

RESEARCH ARTICLE

# A Classical Delphi Study to Identify the Barriers of Green Information Technologies

Dr. Jose A. Gotay, DM/IST<sup>1\*</sup>

<sup>1</sup>Associate Faculty, University of Phoenix, College of Business and Information Technology, United States of America

\*Corresponding author: Jose A. Gotay: josegotay@verizon.net



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## Abstract:

This qualitative, classical Delphi study explored the apparent lack of corporate commitment to prioritized Green Information Technologies (GITs), which could delay the economic benefits for maximizing the use of energy resources. The purpose of this study was to examine the leadership barriers impeding the adoption of GITs. A panel of nineteen Information Technology and Sustainability experts participated in this study. The panels' members were from industry, government, and academia. The NVivo 9 software was used for the qualitative data analysis and reports the results. The leadership barriers identified in this study as impeding were the lack of understating of GIT and the benefits it can yield for organizations. To gain energy cost reductions, and to meet future environmental regulations, a paradigm change is needed to integrate GIT into organizational strategies, processes, and culture. The results of this study give useful recommendations to rationalize the adoption of GIT to overcome implementation barriers.

**Keywords:** Information technology leadership strategies, Applied sciences, Energy conservation, Energy cost reduction, Environmental regulations, Green Information Technology and Communications, Leadership barriers, Natural energy resources

## Introduction

In a global competitive business environment, organizations must endure in a changeable world of limited resources while sustaining an economic posture. Information Technologies (ITs) demand natural resources for their development and consume a tremendous amount of energy resources for operating. As the

world populations continue to grow, developing countries will demand greater use of natural resources. Global warming and climate change coalescing with limited availability and increasing costs in energy pose serious challenges for the sustaining the digital global economy (Molla, Cooper, Deng, & Lukaitis, 2009). ITs will continue to be an integral part in every activity in modern life and businesses.

For the purpose of this study, GIT is defined by the Gartner Group defined green IT within the context of an enterprise as the “optimal use of information and communication technology (IT) for managing the environmental sustainability of enterprise operations and the supply chain, as well as that of its products, services and resources, throughout their lifecycles” (Mingay, 2007, p. 2). The definition includes expanding material resources and reducing energy consumption of the enterprise IT infrastructure, thereby maximizing industry activities while protecting the environment and saving natural resources (Mingay, 2007). In this study, the terms green IT and green ICT have the same meaning and are used interchangeably. ICTs are information systems and communication technologies.

This study focuses on overcoming the leadership barriers to implement GIT initiatives for organizations willing to reduce their energy costs while sustaining a competitive edge. The concept of GIT consists of merging two definitions: Green and ITs. Green refers to sustainable technologies aimed at minimizing environmental pollution by producing fewer greenhouse gases, as well as recycling, reusing, and disposing of electronic equipment (Esty & Winston, 2009). ITs are computer-based information systems and communication technologies used for personal and business activities. When combined, green and ITs are environmentally sustainable technologies, which reduce energy consumption, are less harmful to the environment, and contribute to providing analytics on harmful gases. Furthermore, ITs are consumers of large amounts of energy and natural resources, and they create a staggering amount of toxic material and waste (Esty & Winston, 2009).

GITs are the most favorable practice of information and communication technology for the management of environmental sustainability of enterprise operations, management of supply chains, and for the lifetime management of products, services, and resources (Mingay & Di Maio, 2007). The intent of using GIT is to maximize on the use of natural resources by use, recycling, and disposal. These green practices should be an integral part of business strategies. Such business strategies could help organizations to reduce energy consumption, greenhouse gases, and gain an economic edge. Meanwhile, IT vendors have been aiming for innovative solutions for addressing energy consumption of electronic devices. These new technologies aim in consolidating electronic devices, computing services, and building energy-efficient facilities (Raskino, 2007). GITs can play an important role in reducing an organization’s carbon footprint by monitoring, controlling, and improving workflow processes across an organization.

## Purpose statement and research questions

The purpose of this qualitative, classical Delphi study was to identify the leadership barriers for executives and organizations inclined to implement Green IT. This study focused on economic concerns, policies, risks, and corporate strategies affecting or motivating the adoption Green IT. The appropriateness of

the classical Delphi study allows for using a panel of experts to resolve a complex technical problem by consensus (Peñuelas & Carnicer, 2010).

**Expert Panel.** A panel of 19 Information Technology and sustainability experts participated in this study. The panel of experts selected for this study was comprised of a group of professionals recognized by the IT community with special interest in the development, design, and use of Green ITs and sustainable technologies. The study-specific population was IT and sustainability experts in private industry, academia, and government involved in the design, use, recycling, and disposal of green technologies in the United States and Europe.

**Research Questions.** The following research questions included two central research questions and five sub-questions. The central research questions are broad questions and serve as an inquiry to explore the central phenomena of the qualitative study (Creswell, 2009). The two central research questions are

- What are the leadership barriers impeding the implementation of GITs?
- How can senior leaders help to remove the barriers of adopting GIT?

The two research questions were used to address the issues associated with identifying the barriers of implementing GIT. Qualitative research requires several sub-questions that follow the central research questions, which narrow the scope of the study. A sub-question “narrows the focus of the study but leaves the open questioning” (Creswell, 2009, p. 129). The five sub-questions are

- How CEOs and CIOs communicate in formulating corporate strategies that incorporates GITs goals and objectives?
- How can government incentives and legislation encourage corporations to adopt environmental-friendly technologies, whereas still supporting a competitive industry?
- How does corporate social responsibility embrace environmental concerns and regulatory compliance in reporting and reducing pollution related to services and products?
- How GIT can contribute to long-term corporate stability or profitability of the organization?
- What are the strengths, weaknesses, opportunities, and threats of implementing GIT?

## Literature review

The search for literature on GIT revealed the lack of academic research that explores the adoption of GIT as a business strategy in current national and global organizations. This study attempted to fill the scholarly research gap and suggest business strategies that could provide guidelines for businesses wanting to implement GIT. The use of technology for protecting the environment has been a prominent concern of environmentalist and sustainability practitioners for many decades (Murray, Haynes, & Hudson, 2010; Prattipati, 2010; Vaccaro & Echeverri, 2010). Identifying the barriers for adopting GITs requires a sound understanding of the complex issues surrounding the effects of technologies on the environment; and the benefits of conserving valuable natural resources have both political and the economic significance (Shah, Christian, Patel, Bash, & Sharma, 2009).

The review of the literature focused on corporate culture, CSR, environmental regulations, GIT strategies, green computing, and communications technologies. An extensive review of the literature regarding industry surveys on the adoption of GIT across several international organizations provides a justification for further academic research. Corporate leaders should develop sustainability strategies in which integrate environmental and cultural concerns in fulfilling their corporate social responsibilities with society and future generations. Organizations that manage environmental sustainability and are engaging in CSR can benefit by reducing energy costs while protecting the environment.

The research model followed a three-step analysis, based upon the literature review of the current efforts of developers, corporate strategies, and government legislation toward the adoption of GIT. The research model starts from an analysis of the sustainment concept in the content of social, economic, and environmental factors in which cleaner and energy-efficient technologies should be developed. Second, the theories of innovation, disruptive innovation, and globalization were reviewed in the context of implementing GIT. Third, a review of the literature of corporate culture and CSR was discussed to determine how green technologies could benefit organizations and society. The conceptual model assisted in uncovering leadership barriers of implementing GIT. The theories of innovation and disruptive technologies have become the means for business to create new products and to expand into global markets (Dismukes, 2005; Kanji & Chopra, 2010; Tellis, 2006; Tellis, Prabhu, & Chandy, 2009). As new innovative technologies continue to enter the world market, and globalization continues to cross boundaries, leadership challenges are becoming more complex requiring a change in paradigm.

## Conceptual framework

The conceptual framework served to identify the problem of the study, facilitate framing the research questions, and aid in the search for suitable literature. The conceptual framework focused on the concepts of globalization, innovation, disruptive innovation, and leadership theories. These concepts link the global aspects of social, political, and economic issues, corporate social responsibilities, and environmental concerns. The conceptual framework is shown in Figure 1.

A classical Delphi study is appropriate for this study because of the use of a panel of experts to reach consensus to resolve a technical problem. Baker et al. (2006) stated experts are a source of information who are rapidly accessible and exploited to gain professional opinion and provide knowledge in subject matter areas lacking research. Adler and Ziglio (1996) stated Delphi participants should meet four criteria: (a) knowledge and experience with the issues of the investigation, (b) capacity and willingness to participate in the study, (c) sufficient time to participate in a classical Delphi study, and (d) effective communication skills.

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developed. Second, the theories of innovation, disruptive innovation, and globalization were reviewed in the context of implementing GIT. Third, a review of the literature of corporate culture and CSR was discussed to determine how green technologies could benefit organizations and society. The conceptual model helped in uncovering leadership barriers of implementing GIT. The model further could support corporations to become more sustainable by expanding their corporate social responsibilities, reducing energy costs, protecting the environment, and meeting environmental regulations.

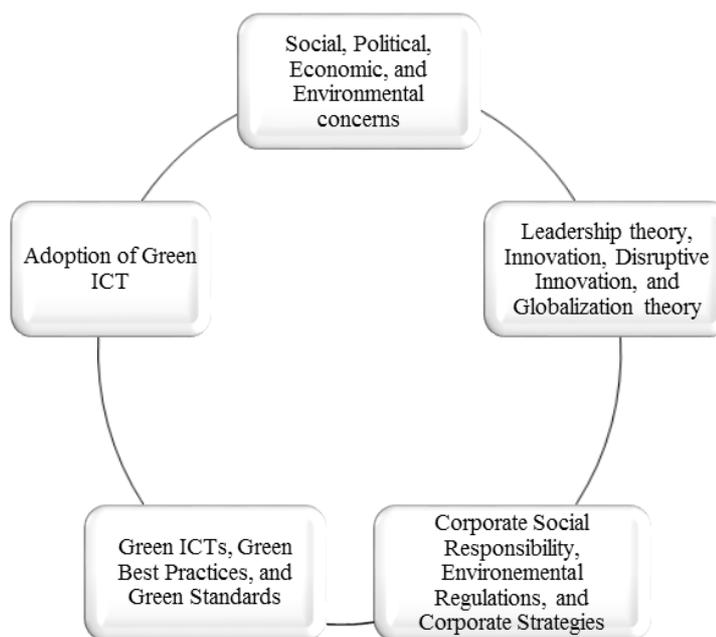


Figure 1. Green IT Model

## Corporate culture and sustainability strategies

Corporate culture and sustainability strategies contribute significantly in advancing the competitive edge for an organization in a global environment. In developing corporate strategic plans, culture is the foundation of decision-making and organizational behavior (Leon Soriano, Munoz Torres, & Chalmeta Rosalen, 2010). Sustainability is essential for organizations to survive in a world of limited resources and global markets.

**Corporate culture.** Corporations build on a culture to decide on the adoption of new technology as an advantage to sustain or expand their markets. Corporate culture reflects the common values, beliefs, and behaviors of an organization (Shieh & Wang, 2010). The term corporate culture is widely used in European scholarly literature, as well as in business. In the United States, business and scholarly literature use the term corporate culture interchangeably with organizational culture. An organizational culture is a unique human product that develops over time, is implicit, cannot be transferred across organizations, and is difficult to define (Tellis et al., 2009). Corporate culture is the shared collective principles, values, and norms to which, within an organization, individuals model their behavior (Grant, 2013). Corporate values give members an understanding of what the organization's values are, while

norms of behavior are derived from corporate values established by the rules of interpersonal relationships, and decision-making processes within organizations (Mello, 2010).

Corporate culture plays a significant role in implementing GIT and in establishing sustainability strategies for businesses. The terms sustainability and sustainability development started in the 1980s. Sustainability developed out of understanding and knowledge of the adverse effects of human-made pollution on health, workers, and ecosystems (Box, 2002). Corporate leaders should develop sustainability strategies to integrate environmental and cultural concerns while fulfilling their corporate social responsibilities with society and for future generations. A distinctive corporate culture that builds on sustainability aids managers and decision makers in organizing tradeoffs that coincide with the management of the frequently used social, environmental, and economic goals (Epstein, Buhovac, & Yuthas, 2010).

**Sustainability strategy.** In a competitive and complex business environment, organizations must endure in a changeable world of limited resources, while sustaining an economic posture. Businesses are facing an environment of extreme national and global competition, rapid changes in technology, and inhibited resources (Shieh & Wang, 2010).

A business sustainability strategy must consider the business and community's social, economic, cultural, and natural effects (Werbach, 2009). Environmental sustainability goes beyond IT energy savings, which include activities such as product or service design, supply chain, production, logistics, distribution, facilities, travel, and procurement policies (Mingay & Di Maio, 2007). Organizations should develop sustainability strategies that go beyond the dimension of implementing green initiatives. According to Werbach (2009), true sustainability has four components: social, economic, environmental, and cultural. Effects on society are examined through social components such as poverty, violence, public health, and human rights. The economic provision is aimed to help individuals and businesses meet their basic financial needs. The intent of the economic condition is to help people in securing food, water, shelter, comfort, and businesses to produce wealth and profits.

## Green information technology strategies

Chief Executive Officers (CEOs), Chief Information Officer (CIOs), and Chief Technical Officers (CTOs) are beginning to embrace social responsibility initiatives, playing an important role in implementing GIT (Hennessy, 2008). CTOs can lead the technical development efforts to create IT sustainable energy-efficient and environment-friendly infrastructures. Such innovative green initiatives must have longer product lifecycles, require minimum maintenance, and should be able to be recycled or disposed of with minimal effect to the environment.

Organizations may use a to integrate the basic concept of GIT is shown in Figure 2. The "Reduce, Reuse, Recycle" portion of the lifecycle is known as the global green mantra (T. J. Velte, A. T. Velte, & R. C. Elsenpeter, 2008, p. 3). Organizations can reduce the cost of IT equipment by consolidating, virtualizing, using power management, and using energy-efficient data center facilities.

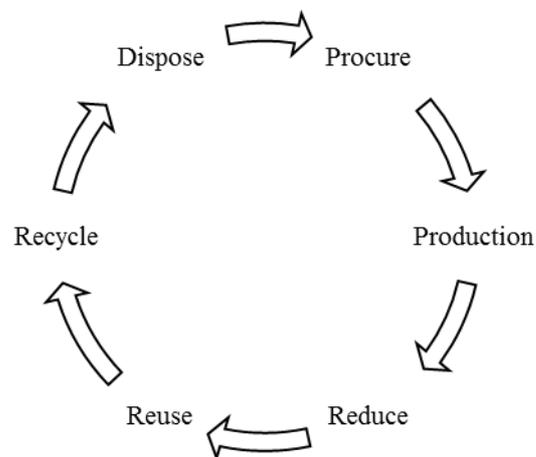


Figure 2. GIT lifecycle management process

The benefits of reusing electronic equipment can lower the demand for new products; therefore, requiring less raw materials for new products. The recycling process involves the management of electronic waste. Recycling electronic waste requires dismantling the equipment components, such as metal parts, electronic boards, and plastics (Velte, T. J., Velte, A. T., & Elsenpeter, R., 2008). The remaining two portions of the GIT lifecycle management process deal with the production and disposal of electronic equipment. The production of electronic equipment requires a significant amount of natural resources and an extensive manufacturing process that consumes energy. Disposal of electronic equipment occurs when it becomes obsolete or is not recyclable. Improper disposal of electronic waste can become a major source of hazardous materials.

GIT can assist organizations in managing environmental sustainability of their supply chain, products, services, and resources throughout their lifecycles (Mingay, 2007). GIT has the capabilities to monitor resources across organizations production and service processes. Comparative analysis of raw materials, consumed energy, and waste generated simplifies the process of spotting best practices and capturing potential efficiency gains (Bartlett & Preston, 2000). Organizations that manage environmental sustainability can benefit by reducing energy consumption while protecting the environment and saving natural resources. Clean technologies also include green technologies related to reducing carbon footprints, pollution abatement, water treatment, and resource management (Pomianek & Teja, 2009).

## Green technologies and sustainability

According to the U.S. Census Bureau (2013), the world's population was reported at 7.5 billion people as of February 2013 and is projected to reach more than 9 billion people by 2050 (U.S.-Census-Bureau, 2013). As the world's population continues to grow, the need for increased agriculture production (Kasturi, 2009), renewable energy, energy-efficient housing, e-health care, education, and transportation will become the greatest challenges for future generations. According to Kasturi (2009), "Numerous organizations around the world are focused on gaining the benefits of IT for the agricultural sector" (Kasturi, 2009, p. 165).

Many countries are improving their infrastructures and production capabilities to leverage the benefits of technology and global communications. GIT could benefit global societies by monitoring hazardous materials and in the development of information systems to maximize the use of natural resources in the production of goods and services. According to Prattipati (2010), “ITs play a major role in providing education and knowledge on sustainability, carbon emissions, renewable energy, and other related topics” (Prattipati, 2010, p. 37). Global telecommunications, the Internet, and mobile technologies will continue to play an important role in education and training and sharing information on sustainability development and awareness.

Societies and organizations must identify the potential role of green technologies to build a green global environment that fosters economic growth and promotes renewable energy sources for future generations. As Jorgenson and Jorgenson (2009) stated, “Technological change is a continuous process, where technology and social and environmental aspects are co-shaped by the priorities and focus in research, in innovation and in the applications of technology” (Jorgensen & Jorgensen, 2009, p. 364). Current and future generations must focus on the importance of creating environmental, green-based, socio-technical societies to meet the challenges of the world population, such as energy, food supplies, and conserving vital natural resources.

## Leadership and green technologies

Adopting GIT is a leadership-driven initiative based on knowledge of environmental issues and the benefits that green technologies has to offer to an organization (Molla, Pittayachawan, Corbitt, & Hepu, 2009). Research in GIT over the past several years has revealed that leadership support enhances an IT department’s success in innovating and implementing energy-efficient and environmental-friendly policies and technologies (Marsan, 2008; Moss, 2009; Varon, 2007). The benefits of adopting green technologies can help corporate leaders improve their firm’s social image, meet regulatory requirements, and manage their energy resources and facilities better.

For an organization to become environmentally conscious, leaders must build a culture that fosters environmental thinking and shapes people’s behavior (Esty & Winston, 2009). Such leadership must inspire a culture of ecological advantage (Esty & Winston, 2009). To reach such ecological advantage, four building tools are required. (a) develop a vision with specific goals, (b) encourage environmental thinking into all strategic thinking, (c) create incentives and accountability in meeting environmental goals, and (d) encourage internal and external communications across all audiences.

## Globalization and the role of technology

The term globalization “has many meanings when used in various sources of literature review and in the business world” Friedman’s (2008) viewed globalization in terms of globalized trade, outsourcing, off-shoring, supply chain management, and political forces that have changed the world. Globalization is a process that embraces the transformation of organizations’ social relationships,

creating a transcontinental environment and network of interactions and power (Held & McGrew, 1999).

Globalization has had a major effect on organizations and boundaries. As Reza et al. (2009) put it, “Economic development, consumer goods, social justice and an environmentally friendly attitude are among the societal expectations from global organizations” (Reza, Eric, & Thodoros, 2009, p. 172). Graetz and Smith (2005) explained “the effect of globalization on firms in terms of changing boundaries, growth of economic knowledge, expanding flexibility of networking and interconnectivity between structure, systems, people, and processes as a fundamental need of these relationships in organization design” (p. 313). Therefore, globalization has created new markets, globalized trade has increased, transnational supply chain management evolved, and countries joined the movement, causing rapid world market changes.

## The theories of innovation and disruptive innovation

Implementing a successful GIT program is driven by business strategies and innovation. Tidd, et. al (2005) described innovation as a “knowledge-based process, which serve to create new possibilities through combining knowledge sets” (p. 15). According to Damanpour (1991), “The adoption of innovations is conceived to encompass the generation, development, and implementation of new ideas or behaviors” (Damanpour, 1991, p. 556). Innovation has become a major driver for businesses to survive and maintain a competitive advantage in a competitive global markets; nevertheless, “while the benefits of innovation are self-evident, businesses want to know that investing in it will yield growth” (Chow, Goodman, Rooney, & Wyble, 2007, p. 639). Developing innovative products requires commitment and resources at all levels of the organization. In addition, there are uncertainties when selecting new products because not all innovative products yield growth or profits, and such investment could be risky.

**Theory of innovation.** Innovation creates an opportunity for firms to develop new products or processes in the marketplace that could yield a competitive advantage. Developing new products that are “faster, cheaper, higher quality—has long been seen as a source of competitive advantage” (Tidd et al., 2005, p. 6). Innovating requires change in the way an organization exploits new ideas.

**Disruptive innovation.** According to Christensen and Hwang (2008), “the theory of disruptive innovation helps explain how complicated, expensive products and services eventually converted into simpler, affordable ones” (p. 1329). Christensen’s model of disruptive innovation is a theory used to describe the effect of new technologies on existing firms. The theory is fixed in the dichotomy of sustaining and disruptive innovation. A sustaining innovation supports the continual improvement of an existing proven product or service that supports a firm over time. Such products hardly cause a company to collapse because their continued performance improvement adds value to customers; however, disruptive innovations may seldom have features and capabilities that traditional products have, in which case, customers may not consider necessary as the product is introduced. Initially, such disruptive innovation products may be cheaper, simpler, and of lesser quality when compared with current sustaining products.

## Method and design

A qualitative Classical Delphi study comprised of three rounds, including the pilot study, was used to identify the leadership barriers for executives eager to implement GITs. The appropriateness of this method is that it provides consensus among a panel of experts to resolve a complex problem (Baker et al., 2006). A qualitative research method is most appropriate for research involving the exploration of a topic in which the literature yields little information about the phenomena (J.W. Creswell, 2005). The Delphi classical method establishes the facts surrounding a particular problem, and uses an open Delphi first round to facilitate idea generation to elicit opinion from a panel of experts and can be administered online (Peñuelas & Carnicer, 2010).

The appropriateness of the classical method provides the research a method to address the study problem statement and facilitates responses to the research questions. The goal of a classical Delphi study is to gain consensus of a panel of experts to solve the research problem. The study starts once the panel of experts agrees to engage in the study, and it becomes an exercise focused on group communication among the panel of experts. The research design of this current study used a three round Delphi process as shown in Figure 3.

The goal of the pilot study was to test and adjust the questionnaire to refine the initial questions and comprehension of the survey and delivery method. The Delphi process starts with introducing the problem, research question, and systematically manages and analyzes the individual and collective responses through several rounds. The panel member received the initial questions in the form of a questionnaire, designed for individual responses, allowing the expert to provide opinions as the group work to solve the problem. questionnaire, designed for individual responses, allowing the expert to provide opinions as the group work to solve the problem.

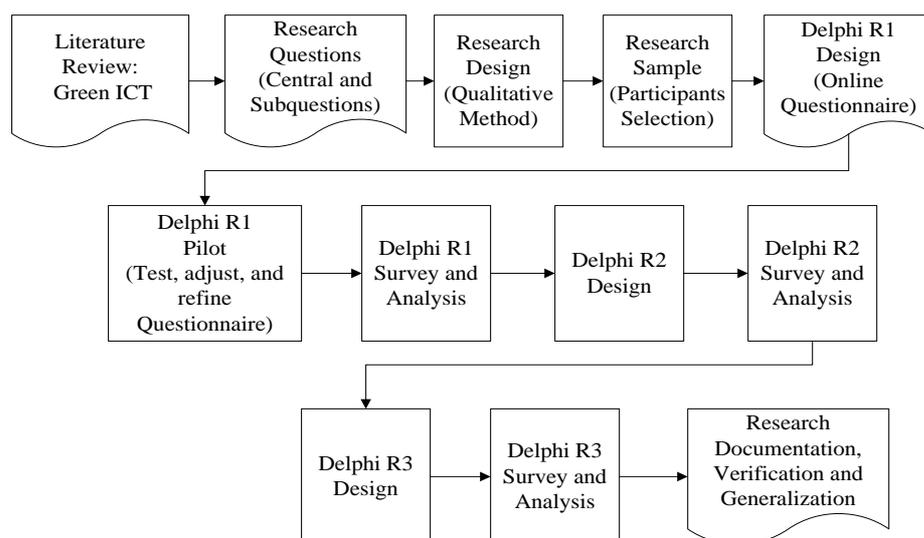


Figure 3. Three-round Delphi process

A qualitative research method is most suitable for “an exploratory research study of a topic in which the literature yields little information about the phenomena” (Creswell, 2005, p. 46). The purpose statement of qualitative research is open-ended when compared with that of a quantitative research

study. The research initial questions are general and broad to ensure a better understanding of the participants' views about the phenomena. Data collection includes forms with general questions to motivate the participant to produce responses. Qualitative data collection consists of text or images using small numbers of individuals or sites. Analyzing qualitative data consists of text analysis and describing emerging themes. Interpreting such data consists of stating the large meaning inferred from the emerging themes or broad categories that represent the discovery of the results of the study.

This Classical Delphi study assumes panel members will respond honestly to the research questions. In qualitative research limitations are weaknesses the researcher cannot control, such as lack of participation, small sample size, or errors in data collection and analysis (J.W. Creswell, 2005). Industry and government proprietary information may limit the panel in responding to the research questions. Participant's background, honesty, and field of expertise may also limit panel members' opinions in responding to questions outside his or her field of expertise. The Classical Delphi study might be limited in gaining consensus among the panel members.

Validity may be evaluated by measuring how well the research questions represent all possibilities, how well the participants' statistics scores relate to the consensus outcome, how the statistical responses may forecast the future, and the significance of the scores (Keeney, Hasson, & McKenna, 2011). The goal of this current research was to follow a methodological rigor that would ensure trustworthiness, credibility, believability, and reliable and valid results (Shento, 2004). The purposeful selection of verifiable experts focused on improving truthfulness, credibility, and believability of the results. Therefore, to strengthen the validity and trustworthiness of the results from this present study, a rigorous methodological process was exercised throughout the research. Furthermore, an audit trail in qualitative research assists in improving trustworthiness (Keeney et al., 2011), so a journal was kept during the processes of capturing the key theoretical and methodological decisions to substantiate trustworthiness.

## Effects of limitations and delimitations

In qualitative research, limitations are weaknesses the researcher cannot control, such as lack of participation, small sample size, or errors in data collection and analysis (J. W. Creswell, 2005, p. 593). A major limitation when conducting a Classical Delphi study might be the inability to produce meaningful results (Linstone & Turoff, 2002). The results of findings of the study were limited because of the size of the population and the expertise of the participants. Most of the participant responses were broad concerning how their organization have benefited from GIT, and participants did not provided comments of how to implement the technology. CIOs and sustainability officers participation was low limiting the study from their opinions concerning their strategic IT direction and sustainability programs. In addition, because GIT is view as an immature technology, there was no coded evidence from the participants accounting for cost savings or reduction of CO2 pollution from data centers.

The study was delimited because of the small population size of the Delphi panel of experts who makes it difficult in generalizing the results. Non-responses from CIOs and sustainability officer to accept the invitation to participate in the study was also delimitation. Additionally, invitations sent to candidates in

Europe responded that company policies and partnership with their host-country government did not approve participation in the study, because they could disclose proprietary company information. Last, some of the participants who accepted the invitation to participate in the study, before collecting the data withdrawal because they did not consider themselves as an expert in GIT. Although the findings were similar to industry surveys and reports, the study contains helpful data for overcoming the barriers of fulfilling GIT.

## Population and sample

**Population.** The population of this classical Delphi study from which participants were obtained is comprised of Green IT experts, sustainability experts, developers of Green IT, and scholars. These experts are practitioners in the design, use, and reuse of green technologies and they provide services for new and existing IT infrastructures supporting business information systems and the telecommunication industry. The specific population for the study was IT and sustainability experts employed in private industry, academia, and government throughout the United States and Europe. Purposive sampling assisted in achieving an equal distribution of participants within the four disciplines of this study, as explained in the sampling frame section that follows.

Uncovering the barriers of implementing GIT may provide the answers to corporate leaders and help them to define sustainable business strategies to build the knowledge and develop the skills needed to adopt GIT initiatives. This study assumes that when exploring a complex problem, forming a panel of experts is most desirable (Gotay, 2013). These experts must have the education, experience, and knowledge that can lead to possible consensus in solving the research problem. In this study, it is assumed that other developed countries practice the environmental compliance standards and IT operations' practices exercised as the United States.

**Sample.** A qualitative classical Delphi study requires a minimum of 15 panelists (Clayton, 1997). Further, Armstrong, Parsons, and Barker (2000) argued "there is no recommended sample size for a classical Delphi study" (p. 299). The sample size depends on the scope of the problem and resources available to the researcher (Powell, 2003) as well as the data needed (Hasson, Keeney, & McKenna, 2000). The sample size required to get the necessary number of expert opinions must be large enough to allow possible dropouts (Armstrong et al., 2000). Skulmoski et al. (2007) proposed, "while there are no specific rules in determining the sample size in a classical Delphi study, several factors must be considered, such as heterogeneous, or homogeneous sampling" (p. 10).

When selecting homogeneous groups, a smaller sample ranging from 10 to 15 people may yield sufficient results; however, if disparate groups are used, a larger sample of several hundred might be required to participate. The participants of the classical Delphi study were recruited from a list of professionals involved in Green IT and authors of scholarly articles. The Delphi technique did not require a statistical representation of the study population. Representativeness were assessed on the qualities of the expert panel, instead of the sample size (Powell, 2003). Round 1 of the pilot study consisted of 10 participants, Round 2 had 19 participants, and Round 3 had 18 participants.

## Data collection

A secured Internet-based website was reserved for data collection because of the geographic location, time constraints, and availability of the panel participants. The SurveyMonkey Internet services were used to create and administer the survey questionnaire and to collect the data. Skulmoski and Hartman (2007) proposed the following data collection within the Delphi method, as shown in Table 1 below.

Table 1. Delphi data collection and analysis process

Round 1 Pilot Study	Data Collection, statistical and qualitative data analysis and adjust questionnaire for use in round 2
Round 2	Data Collection, statistical and qualitative data analysis, publish results to participants and prepare round 3
Round 3	Data collection, statistical and qualitative data analysis, prepare reports of results and end of study

Each participant received an email through the Internet with the URL to access a secure website. After the completion of each round, the questionnaire data was retrieved, transcribed, and transferred into NVIVO 9 for data analysis. The qualitative method of constant comparison was used when the entire data set is desired to identify underlying themes. This method can consist of deductive, inductive, or abductive reasoning. Constant comparison is ideal to analyze data collected from a classical Delphi study involving a series of rounds. The constant comparison method allows extra participants, events, incidents, to develop emergent themes and refine new ideas.

## Instrumentation

The NVivo 9 software application developed by QSR International was used to store and organize textual data collected in this qualitative classical Delphi study. The software application is widely used in health science, education, IT, and social science (Andrew, Salamonson, & Halcomb, 2008; Lewis, 2008; Yaman, 2009). NVivo 9 can be used to import quantitative data and integrate it with qualitative data (Andrew et al., 2008). The software helps qualitative researchers in assigning labels, coding data, and creating a database of the collected textual data simplifying searching specific texts and words collected. NVivo 9 is used in case studies and grounded theory for analysis and modeling of research data (Yaman, 2009).

SurveyMonkey.com was employed to deliver Round 1, the pilot study's initial questionnaire, to a selected group of participants to verify the research instrument and means of delivery (SurveyMonkey.com, 2010). SurveyMonkey.com was used throughout the study to administer the survey questionnaire and collect the qualitative and quantitative data. The initial questions used in the questionnaire were developed after an extensive review of the literature and industry surveys dealing with the adoption of Green IT.

## Delphi pilot study

### *Round 1 pilot*

The findings of the Delphi pilot study (round 1) revealed the research questions were suitable to motivate the participants to share experiences and knowledge of the current Green IT industry, government trends, and best practices. The pilot study results and findings provided face validity of the research questions, and a second pilot was not required. In addition, SurveyMonkey.com Internet services provided an effective online-secure and confidential Internet portal for participants to respond to the research study.

The pilot study participants' responses grounded the research questions with two minor changes: (a) the research questions were rearranged for consistency and logical flow, and (b) the time to complete the survey was reduced from 25 minutes to 10 minutes. The classical Delphi study consisted of three rounds. Round 1 (pilot study) involved five open-ended research questions and Round 2 included three research questions. Qualitative data collected in Round 2 were based on the research questions tested in the pilot study. Round 3 consisted of two open-ended questions and one multiple-choice question.

The results of the classical Delphi study revealed the opinions of the panel of experts concerning the barriers of adopting Green IT. The five research questions of Round 2 and the three research questions of Round 3 aimed to discover Green IT corporate strategies, government incentives and legislation, SWOT corporate social responsibility, corporate long-term stability, removing Green IT barriers, data center proliferation, and risks associated with green IT strategies.

## Results of the three round Delphi and discussion

### *Round 2 results*

Green IT strategies. The results for Research Question 1 showed that the participants were in consensus about the CIOs' priorities of developing Green IT strategies, which are driven by reducing cost, proliferation of data centers, cloud computing, demand for services, and business growth. Some participants agreed that Green IT energy efficiency assists in the reduction of CO<sub>2</sub> emission reduction, and therefore, are main factors in corporate strategic planning. In addition, most CEOs are largely unaware of green targets embedded in IT decisions.

Government incentives and legislation. Research Question 2 addressed how government incentives and legislation encourage corporations to adopt energy and environmental-friendly technologies, while supporting a competitive industry. Most of the participants agreed that government should provide tax incentives and grants to help industry get over the initial costs of transitioning to Green IT, and tax incentives should include recognition of the size of the IT corporate infrastructure cost, or require organizations to pay for environmental damages. Some participants agreed, CEOs have a view that it costs more to be green, but the view may be overcome by careful investment, efficiently designed systems, efficiencies gained through energy savings, and retrofitting as part of regular equipment maintenance or recapitalization.

Green IT strengths, weaknesses, opportunities, and risks. Research Question 3 identified the strengths, weaknesses, opportunities, and risks (SWOR) of implementing Green IT. The Green IT strengths participants reached consensus on were energy-efficient and environmental-friendly technologies, reduced operations cost, and IT capacity to plan and monitor smart buildings' energy use. Other important strengths recognized by the panel members for which consensus was not reached were (a) compliant with WEEE and RoHS rules, (b) Green IT fosters a new way of thinking, (c) great marketing strategy to support an environmentally friendly movement, and (d) firms with embedded Green IT targets have significantly contributed in all sectors of society.

The panel members agreed with the following weaknesses: implementation cost, immature technology, Green IT education and training, lack of clear standards, and the lack of quantified benefits as compared to other business investments. The panel members agreed with the following Green IT opportunities: (a) promote training and education in Green IT disciplines, (b) reduce equipment lifecycle cost, and (c) support a cleaner environment. Participants also recognized that by actively aiming for Green IT and engaging in green technology, their organizations could be ready to transition to an energy-efficient and environmental-friendly sustainable organization.

The panel members agreed with the following Green IT strategic implementation risks: (a) unproven or immature technology, (b) lack of documentary evidence to determine return-on-investment, and (c) implementation cost. Other important risks suggested by the participants were (a) possible rising energy costs could be a threat to organization energy security, which could affect continuous business operations; and (b) not receiving possible financial tax credits for obsolescing equipment not fully depreciated, if an organization decides to implement Green IT.

Corporate social responsibility. Research Question 4 addressed how organizations' CSR embraces environmental concerns and regulatory compliance in reporting and reducing pollution related to services and products. The panel reached consensus that CSR strategies should include (a) capturing metrics, (b) reporting, (c) showing sustainability in the marketplace, and (d) meeting compliance with existing government environmental laws.

Supporting corporate long-term stability. Research Question 4 results showed the participants reached consensus in explaining how Green IT contributes to the long-term corporate sustainability and profitability of an organization. Further, Green IT could reduce the organization's technology footprint, and reduce energy cost, which may result in an improved organization stability and profitability. In addition, data center and server virtualization reduces energy use, and equipment maintenance costs. Participants also suggested that Green IT could attract employees with special interest in environmental concerns and retain talent.

Participants believed that by adopting Green IT, organizations could avoid potential government policies mandating reducing pollution and non-compliance of regulatory policies and penalties. Participants indicated that lower power and cooling use decreases IT equipment aging, resulting in longer equipment lifecycle and reduced replacement cost. In planning for long-term corporate stability, participants suggested the return-on-investment should be part of the business model, and the public's attitude towards the organization's behavior that could affect public opinion.

### *Round 3 results*

Removing Green IT barriers. Research Question 1 of Round 3 addressed how senior leaders could help in removing green IT barriers. Panelists reached consensus that senior leaders could help in removing the barriers of GIT by defining strategies to realize cost savings, reduce the organization's carbon footprint, monitor performance, measure energy consumption, and communicate results. Such a strategy must include clear values, not only based on financial benefits, but also social and environmental targets. Senior leaders should support training and education in Green IT for executives and the workforce to understand the full range of mature Green ITs.

Data center proliferation. Research Question 2 of Round 3 dealt with gaining the opinion of the panelists on current CEOs' and CIOs' practices of data center centralization as a solution to meet future market IT demands and compliance with environmental laws. The panel reached consensus on the CIOs' efforts of data center centralization as a good start towards greening IT, but not as a long-term solution to meet future market needs. Participants indicated data centers are fundamentally CIOs' response to shrinking IT budgets. Further, CIOs need to plan for using renewable energy, and consider data center growth in a mature economy as well as the impact on the environment. In addition, current CEO and CIO initiatives are lacking in knowledge and awareness for managing and maintaining GIT.

Risks associated with Green IT strategies. Research Question 3 of Round 3 identified the risks in strategic planning that are viewed as Green IT barriers. The major risks associated with carrying out Green IT were investment cost, immature technologies, Green IT training, return-of-investment, and lack of standards. Other risks were (a) disposal, recycling, and reuse of electronics; (b) lack of Green IT technical skills, (c) network and data security, (d) documented Green IT benefits, (e) disruption of operations, (f) government regulations, and (g) the state of the economy. The lowest rated risks were (a) increased demand for IT services, (b) damage to corporate public image, (c) storing Big Data, (d) energy security, (e) financial stability, (f) cloud computing, and (g) government tax incentives.

### Partial conclusions

The leadership barriers identified in this study impeding the implementation of GIT centered in the understating of GIT, and the benefits it can yield for organizations. To gain energy cost reductions, and to meet future environmental regulations, a paradigm change is needed to integrate GIT into organizational strategies, processes, and organization culture. Further, corporate leaders will need to be aware of Green targets embedded in GIT. Such green targets aimed in reducing CO<sub>2</sub> pollution from data centers and efficiencies by managing the use, recycle, and disposal of electronic equipment. Organizations that have adopted green targets have established goals and objectives to meet metrics and report the results. Businesses that have adopted energy-efficient technologies have increased public support for green products and services, and improved public attitude toward organization corporate behavior.

Without a clear understanding of GIT, corporate leaders will not consider investing in technologies that are energy-efficient and environmental-friendly. Although current U.S. laws require some level of reducing pollution and electronic waste, such laws do not impose compliance, either fines for damage to the environment or rewards for reducing pollution. Senior leaders could seek to promote government legislation to acquire government grants, tax credits, research and development, and preferential vendor status for implement GIT.

As the world population and global markets continue to increase, the demand for IT services and products will increase proportionally requiring greater use of energy sources and raw materials. The dependency and volatility of the world energy supplies and unexpected increase of fuel prices could cause a disruption of energy affecting the financial stability of firms. GIT could address the scarcity of natural resources; decrease the cost consumption of energy, and the CO<sub>2</sub> footprint that has increasingly become a concern for government, businesses, and citizens. GIT can play a key role in corporate sustainability. Such technologies are more energy-efficient, which could support long-term growth, security, and business resiliency. GIT can attract a workforce that is concerned with the environment and contribute to a cleaner work environment. Technology has played a key role in business sustainability and society (Molla et al., 2009). CIOs could consider the use of renewable energy; plan for data center growth in a mature economy, and the long-term effect of environmental pollution.

## Recommendations

Suggestion for removing the barriers of GIT. Central Research Question 2: How can senior leaders help to remove the barriers of adopting GIT?

Organization leaders are questioning the lack of GIT quantified business benefits, compared to other uses of corporate dollars. Additionally, there is a perception that GIT has an initial high cost. To overcome such perception, senior leaders could consider changing from a cost-based model to a value-based IT model, centering on the total value of ownership. By using the total value cost of ownership, GIT could help in optimizing the environmental sustainability across business processes, such as supply chain management, longer lifecycle maintenance, as well as products, services and resources. In addition, CIOs could plan for using renewable energy; consider data center growth in a mature economy, and the effect of environmental pollution. Table 2 illustrates four major barriers of GIT and suggest possible actions leaders may consider to overcome the barriers, according to the findings of this study.

Table 2. GIT barriers and suggested removal actions

GIT Barriers	Actions to Overcome GIT Barriers
Developing GIT Expertise	<ul style="list-style-type: none"> <li>• Support GIT education and Programs</li> <li>• Acquire skills in selecting and implementing GIT</li> </ul>
Overcoming Implementation Cost	<ul style="list-style-type: none"> <li>• Move from a cost-based to a value-based financial model</li> <li>• Support legislation for tax credits and incentives for energy and environmental efficient facilities and technologies</li> <li>• Small and medium companies could leverage from energy and environmental efficient shared services from data centers</li> </ul>
Environmental Regulations	<ul style="list-style-type: none"> <li>• Measure energy use and report reduction of CO2</li> <li>• Establish a recycle, reuse, and waste disposal program</li> <li>• Seek the use of renewable energy sources</li> <li>• Engineer environmental friendly designs into product and services</li> </ul>
Refining Immature Technology	<ul style="list-style-type: none"> <li>• Support Research and development of GIT</li> <li>• Research vendors for proven GITs</li> <li>• Use Case Studies of organizations that have successfully implemented GIT</li> </ul>

With proper management of GIT can meet environmental compliance for waste disposal, recycling and reuse of electronic. GIT can help organizations to get ahead of potential risk of mandated government policies that could create unexpected costs for non-compliance with environmental law. Senior leaders could seek to promote government legislation to gain government grants, tax credits, and preferential vendor status to implement GIT. These incentives can help firms to ease the initial cost of investing in GIT.

Further, by integrating the concepts of the model into a combined IT and CSR strategic plan using a value-based IT model, rather than a cost-based model, organizations could derive corporate profits and seeks to become sustainable. To further assist senior leaders in overcoming the barrier of GIT, Figure 4 delineates a business process summarizing the opinions of the panel of experts of this study.

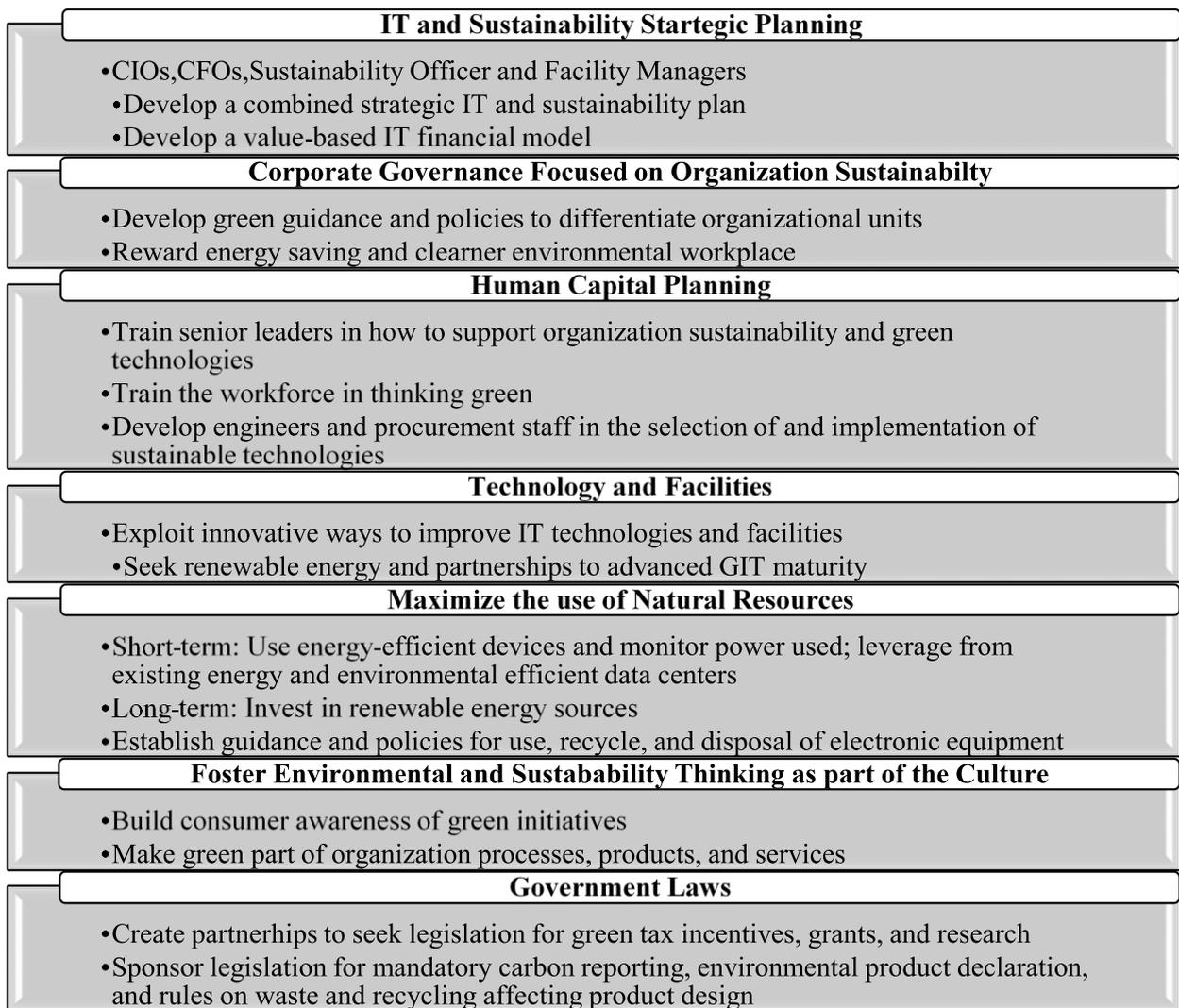


Figure 4. Combined IT and sustainability strategic planning business process

The following recommendations could assist leaders on overcoming GIT barriers:

- Develop training programs for senior leaders and IT professionals to understand what GIT is, cost saving benefits, standards, green targets, monitoring energy use, and pollution reduction.
- Develop sustainable enterprise-wide strategies to include ITs lifecycle management, monitoring energy use, and reporting CO2 reduction.
- Establish corporate governance to establish GIT policies and guidance, standards, rewards energy-saving initiatives, and foster environmental thinking.
- Use data center and cloud computing shared services to reduce IT operational cost.
- Exploit innovative solutions to improve IT and facilities, while seeking the use of long-term renewable energies.
- Make green thinking part of the organization culture and build consumer awareness of product and services green practices.
- Create partnerships to seek legislation for green tax incentives, grants, and research.

The findings of the classical Delphi study provided useful recommendations to rationalize the adoption of Green IT, and recommendations to overcome implementation barriers. The findings supporting the benefits of Green IT as claimed by the study participants did not provide evidence of IT operational cost reduction or quantifiable examples of a positive return-on-investment, as it was expected. On the other hand, the findings yield substantial new information to fill some of the gaps in the literature. Green IT is still viewed as an immature technology in its initial stage of development (Molla, 2009).

## Conclusions

The purpose of this qualitative classical Delphi study was to identify the leadership barriers for executives and organizations inclined to implement Green IT. The findings of this study provided useful information for executives and IT practitioners willing to establish business strategies to adopt Green IT. The Dalkey and Helmer (1963) classical Delphi method served as the most suitable method for this exploratory research. The three round classical Delphi study enabled the exploration of the barriers impeding the adoption of Green IT, for executives inclined to adopt the technology. The findings of the classical Delphi provided useful recommendations to rationalize the adoption of Green IT, and recommendations to overcome implementation barriers. The findings supporting the benefits of Green IT, as claimed by the study participants, did not offer evidence of IT operational cost reduction or quantifiable examples of a positive return-on-investment, as it was expected from the study. On the other hand, the findings yield substantial information to fill some of the gaps in the literature. However, the benefits of implementing Green IT practices may significantly conserve natural resources, by reducing the use of natural resources, energy usage, and protecting the environment. Furthermore, as the world population continues to grow, society and businesses could benefit from a cleaner environment improving quality of life and controlling IT cost and meeting future demands for IT services.

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