espoused strategy). These policies and practices are not subsequently implemented. Intentions can be "green" (authentic) or "greenwashing" (not authentic).	Announcing a strategy to reduce energy use in the organization's supply chain by using IT/S.	Although intentions are authentic, there are insufficient resources (for example, financial and human resources) to implement the IT/S application.
Type 1: Prevent, control, eco-efficiency	Involves making efficient use of natural and firm resources in order to reduce negative environmental impacts. Focuses on resource efficiency, waste prevention and control.	Introducing an objective to reduce IT/S power consumption across the company.	Implementing energy efficient servers and powering off PC's when not in use (Setterstrom, 2008).
Type 2: Product stewardship, eco-equity	Subsumes type 1 strategy and also involves attempts to achieve eco-equity goals (balancing the firm's and society's short and long term needs for natural resources) by minimizing environmental impacts throughout a product's lifecycle (product stewardship).	Developing a strategy to use IT/S to help reduce the environmental impact of an organization's product(s).	Implementing an IS and associated technology to capture environmental data during product distribution, use and maintenance for product design improvements (Yang et al., 2007).
Type 3: Sustainable development, eco-effectiveness	Subsumes type 1 and 2 strategies; involves infusing environmental sustainability considerations throughout all of the firm's activities and interactions with the goal of stopping environmental degradation altogether.	Introducing a goal to substantially reduce business travel using IT/S.	Implementing videoconferencing, telepresence and collaboration tools as substitutes for travel (Watson et al., 2008; Setterstrom, 2008).

these policies. It is important to differentiate between Type 0 strategies in which the organization has "greenwashing" intentions versus "green" intentions. In the former case, an organization may be concerned with their image, but not with the actual completion of environmental activities. In the latter case, they may have authentic intentions, but are unable to complete environmental activities due to organizational inertia or lack of resources and knowledge. The management literature has devoted much attention towards understanding the greenwashing phenomenon (e.g., Laufer, 2003). Although some suggest that greenwashing might work (e.g., Westphal & Zajac, 2001), others propose that an incongruence between a corporation's external image and its internal practices regarding sustainability could trigger a backlash, ultimately decreasing its legitimacy (Ashforth & Gibbs, 1990; DiMaggio & Powell, 1983). In support of this, management researchers have noted that organizations should implement practices that encourage employee behaviors to be congruent with the policies for environmental responsibility that organizations actually say they support (Peloza & Hassay, 2006).

A greenwashing, or type 0 example for Green IT/S might include a case where a company states on their company website that their data center adheres to environmentally sustainable practices such as using virtualization technology to consolidate servers. However, this company has no intention of implementing virtualization technology.

The remaining types of environmental strategies arise from two dominant environmental strategy typologies that are well-established in the management literature. First, Hart's (1995) natural resource-based view describes three strategies: pollution prevention and control, product stewardship, and sustainable development. Hart (1997) later decomposes sustainable development into clean technologies (i.e., environmentally sustainable technologies) and sustainable vision (i.e., plan for moving towards sustainable development) as part of the sustainability portfolio he proposes. The other dominant typology includes three strategies: eco-efficiency, eco-equity and eco-effectiveness (Dyllick & Hockerts, 2002). These typologies have been recently integrated into the domain of Green IT/S (e.g., Chen et al., 2008; Setterstrom, 2008). Our interpretation of these two typologies is that they are both progressive. That is, the three "types" in each typology progress in terms of degree of integration into business activities and impact on the environment. Although the two typologies do not have the same focus and level of specificity, we believe they are related and that integrating them provides a richer conceptualization of environmental strategy. That is, Hart's (1995) environmental strategies can be seen as mechanisms for achieving Dyllick and Hockerts' (2002) eco-goals. For example, prevent and control activities are primarily focused on eco-efficiency goals. We also view these strategy types as a hierarchy, where each higher type strategy subsumes the lower types. For example, Type 2 product stewardship encompasses Type 1 activities and includes the goals of eco-efficiency as well as eco-equity. The strategy types in this combined typology are described in more detail below.

Type 1 strategies, which involve eco-efficiency, pollution control and prevention, are typically the next easiest to implement after Type 0 strategies, but have a smaller overall impact than the remaining types (Dyllick & Hockerts, 2002; Hart, 1995). Type 1 strategies focus primarily on the eco-goal of making efficient use of natural and firm resources in order to reduce negative environmental impacts (eco-efficiency) and often require making only incremental changes to business operations. These changes can include implementing mechanisms to capture and properly dispose of waste in order to minimize environmental harm, mechanisms to prevent and reduce waste, and mechanisms to improve resource efficiency.

Green IT/S with direct impacts on the proper disposal and prevention of waste may, for example, include those designed to reduce: 1) power consumption by purchasing energy efficient servers, powering off PC's, and consolidating servers using virtualization technology, and 2) waste associated with disposing of obsolete computer equipment by upgrading components, refurbishing computers, and recycling computer components (Setterstrom, 2008). Green IT/S with indirect impacts focus on improving eco-efficiency. They can reduce negative environmental impacts, for example, by focusing on incrementally or partially: 1) implementing IT to reduce paper consumption (e.g., using email and electronic documents) and 2) implementing IT to reduce travel (e.g., facilitating telecommuting) (Allenby, Compton, & Richards, 2001; Setterstrom, 2008; Watson et al., 2008).

Moving beyond efficiency considerations, yet still encompassing Type 1 activities, Type 2 strategies include product stewardship and eco-equity – balancing the firm's and society's short and long term needs for natural resources (Dyllick & Hockerts, 2002). Product stewardship, based on the natural resource-based view of the firm, attempts to achieve eco-equity goals by minimizing negative environmental impacts

throughout a product's lifecycle – raw material utilization, design, production, packaging and distribution, and disposal (Hart, 1995). Although the difficulty and number of changes to business processes is greater for Type 2 strategies, so too are the benefits to the environment and the firm (Dyllick & Hockerts, 2002; Hart, 1995).

Green IT/S that support Type 2 strategies may include redesigning IT and the manufacturing process to reduce negative environmental impacts, for example by: 1) designing IT to be energy efficient, easily upgradable, and easily recyclable, 2) designing packaging for IT, and 3) using non-hazardous or recyclable materials in the design of IT components (Setterstrom, 2008). Although all of these examples are related to IT manufacturing and have a direct positive impact on the environment, it is possible that Green IT/S applications could involve other products' design, manufacturing, distribution, use and end-of-life stages, as well as the entire supply chain. This would reduce other negative environmental impacts and, thus, provide an indirect positive impact (Allenby et al., 2001; Pearce, Johnson, & Grant, 2007). Examples include: an IS to help reuse and recycle material from building deconstruction (Jain et al., 2008); an IS to capture environmental data during product distribution, use and maintenance for product design improvements (Yang et al., 2007); and integrating Google Earth for fleet route optimization or shipping mode optimization (Pearce et al., 2007). Thus, Type 2 strategies for Green IT/S can involve either direct or indirect positive impacts on environmental sustainability.

Whereas Type 2 strategies embed environmental sustainability considerations throughout the product lifecycle, Type 3 strategies – sustainable development and eco-effectiveness – are recognized as larger in scope. They involve fundamentally rethinking how the firm operates in order to infuse environmental sustainability considerations throughout all of the firm's activities and interactions with a goal of stopping environmental degradation altogether (Hart, 1995). Thus, Type 3 strategies also encompass the goals and activities of Type 1 and 2 strategies, but to a larger extent. The difficulty and degree of change required for Type 3 strategies is higher than for the other types, but the potential benefits to the environment are much larger. This strategic approach has also been applied to assess Green IT/S (Chen et al., 2008; Goodman, 2000; Setterstrom, 2008). Type 3 Green IT/S involve supporting radical changes to how business is done, for example: substituting travel and physical meetings with videoconferencing, telepresence and collaboration tools, completely eliminating paper-based workflows and reporting, and conducting business transactions through e-commerce (Watson et al., 2008). In addition to these applications, other studies describe the indirect positive impact of using IS for reporting and measurement of environmental business practices (Rikhardsson, 1998; Shaft et al., 2001) or collaborating on environmental initiatives (Allenby et al., 2001; Fuchs, 2008). Thus, Type 3 strategies for Green IT/S can also have both direct and indirect impacts on environmental sustainability.

Motivating forces and the organization's environmental strategies provide the context within which an organization's espoused Green IT/S strategies and actual Green IT/S exist. In addition to exploring this context, management and Green IT/S articles have examined the successful use of Green IT/S, through studying individual and organizational attitudes, cognitions, and behaviors (or, environmental orientation).

2.1.3. Overall environmental orientation

In order to understand the linkage between environmental initiatives and impacts, we consider environmental orientation. We propose that it is made up of three factors that can be studied at multiple levels of analysis (such as individual and organizational): environmental attitudes, cognitions, and behaviors. This results in a "homologous" multilevel framework, or one in which the relationships between variables hold at multiple levels (Klein & Kozlowski, 2000). That is, there are "parallel nomological networks among similar constructs across levels of analysis" (Chen, Bliese, & Mathieu, 2005, p. 376). For instance, for a multilevel model examining usage and performance, employee system usage may relate to individual task performance at the individual level, while collective system usage may relate to organizational performance at the organizational level (Burton-Jones & Gallivan, 2007). Consequently, for our framework, we expect that environmental orientation relations at the employee level will be similar to those at the organizational level (that is, the relations between attitudes, cognitions, and behaviors at each of the levels will be similar). Homologous multilevel models are powerful and parsimonious; they allow researchers to generalize constructs and relations across different levels, resulting in a better integration of micro and macro approaches (Klein & Kozlowski, 2000).

Environmental attitudes at the employee level represent feelings of favorableness or unfavorableness toward a behavior (Ajzen, 1991); at the organizational level, they can be viewed as organizational climate or culture. Cognitions are "assumptions, expectations, values and beliefs" (Tan & Hunter, 2002, p. 40) at the employee level; they are shared understanding at the organization level. Behaviors represent individual actions at the employee level and organizational routines at the organizational level. Although a particular Green IT/S could be successfully designed, developed and implemented, achieving the organization's espoused Green IT/S strategy depends on the actual behaviors of the employees and the organization. In other words, success is determined by how the Green IT/S is used.

Consider the following Green IT/S resulting from a pro-environmental strategy –– implementation of duplex printers in order to reduce paper consumption –– and how it might relate to environmental orientation. Concerning individual-level orientation, the implementation of duplex printers may translate into actual behaviors for some employees (who print double-sided). This Green IT/S could also affect employees' environmental cognitions (if, for example, the implementation of the printers is accompanied by an explanation of how/why duplex printers will have a positive effect on the environment) and/or their attitudes (if, for example, the new Green IT/S taps into feelings of connectedness to the environment). In terms of organization-level orientation, this Green IT/S could result in organizational routines such as the standard use of printing defaults to automatically print on both sides, an organizational culture that becomes more environmentally-focused, and/or a shared understanding around the importance of reducing paper consumption. Table 2 provides further illustrative examples of positive and negative environmental orientations that could result from a Green IT/S at both employee and organizational levels.

As we describe later, we take a Gestalt view of environmental orientation and propose that alignment is important to consider both within and between levels. First, the extent to which the three factors co-align (i.e., have similar values) and have positive valence (within levels, for both employee and organization) will result in higher overall environmental orientation. Second, the extent to which employee and organizational orientations co-align between (across) levels and have positive valence, the more positive the environmental impact. Alignment is important to take into account because environmental issues are 'wicked' due to the need to cope with uncertainties, knowledge imperfections, and trans-disciplinary issues (Hasan & Kazlauskas, 2009; Sage, 1999). For example, employees may have positive attitudes, yet

Table 2
Multilevel environmental orientation: employee- and organizational-level examples.

	Examples	
Green IT/S	Implemented online reporting system to reduce paper consumption.	
More positive environmental orientation	Employee-level	Organizational-level
Behaviors	Employee reduces the number of reports printed; views reports online; creates electronic reports for electronic distribution using the new reporting system.	Organization updates reporting policy to encourage the use of electronic reports, rather than requiring printed copies of reports.
Cognitions	Employee believes that reducing paper consumption will help the environment.	Organization has a shared understanding that reducing paper consumption helps the environment.
Attitudes	Employee feels positively disposed towards helping the environment by reducing his/her paper consumption.	The organization culture is one that positively values supporting environmental sustainability and as a result, reduction in paper consumption.
More negative environmental orientation	Employee-level	Organizational-level
Behaviors	Employee continues to print reports.	Organization still requires certain reports to be submitted and distributed on paper.
Cognitions	Employee feels reducing paper consumption will do little to affect the environment.	Organization lacks a shared understanding regarding the implications of paper consumption on the environment.
Attitudes	Employee does not feel positively disposed towards helping the environment.	The organization culture does not value supporting environmental sustainability. Culture is predisposed towards using paper documents and reports.

these attitudes may not carry through to positive behaviors due in part to a lack of knowledge of the effects of their behaviors. Further, changing deeply entrenched behaviors and routines is often very challenging, particularly so for environmental initiatives. Thus, understanding environmental attitudes, cognitions, and behaviors, in terms of how they relate to one another, is central to advancing the successful use of Green IT/S. These three constructs have long been studied at multiple levels of analysis in the management and environmental psychology literatures, and more recently in the Green IT/S literature.

In the management literature, the importance of attitudes, cognitions, and behaviors to environmental sustainability initiatives have been discussed largely at the organizational level, and to a lesser degree at the individual level (e.g., Egri & Herman, 2000). Several studies point to the importance of developing an organizational culture that values the environment, is committed to sustainability and supports environmental innovations (Andersson & Bateman, 2000; del Brio, Fernandez, & Junquera, 2007; Starik & Rands, 1995). The importance of organizational leadership (Andersson & Bateman, 2000; Fernandez, Junquera, & Ordiz, 2003; Ramus, 2002; Ramus & Steger, 2000) and communication in developing this culture and shared understanding (Ramus & Steger, 2000) have been identified. The choice of proactive environmental strategies and corporate actions (Branzei et al., 2000) have also been studied. Overall, these management studies focus on the influence that leadership values and culture have on behaviors related to the environment.

Research in environmental psychology focuses on the individual level of analysis. It examines predicting pro-environmental behaviors based on a variety of factors such as environmental attitudes (Milfont & Duckitt, 2004) and affect (for example, connectedness to nature: Mayer & Frantz, 2004). Researchers have also examined the influence of positive and negative emotions (Russell, 2008), values (Karp, 1996; Schultz & Zelezny, 1999) and norms (Schwartz, 1970; Van Liere & Dunlap, 1978). Psychological research has concluded that pro-environmental behaviors are motivated by a mixture of self-interest and more general pro-social concerns about other people, other species, and whole ecosystems (Bamberg & Moser, 2007). Those researchers focusing on self-interest often use rational-choice models like the theory of planned behavior (Ajzen, 1991), while those looking at pro-social motives often draw on the norm-activation model (Schwartz, 1977). Generally, this research examines consumers or citizens (e.g., Thøgersen, 2004) and it is important to keep in mind that the determinants of employee behaviors in the workplace may be different (Andersson, Shivarajan, & Blau, 2005).

The literature on Green IT/S is more recent and less developed. To date, researchers have examined attitudes, cognitions, and behaviors across different levels of analysis, yet only one empirical study (Molla et al., 2009b) incorporated all three constructs. Several empirical studies have explored individual adoption issues of environmental information systems (e.g., Haigh & Griffiths, 2008; Smart et al., 2007). In these studies, cognitions, behaviors, and to some degree attitudes regarding Green IT/S were deemed important during systems analysis and design (SA&D) and adoption. For example, by not questioning and changing existing inefficient business processes during SA&D, the new system can perpetrate further negative impacts on the environment (Haigh & Griffiths, 2008).

Although there is some research at the individual level, the majority of the Green IT/S studies are at the organizational level of analysis. These studies examine changes to collective cognitions, values and norms, as well as changes to routines that take place at the organizational level. Two examples include the changes that take place as an organization develops capabilities in using IT/S for environmental sustainability (Elliot & Binney, 2008), and those that take place during sustainable software development (Huang, 2008). Further, Chen et al. (2008) look at how IS affects the adoption of environmental sustainability strategies under different institutional pressures; they explore how IS can help bring about changes in mindsets regarding the environment, which spur behavioral changes.

Other Green IT/S studies describe how collecting and disseminating information about sustainability can help change cognitions, behaviors and routines. These include how IT/S helps change cognitions at both the individual and organizational levels by diffusing information about the need for changes in environmental practices and, thus, help to initiate a paradigm shift in thinking (Manning, 2007); how IT/S supports changes to cognitions and behaviors by collecting and reporting several environmental indicators (Goodman, 2000); and how an IS to support building deconstruction helps change behaviors by providing information regarding salvaged components for reuse (Jain et al., 2008). Similarly, collecting and reporting environmental data can change individual (e.g., energy consumption when a computer is left running) and organizational (e.g., accounting measurement) cognitions (Rikhardsson, 1998). Further, some studies

describe the importance of creating an organizational culture that supports environmental sustainability initiatives (Goodman, 2000). In sum, while most studies investigating the importance and challenges associated with changing attitudes, cognitions and behaviors for Green IT/S initiatives focus on the organizational level of analysis, some also discuss these components at the individual level.

2.1.4. Environmental impacts

Although organizations may be motivated to adopt Green IT/S strategies and implement the corresponding Green IT/S, the success of these and associated changes to environmental orientations is ultimately assessed by the impact of these activities on the environment. In the management literature, environmental impact has been noted as a key outcome measure for assessing corporate environmental performance (e.g., Ilinitch, Soderstrom, & Thomas, 1998). Yet, despite acknowledging its importance, much of the literature in this area is conceptual (e.g., Starik & Rands, 1995) or the meaning of the term is left ambiguous. For instance, numerous articles suggest reducing and understanding organizational environmental impacts or stress the importance of organizations having a low negative environmental impact without detailing what is meant by environmental impact (e.g., Ramus & Steger, 2000). The empirical work in this area tends to examine environmental issues in relation to more tangible firm outputs such as sustainability reports (e.g., Jose & Lee, 2007) and environmental policies (e.g., Ramus & Montiel, 2005).

Our review of the Green IT/S literature shows that only eleven papers measured environmental impacts. These range from more specific measures (e.g., greenhouse gas emissions: Dewick, Green, & Miozzo, 2004) to more comprehensive ones (e.g., environmental certifications and consumption of water, electricity, gas, and oil, etc.: Caldelli & Parmigiani, 2004). As in the management literature more generally, there is little understanding of how to accurately measure environmental impacts. To date, much of the research has been conceptual (e.g., Manning, 2007).

In summary, the framework presented in Fig. 1 provides a comprehensive guide for researchers interested in Green IT/S. It relates the well-established environmental management and environmental psychology literatures with the emergent area of Green IT/S. In integrating these areas, the framework reveals that, while other academic research has done a good job in certain areas of the framework, there still exist many gaps that represent opportunities for Green IT/S research. Therefore, in order to guide future Green IT/S studies, we now turn to the development of propositions to explain the linkages between the components identified in our framework.

3. Theoretical propositions

We develop high-level propositions to theoretically justify and explain the relationships in our conceptual framework. These propositions were developed based on our review of the literature and our on-going research and experience in the field. We begin with developing propositions for the model's main effects (P1–P4), which focus on areas that are more developed in the supporting literatures. We then move on to alignment propositions relating to environmental orientation, focusing mainly on employee-level relationships in our multilevel model (P5–P11). This is an area that has received little attention in the Green IT/S literature.

3.1. Examining main effects

The influence of motivating forces on an organization's strategies are often explained using institutional theory (DiMaggio & Powell, 1983), resource dependency theory (Pfeffer & Salancik, 1978), resource-based view of the firm (Barney, 1991; Wade & Hulland, 2004; Wernerfelt, 1984), and natural resource-based view of the firm (Hart, 1995). Drawing on these theories, the extant literature indicates that institutional pressures, the desire for social legitimacy, the need for scarce resources, as well as the ability to create unique and valuable resources all shape an organization's environmental sustainability strategies. For instance, the natural resource-based view of the firm implies that motivational forces, such as the need to acquire a “sustained competitive advantage through accumulation of rare and firm specific resources” (Hart, 1995, p. 1003) may lead firms to engage in more intense environmental strategies. Similarly, drawing on institutional theory, Daly and Butler (2009) suggest that when an organization is subjected to

stringent regulatory structures such as "rigorous and comprehensive environmental regulations", they are more likely to be environmentally responsible (p. 6). Implicit in this statement is that regulatory pressures likely act as motivating forces, driving organizations to adopt higher-level environmental strategies in order to avoid penalties and sanctions. Organizations may confront similar pressures when there are strict environmental norms within their industry or community (Daly & Butler, 2009), thus making it necessary to pursue higher-level environmental strategies to gain legitimacy in the eyes of critical stakeholder groups. In contrast, if an organization operates in a less-regulated environment or one with less embedded environmental norms, they may be able to gain legitimacy by adopting a lower-level environmental sustainability strategy. Evident in these examples is the notion that more and stronger motivating forces (both across and within types of forces) may greatly influence an organization's environmental sustainability strategies. Given the strong connection between an organization's business and IT/S strategies (e.g., Chan & Reich, 2007), these motivating forces should also influence an organization's Green IT/S strategy. That is, the higher the motivating forces, as determined by both number and the strength, will influence the organization to strive for higher types of Green IT/S strategy. Thus, we propose that:

P1. *The higher the environment-related motivating forces affecting an organization, the higher the type of Green IT/S strategy to which the organization will strive.*

We now turn to an examination of the relationship between Green IT/S strategies and actual Green IT/S. The natural resource-based view of the firm (Hart, 1995) predicts that higher types of strategy (e.g., Type 2: product stewardship, and Type 3: sustainable development) will help to embed environmental considerations throughout more of the organization's ongoing business practices. On a broader level, this prediction is reiterated by others (e.g., Azzone & Bertel, 1994; Henriques & Sadorsky, 1999) in their related work on various treatments (i.e., proactive, defensive, accommodative, reactive) of the "business/natural environment interface" (Sharma & Vredenburg, 1998, p. 733). Generally speaking, it is noted that companies with high-level environmental strategies engage in pro-environmental programs across all dimensions of corporate activity. Specific to Green IT/S, we predict that organizations espousing higher types of Green IT/S strategies will initiate the implementation of more Green IT/S corresponding to these types. For example, an organization focusing on eco-efficiency as a strategy might implement more energy-efficient computers (see Table 1). Thus, we propose that more IT/S that are green will be implemented:

P2. *Organizations that espouse higher types of Green IT/S strategies will initiate the implementation of more Green IT/S corresponding to these higher types.*

Further, we propose that the implementation of Green IT/S in the organization will positively impact environmental orientation. The success of this implementation and the resulting environmental impact depends on the actual behaviors, as well as cognitions and attitudes, of employees and the organization as a whole. For instance, Hart (1995) notes that sustainable development involves creating both a shared vision and a fundamental sense of purpose for positive environmental change. This notion is also supported in other research, which suggests that organizations wishing to adopt an environmental orientation must first develop an appropriate corporate strategy that acknowledges the importance of environmental issues by formalizing environmental practices (Banerjee, Iyer, & Kashyap, 2003), for example, by implementing Green IT/S. Similar research, though focusing on how corporate environmental initiatives influence employees, suggests that proactive (i.e., high-level) programs foster a culture that encourages employees to experiment with ideas about integrating business and environmental issues (Sharma & Vredenburg, 1998). Additional research finds that when employees perceive a strong signal from their organization regarding environmental policy, they are more likely to be engaged in the environmental initiatives (Ramus & Steger, 2000).

Although these studies rely on slightly different labels for perceived environmental approaches, they implicitly suggest that higher-level environmental initiatives positively influence environmental attitudes, cognitions and behaviors. Thus, implementing higher types of Green IT/S will lead to a more positive overall environmental orientation. Therefore, we propose that:

P3a. *The organization's Green IT/S will influence its environmental orientation. Specifically, the higher the type of Green IT/S, the more positive the overall environmental orientation.*

Before turning to the reciprocal relationship (environmental orientation to Green IT/S), it is instructive to consider how the design of the Green IT/S could reinforce the relationship between Green IT/S and environmental orientation. That is, what methods are available for strengthening the relationship between Green IT/S and overall environmental orientation? Although this relationship could be examined at either employee or organizational levels, we utilize illustrative examples at the employee level for reasons of parsimony and a dearth of research at this level. To do so, we draw on both MIS and social marketing research.

Social marketing represents interventions in which "promoters identify the activity to be promoted and the barriers to this activity and then design a strategy to overcome these barriers, using psychological knowledge regarding behavior change" (McKenzie-Mohr, 2000, p. 531). Social marketing research utilizes techniques to change behaviors without concern for the underlying environmental attitudes. There are several social marketing techniques advocated for engaging individuals in pro-environmental behaviors, including: commitment techniques (Katzev & Wang, 1994), such as agreement to a small initial request (the foot-in-the-door technique (Freedman & Fraser, 1966)); prompts as reminders (Austin, Hatfield, Grindle, & Bailey, 1993), such as visual or auditory aids; making norms visible and using personal contacts to reinforce norms, such as modeling of the behavior by influential others (Bandura, 1986); framing messages to be positive, vivid, and easy to remember (Bator & Cialdini, 2000); and providing feedback (Govindarajulu & Daily, 2004).

We suggest that Green IT/S that embed feedback about the relative impacts of different types of behaviors can positively shape cognitions. Many individuals do not know the impacts of different behaviors or they believe in certain myths concerning impacts (Chinander, 2001). For instance, many believe that turning off lights when leaving a room will not save energy if returning soon because of the "additional energy needed to turn on the light". These types of myths often result in unnecessary energy waste. In contrast, Green IT/S could provide information about the impact of certain behaviors so that effort is channeled towards the highest ecological impact behaviors. The type and quality of information provided to the individual may update cognitions and promote appropriate use of IT/S (DeLone & McLean, 1992,2003). For example, using software to capture and provide employees with feedback on their consumption patterns and how behavior changes reduce their environmental footprints (e.g., Yang et al., 2007; Zerofootprint, 2009) would help update cognitions. Providing feedback (on individual improvements as well as on total improvements across the group and organization) can help employees see the bigger picture and motivate behavior change (McKenzie-Mohr, 2008) and can help individuals develop new heuristics regarding their behaviors (Amel, Manning, & Scott, 2009). Therefore, Green IT/S that embed information about the relative impacts of different types of behaviors will positively shape cognitions and behaviors (and therefore environmental orientation).

Although embedding information on Green IT/S is important, informational campaigns rarely affect behaviors in the short term. In contrast, behavior change is more likely to occur when barriers to actions are reduced (McKenzie-Mohr, 2000). For example, barriers to reducing IT/S power consumption might be lowered by implementing software to automatically turn off PC's at night. By removing these behavioral barriers through Green IT/S, new behaviors are enacted, which result in more positive attitudes towards the behavior.

Designing and implementing Green IT/S that encourage engagement, such as visual and graphical displays, will also positively affect employees' attitudes. Engaged users enjoy the computer interaction, resulting in more positive attitudes (Webster, Trevino, & Ryan, 1993). Research on the related construct of flow (Csikszentmihalyi, 1990) has also demonstrated positive attitudinal outcomes in a variety of IT applications (e.g., Trevino & Webster, 1992). Therefore, we suggest that Green IT/S that encourage engagement will positively affect employee attitudes toward the environment.

Drawing from these streams of research in MIS and social marketing, it seems that Green IT/S that adhere to the design principles described above (feedback, barrier reduction, and engaging features) will reinforce the positive influence of Green IT/S on environmental orientation. That is:

P3b. *The more that the Green IT/S incorporates the design principles of feedback, barrier reduction, and engaging features, the more positive will be the overall environmental orientation.*

Environmental orientation may also feed back and influence environmental sustainability initiatives. The management literature suggests that employees often drive bottom-up environmental-oriented

change that permeates all levels of the organization (Andersson & Bateman, 2000; Drumwright, 1994; Menon & Menon, 1997). For example, Andersson and Bateman (2000) suggest that certain employees "convince and enable organization members to turn environmental issues into successful corporate programs" (p. 548). Implicit in this research, particularly given the efforts of environmental champions to engage both their managers and their colleagues, is that employees can play an influential role in determining the environmental initiatives of their organizations. In terms of Green IT/S, this suggests that when overall environmental orientation is more positive, employees may suggest or start environmental initiatives they feel the organization should implement. Thus, we propose that:

P3c. *The overall environmental orientation will influence the organization's environmental initiatives. Specifically, the more positive the overall environmental orientation, the higher the type of Green IT/S strategy to which the organization will strive and the higher the type of Green IT/S implemented.*

Also of interest is the relationship between overall environmental orientation and environmental impacts. Previous research suggests that organizations can reduce their environmental footprints by first recognizing their environmental impacts, creating a shared vision of environmental initiatives and devoting both effort and dedication towards change over the long-term (Hart, 1995). Similar research stresses that organizations able to embed environmental values and routines and make environmental visions a part of corporate identity are more successful in reducing negative environmental impacts, solving environmental problems, and developing more eco-efficient products and services (del Brio et al., 2007; Ramus, 2002; Starik & Rands, 1995).

Although this research speaks to the relationship between organizational environmental orientation and environmental impact, additional research suggests that employee buy-in is critical to successful corporate environmental initiatives and, more broadly, to helping the firm have a more positive environmental impact (del Brio et al., 2007; Ramus, 2002). This research denotes the importance of engaging employees in corporate environmental initiatives (e.g., fostering environmental stewardship values, encouraging eco-ideas, instilling environmental values) to enhance the positive impact of the organization's environmental initiatives (Andersson & Bateman, 2000; Drumwright, 1994; Menon & Menon, 1997). Accordingly, we anticipate that environmental orientation will influence environmental impact. Thus, we propose that:

P4. *The more positive the overall environmental orientation, the more positive will be the environmental impact.*

3.2. Examining Alignment

But what is more positive environmental orientation? We suggest that environmental orientation will be higher when attitudes, cognitions, and behaviors are positive and when alignment occurs both within and between levels.

3.2.1. Within-level alignment

Implicit in within-level alignment is the need for consistency across environmental attitudes, cognitions and behaviors in order to generate more substantial positive environmental impacts. That is, like strategic alignment (as measured in Bergeron, Raymond, & Rivard, 2004), we take a Gestalt view of environmental orientation, and propose that each of its factors must be co-aligned (i.e., similar values for all factors) and positive in valence (e.g., positive environmental attitudes) for environmental orientation to be high. Building on this premise, we anticipate that organizations can achieve higher overall environmental orientation by positively aligning their environmental attitudes, cognitions, and behaviors within levels (employee and organizational). The underlying rationale for aligning the environmental orientation factors is that when things are "congruent" with one another, they tend to create synergies that result in improved performance (Chan, Huff, Barclay, & Copeland, 1997; Chan & Reich, 2007). That is, alignment between positive environmental attitudes, cognitions, and behaviors will compound to create a more positive orientation. Specifically, we anticipate that co-alignment between factors with positive valence will lead to high levels of environmental orientation and, in

contrast, co-alignment between factors with negative valence will lead to low levels of environmental orientation. Thus, we propose:

P5. *Within-level co-alignment between environmental attitudes, cognitions and behaviors with positive valence will lead to a more positive environmental orientation.*

One of the many challenges associated with environmental orientation is that there are often disconnects between behaviors, cognitions, and attitudes. However, as just described, the more they are co-aligned and positive in valence, the higher the environmental orientation. Therefore, we now turn to methods by which within-level alignment might be fostered. We focus on the employee level of analysis, but later suggest extensions to the organizational level. We draw primarily on theoretical perspectives from both MIS and learning theories that are known to influence individual attitudes, cognitions, and behaviors. Therefore, we provide illustrative propositions that describe how the components of environmental orientation interrelate at the employee level of analysis.

Although theories such as the theory of planned behavior (Ajzen, 1991) tell us that attitudes should relate to behaviors, this relationship is often weak for environmental issues. Instead, individual attitudes and beliefs about the environment are often incongruent with behaviors (Ohtomo & Hirose, 2007). For example, a meta-analysis of pro-environmental behaviors demonstrates that intentions predict only 27% of the variance in behaviors (Bamberg & Moser, 2007). For example, Ohtomo and Hirose (2007) found that recycling behaviors are predicted by both intentions and a more reactive willingness to act in environmentally (un)desirable ways for situational reasons. The researchers explain this through the principle of least effort: non-deliberative processing predominates over deliberative processing (that is, environmentally-friendly behaviors are sometimes viewed as requiring more effort). That is, individuals may have very positive attitudes, yet in the moment of taking an action, self-interest with respect to cost, convenience or other factors predominates. Chinander (2001) has observed that the challenges with promoting pro-environmental behaviors in individuals are associated with two fundamental problems: 1) there is a latency between an individual's action and the consequences (harm or benefit), and 2) there is no immediate feedback on the relative impact (success or failure) of the individual's action. As a result, people often do not make small changes because the connections between environmental behaviors and consequences are unclear.

We turn to the relationship between environmental cognitions and behaviors. For example, Amel et al. (2009) demonstrate that individuals who are more 'mindful' report more sustainability behaviors. This is because mindful individuals are more likely to attend to their surroundings and be aware of environmental impacts. As learning theories (e.g., Argyris and Schon's (1978) double-loop and single-loop learning) tell us, fundamental changes to behaviors and routines require questioning underlying norms and assumptions and modifying cognitive frameworks, which help simplify and organize information (Crossan, Lane, & White, 1999; Day, 2002; Hedberg, 1981; Kim, 1993). This suggests that environmental cognitions influence environmental behaviors. This relationship is also supported by organizational learning theory (e.g., Crossan et al., 1999), which suggests that changes to behaviors and routines are preceded by changes to cognition. Thus, we propose:

P6. *The employee's cognitions regarding environmental sustainability will positively influence his/her environmental sustainability behaviors.*

In addition to the influence that attitudes and cognitions have on behavior, behavior also has an impact on attitudes and cognitions. For example, organizational learning theory suggests there is a reciprocal relationship between changes in behavior and changes in cognitions. Cognitive changes may lead to behavioral changes or vice versa (Crossan & Berdrow, 2003; Crossan et al., 1999; Edmondson, 2002; Hargadon & Fanelli, 2002; Kim, 1993). Similarly, research on persuasion (McGuire, 1973) suggests that if behavior changes, attitude changes will follow (Oinas-Kukkonen & Harjumaa, 2009). Thus, we propose the following relationship:

P7. *The employee's behaviors regarding environmental sustainability will positively influence his/her attitudes toward the environment.*

Cognitions can also influence attitudes. A long history of examining the effects of cognitions on attitudes exists in MIS. Most of this research draws on the theory of reasoned action (Ajzen & Fishbein, 1980) or the theory of planned behavior (Ajzen, 1991). For example, Ajzen (1991, p. 191) argues that

> *attitudes develop reasonably from the beliefs people hold about the object of the attitude. … In the case of attitudes toward a behavior, each belief links the behavior to a certain outcome, or to some other attribute such as the cost incurred by performing the behavior. Since the attributes that come to be linked to the behavior are already valued positively or negatively, we automatically and simultaneously acquire an attitude toward the behavior.*

In support of this, Taylor and Todd (1995b) demonstrate that perceived usefulness of IS relates strongly to attitudes; similarly, in the environmental area, they (Taylor and Todd, 1995a) demonstrate that relative advantage of recycling relates to attitudes. Therefore, we propose that:

P8. *The employee's cognitions regarding environmental sustainability will positively influence his/her attitudes toward the environment.*

3.2.2. Between-level alignment

In addition to aligning within-level environmental orientation components, we propose that it is also important to align between-level orientations. Consistent with the arguments made for the within-level hypothesis (P5), the creation of synergies across levels will result in higher overall environmental orientation. Specifically, we anticipate that co-alignment between positive employee-level and organizational-level orientations will lead to more positive overall environmental orientation. Thus, we propose that:

P9. *Alignment between positive employee-level and organizational-level environmental orientations will lead to a more positive overall environmental orientation.*

We now turn to methods for increasing between-level alignment. First, we consider how organizational-level environmental orientation influences employee-level environmental orientations. Leaders report that what challenges them most in implementing eco-initiatives is motivating employees to fully engage in these activities (Berger, Cunningham, & Drumwright, 2007). Previous research suggests that soliciting employee buy-in is critical to successful corporate environmental initiatives (del Brio et al., 2007; Ramus, 2002). Further, research looking more closely at employee buy-in finds that supervisory support behaviors foster employee engagement in eco-initiatives (Ramus & Steger, 2000) and that organizations need to signal to employees that they are committed to implementing the environmental policies in order to solicit their support (Ramus, 2002). Similarly, Sharma and Vredenburg (1998) note how organizations can use training programs and incentives to foster employee support for eco-initiatives. Implicit in this research is that the environmental orientation of the organization increases the likelihood of employee involvement in environmental problem solving and enhances employee commitment to and identification with environmental initiatives (del Brio et al., 2007; Perez, Amichai-Hamburger, & Shterental, 2009; Ramus, 2002; Shrivastava, 1995). Other research links employee perceptions of organizational performance in the area of social responsibility with organizational identification, which then tends to align employee actions and cognitions with those of the organization (Carmeli, Gilat, & Waldman, 2007). Generally speaking, these findings suggest that the organization's environmental orientation helps shape the environmental orientations of employees because it facilitates employee adoption of environmental attitudes, cognitions and behaviors. Accordingly, we propose that:

P10. *The organization's environmental orientation will influence employee-level environmental orientations. Specifically, the more positive the organization-level environmental orientation, the more positive the employee-level environmental orientations.*

Having discussed how an organization's environmental orientation stands to influence employee-level environmental orientations, we now examine the reverse relationship. That is, how can employee-level environmental orientations influence organizational-level environmental orientation? We again turn to

organizational learning theory (e.g., Crossan et al., 1999), which describes how employee-level changes to cognitions and behaviors can lead to changes in the organization's shared understanding and routines. Institutionalizing new organizational routines and behaviors begins with changes to cognitions at the individual level and progresses by developing a shared understanding and implementing changes to routines at the work-group and department levels. Adoption of the new or updated routines at the organizational level suggests they are now institutionalized and part of the organization's shared understanding and collective cognition (Crossan et al., 1999). It is important to also note that once institutionalized, these organizational routines affect the ways that individuals think and how new ideas are evaluated. Thus, organizational learning theory helps explain why aligning the cognitions with behaviors and routines within and between levels should increase the overall impact and outcomes of Green IT/S initiatives. Thus, we propose the following:

P11. *The environmental orientations of employees will influence the organization's environmental orientation. Specifically, the more positive the employee-level environmental orientations, the more positive the environmental orientation of the organization.*

The three components of environmental orientation may be more or less aligned within and across levels of analysis. Propositions 5–11 have illustrated how these components can co-align. We have not presented propositions for every relationship, nor have we suggested propositions for all levels of analysis. As we discuss below, this represents an opportunity for future research.

4. Implications and conclusions

With the exploding use of information technologies and systems, reducing their direct negative environmental impacts will be critical to mitigating the planet's environmental degradation. However, 'Green' information technologies and systems hold greater promise for addressing broader environmental issues in organizations. Nevertheless, very little research has examined the potential of Green IT/S. This is due, in part, to the general lack of awareness of the impacts of IT/S on organizations' environmental footprints as well as the recent urgency regarding environmental issues. The existing Green IT/S research, albeit fragmented, and recent calls by MIS journals for special issues focusing on Green IT/S, are positive indicators for increased interest and coverage of this topic.

We hope that the framework presented here will motivate further research in this crucial area. Its four components – motivating forces, environmental initiatives (Green IT/S strategies and Green IT/S), environmental orientation, and environmental impacts – provide a context for more fully examining this critical topic for both organizations and the planet. We believe that our high-level propositions represent a valuable first step towards understanding how to overcome the challenges associated with implementing Green IT/S. Further, by integrating diverse areas of research to develop a comprehensive framework, we aim to bring value to both researchers and practitioners by placing IT/S in conversation with the environmental management, environmental psychology, learning, and social marketing literatures. In doing so, managers can better see the central role of IT/S in corporate environmental initiatives and, more generally, how IT/S may fit into their corporate social responsibility programs. For example, our framework provides insights into the range of strategies and Green IT/S, as well as the importance of environmental orientation, in the successful implementation and use of Green IT/S. Although the challenges associated with implementing and using Green IT/S sound daunting, we hope our propositions regarding potential solutions will help guide managers in closing the Green IT/S practice gap – that is, the issues associated with implementing and using Green IT/S. Specifically, our propositions suggest ways of designing Green IT/S to overcome adoption challenges and increase the environmental orientation of employees.

Many more propositions could be developed based on our framework and we encourage others to extend this work further. For example, while we focused on the employee level when developing our within-alignment propositions, these should be extended to the organizational level. Similarly, future research needs to examine the dynamics of group-level environmental orientation. Little Green IT/S research has addressed the group level (for exceptions, see Borri, Camarda, & Grassini, 2006; Lenox et al., 2000). One potential research area concerns the overall ownership of sustainability initiatives. Selection and implementation of technologies and systems typically fall under the domain of the IT department; the

provision of power, cooling, overall management of energy costs, and corporate sustainability initiatives often fall under the domain of Facilities Management (Uhlman, 2008). Although the domains of the IT and Facilities departments are interdependent, the organization's structure often does not reflect this interdependence, resulting in misalignment with organizational goals (Eisenhardt, 1989; Fama & Jensen, 1983), and in particular sustainability-based goals (Pearce & Miller, 2006). Even though it is important for organizational structure (e.g., reporting, decision-making rights, incentives) to change in order to align the goals of IT and Facilities to the organization's environmental sustainability goals, it is also crucial that the cognitions of each group change in order to shape and enact new environmental sustainability practices. Therefore, we suggest that future research examine whether the degree to which new Green IT/S are initiated depends on the alignment of the group-level cognitions of the IT and Facilities departments.

Other theoretical perspectives could also be incorporated into our framework. For example, recent work by Hasan and Kazlauskas (2009) suggests the use of complexity theory to examine how IT/S can contribute to solving 'wicked' problems of climate change. This represents a potentially rich area for future research in the area of Green IT/S. Whereas to date much of the research on environmental issues has drawn on theoretical frameworks such as the natural resource-based view of the firm (Hart, 1995), and the environmental framework put forth by Dyllick and Hockerts (2002), complexity theory offers a different theoretical perspective that has the capacity to enrich our current understanding of how IT/S fits within and contributes to corporate environmental agendas. In contrast to more reductionist approaches, complexity theory embraces the irreducibility of ecosystems and, in doing so, allows researchers to adopt a more holistic and interconnected view of environmental issues. This theoretical perspective enables one to incorporate Green IT/S as critical to the "logistical, business, political and informational issues that surround the science and engineering efforts and thus determine their acceptance, implementation and chances of success" (Hasan & Kazlauskas, 2009, p. 3).

Most importantly, we encourage empirical research on Green IT/S. As described earlier, one of the challenges concerns how to accurately measure environmental impacts. Many of the limited empirical studies to date have relied on third-party, non-standardized environmental ratings in their analyses (e.g., Russo & Fouts, 1997) or focused on a single element of environmental impact (e.g., pollution: Stanwick & Stanwick, 1998) rather than measuring the overarching impact of the firm's actions on the natural environment. Although it remains challenging for organizations to assess and measure their specific environmental impacts, there are now general ISO standards (ISO 14001) available that "help firms identify and control the environmental impact of their activities, products or services and to improve their environmental performance" (www.iso.org). These guidelines, though not tailored to each organization, can help organizations assess the environmental impacts of their actions. Given that the ability to measure environmental impacts is critical to understanding the effects of Green IT/S and necessary for setting benchmarks for improvement, future research is required to develop more accurate and more comprehensive measures of environmental impacts.

Despite recent recognition of the importance of considering multiple levels of analysis to evaluate corporate environmental initiatives (Starik & Rands, 1995) and corporate social responsibility more generally (Aguilera, Rupp, Williams, & Ganapathi, 2007), another challenge concerns the complexity of multilevel research. While multilevel models have been described as "uniquely powerful and parsimonious" (Klein, Dansereau, & Hall, 1994, p. 223), they have also been the source of confusion and controversy, in part because of the challenges associated with empirically testing these models (Klein et al., 1994). As a result, additional research is needed to empirically test whether the pattern of relationships outlined in the current Green IT/S framework is generalizable across multiple levels of analysis.

Measurement of multilevel constructs represents another consideration. Assessing higher-level phenomena (that are also represented at the individual level, such as attitudes) is a question that has intrigued multilevel researchers (e.g., Bliese, Chan, & Ployhart, 2007; Klein & Kozlowski, 2000). Higher level constructs may be global (that is, they characterize the level as a whole, such as team function), shared (they are held in common by employees, such as perceptions of organizational climate), or configural (the pattern, rather than the commonality, in individual-level responses is important, such as variability in employee performance levels) (Klein & Kozlowski, 2000). Thus, measurement needs to be carefully considered when conducting multilevel research.

In order to tackle Green IT/S issues, we especially encourage action research in organizations. Researchers concerned about the environment do not have the luxury of long-term, retrospective studies.

In contrast, we believe that action research, or research in which the investigator tries to generate new knowledge at the same time as s/he is trying to change the social system (Lewin, 1946), is most appropriate. Researchers focusing on environmental issues are "interested researchers" who are "investing in positive change" and "thinking deliberately about what they are doing" (Goebel, 2007). Because action research "results from an involvement with members of an organization over a matter which is of genuine concern to them" (Eden & Huxham, 1996, p. 75), we believe that it will be very appropriate for affecting environmental changes in organizations.

In this paper, we have focused on organizational impacts of Green IT/S, but research at the societal level is also critical. Unfortunately, the Green IT/S literature examining societal level impacts is sparse. Two studies discuss macro level effects of IT on the environment at the industry and national levels (Dewick et al., 2004; Sarkis & Zhu, 2008). Another study diffuses several myths about how IT helps foster environmental sustainability and suggests that facilitating communication, collaboration and increasing awareness about environmental problems may be IT/S's biggest impact on environmental sustainability (Fuchs, 2008). However, there is a need for both a paradigm shift and value reorientation for ecologically sustainable development (Shrivastava, 1995) and for how IT can support this shift (Manning, 2007). This provides an opportunity for Green IT/S research at the societal and national levels.

The conceptual research framework put forth in this article provides a comprehensive look at Green IT/S issues in relation to corporate environmental initiatives and their environmental impacts. While the ideas put forth in this paper necessitate a more in-depth assessment, the multilevel model that we present takes a critical step towards enriching our understanding of how Green IT/S fit within the broader research on the natural environment and, perhaps more importantly, highlights how central Green IT/S are to advancing corporate environmental agendas. This under-researched domain of environmental research provides rich ground for further research that stands to bring valuable benefits to individuals, organizations, communities, and the planet.

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