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Green Information Systems Refraction for Corporate Ecological Responsibility Reflection in ICT Based Firms: Explicating Technology Organization Environment Framework

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Abstract

This study develops a Green Information Systems (IS) interpretive model grounded on Technology Organization Environment (TOE) framework to identify the factors that influence Green IS refraction and further examines to what extent these factors impact Green IS refraction in Information Communications Technology (ICT) based firms for corporate ecological responsibility reflection. For this purpose, a survey was conducted among ICT based firms and analyzed using Partial Least Square-Structural Equation Modeling (PLS-SEM). Results indicate that the technological factors significantly influence Green IS refraction. In addition, results suggest that the organizational factors positively influence Green IS refraction. Moreover, results reveal that environmental factors significantly determine the extent of Green IS refraction. Finally, results show that Green IS reflection initiatives implemented in ICT based firms positively defines corporate ecological responsibility. Respectively, this study offers a comprehensive approach for measuring Green IS practice implemented in ICT based firms.

Keywords: Sustainability; Green Information Systems; Corporate Ecological Responsibility; Technology Organization Environment Framework; ICT Based Firms; PLS-SEM.

Introduction

Green Information Systems (IS) practice adoption has become one of the latest initiatives adopted by organizations to reduce cost incurred and lessen energy consuming of Information Technology (IT) infrastructures (Loeser et al., 2017). Since 2007/2008 Green IS has become an important concept in various domains as such Information Communications Technology (ICT) based firms are beginning to adopt Green IS initiatives (Brooks et al., 2012; Loeser, 2013). But, over the decade existing contribution towards Green IS has either focused on exploring how to make IT Greener by addressing energy management issues (Melville, 2010), implementing energy efficient technologies, as well as examining diverse approaches in which IS can support ecological friendly operations (Molla, 2013; Anthony Jr et al., 2018). Respectively, Green information systems refraction can contribute to corporate ecological responsibility by providing information to practitioners in organization regarding the implications of their behaviour to promote sustainable initiatives (Dalvi-Esfahani et al., 2017a).

Accordingly, an IT manager who is aware of the ecological implications of his or her organizations might come to a different resolution than one who does not care about the environmental conservation (Molla et al., 2014). But on the contrary, Green IS refraction in ICT

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based firms depends on IT mangers' acknowledgment of the need to respond towards ecological issues (Gholami et al., 2013). This is because action occurs only when organization recognizes that events such as global warming and climatic changes require response such as Green IS refraction for ecological friendly practices within the firm (Recker, 2016). For instance, usage of web based video conference results to power reduction depends on the belief that decreasing CO_2 emissions is important to corporate ecological responsibility (Meachan et al., 2013; Boudreau et al, 2008). Therefore, sustainability related action in any enterprise is supported when environmental beliefs of IT practitioners and IT manager are same across the firm (Dalvi-Esfahani et al., 2017b). Besides, Green IS refraction in ICT based firms mostly concerns the deployment of IT related facilities to diminish and mitigate polluting e-wastes that occurs throughout organizational activities (Jnr et al., 2018).

Thus, Green IS refraction initiatives involve innovative use of IS to lessen pollution generated by enterprise activities in mitigating greenhouse gasses (Schmidt et al., 2010; Anthony et al., 2018a). Furthermore, Green IS refraction in ICT based firms may include usage of IS towards innovative energy assessment such as usage of telematics applications to decrease organization's carbon footprint (Ainin et al., 2016). Respectably, Green IS may further involve the deploying of innovative programs to transform enterprise environment by integrating practices that preserve the natural resources (Seidel et al., 2010; Lei and Ngai, 2014). But, congruent with Loeser et al. (2017) the main benefits of Green IS can be cost decrease from ethical natural resource utilization, improved revenues from a positive corporate status, and technological infrastructure that result in eco-friendly products that facilitate economic viability.

Accordingly, this study develops a Green IS interpretive model grounded on Technology Organization Environment (TOE) framework to identify the drivers that influences Green IS refraction and further examines to what extent these factors impact Green IS refraction in ICT based firms. The interpretive model provides an agenda on sustainability implications towards IT deployment in ICT based firms. The model further helps in measuring the ecological friendly practices in ICT based firms, and also help in the actualization of a governance policy for Green IS refraction towards corporate ecological responsibility reflection. Additionally, the Green model provides a set of initiatives for explicating each factor based on several benchmarks to assist firms in managing, revising, and refining their corporate ecological responsibility. Additionally, the model help determine the improvement being made to ensure that staffs remains fully involved with Green IS refraction in their organizations. The organization of this article is as follows. The literature review is presented in Section 2. The model and hypotheses development is shown in Section 3 and methodology has been outlined in Section 4. The survey results are described in Section 5. Discussion of the results is described in Section 6. Section 7 is the implications. Conclusions, limitations and future directions are shown in Section 8.

Literature Review

Strategic Benefits of Green IS Refraction in ICT Based Firms

IT usage in ICT based firms not only result to direct effects but also influence the way staffs in organizations carryout their daily operations which lead to environmental impacts that are mostly challenging to address. These environmental impacts can be resolved by ICT based firms adopting Green IS initiatives which possess enabling impacts (Anthony Jr et al., 2018), on the organizations in one or more of the following methods as shown in Figure 1.

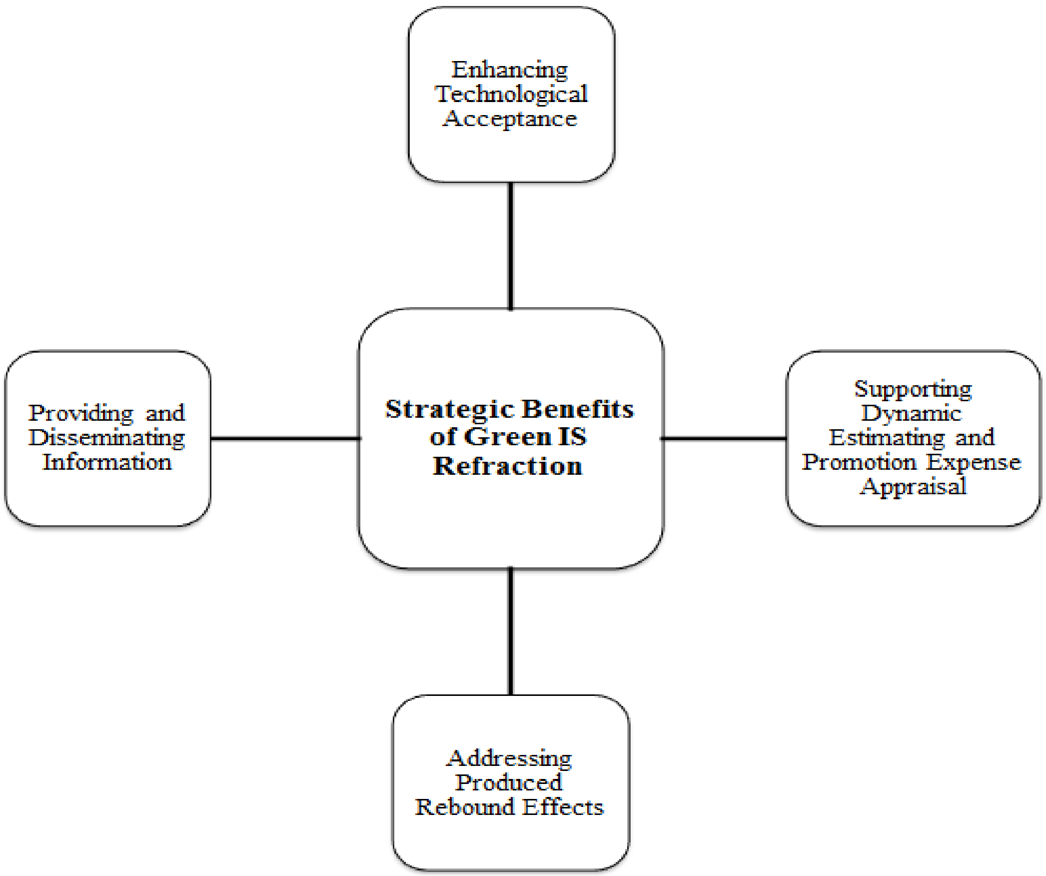

Figure 1 Strategic benefit of Green IS adoption

Figure 1 shows the strategic benefit of Green IS in ICT based firms and they includes;

Providing and Disseminating Information

Green IS can help transmit information across ICT based firms by supporting the measuring, monitoring and reporting of climatic changes regarding the natural environment (Hilty and Aebischer, 2015). In addition, Green IS provides access of data to facilitate decision making of IT practitioners through usage of smart meters that measures CO_2 emission generated, sensor based intranet systems that collect and interprets data on electricity usage in organizations (Mickoleit, 2010).

Supporting Dynamic Estimating and Promotion Expense Appraisal

This involves Green IS applications to promote economic viability in organizations. Accordingly, through the utilization of Green IS initiatives IT practitioners are provided with instantaneous cost update on Green procurement recommendations (Hilty and Aebischer, 2015). Hence, staffs in organization consuming electricity can decide to turn off less useful appliances when cheap or/and renewable energy is not available and switch the equipment on when renewable energy such as solar is available (Mickoleit, 2010). Thus, this can be seen as a significant part of enterprise social obligation that aims to use ecological-friendly initiatives to encourage Green behaviour in organizations towards sustainability attainment.

Enhancing Technological Acceptance

Technological advancement correlates to social behavioral changes in organizations which can change organizations preference. For example, the progression from staffs using desktop Personal Computers (PCs) to netbooks laptops is one instance of changing organizations preferences (Mickoleit, 2010). Likewise, e-mail communications, digital music, teleconferencing etc. are technologies that affect the ways physical components are manufactured and utilized (Hilty and Aebischer, 2015). Conversely, these technologies may leads to direct impact energy consumption from servers that save and offer digital contents and enabling effects that decrease the utilization of physical music hardware media such as cassettes and Compact Disc (CD) (Mickoleit, 2010).

Addressing Produced Rebound Effects

Rebound effects relate to the phenomenon that higher efficiencies at the micro level, for example the usage of ecological friendly product by staffs in an organization do not essentially translate into equivalent cost savings for the organization (Hilty and Aebischer, 2015). This implies that an enterprise deployment of 30 per cent more energy efficient appliances does not automatically translate into electricity savings of 30 per cent. Findings presented by Mickoleit (2010) revealed that rebound effects at the individual level partly offset efficiency gains at the organizational level. As such the exact bases and long term tendencies are not yet certain. Accordingly, Green IS can be adopted to help resolve rebound effects by deploying higher efficiency that result to less demand of energy.

Overview of Technology Organization Environment (TOE) Framework

This Section introduces the theory-based approach to examine the factors that influence ICT based firms toward adopting Green IS for corporate ecological responsibility. Prior studies Nedbal et al. (2011); Cooper and Molla (2014); Zheng (2014) developed theoretical frameworks that aid organizations in implementing Green IT initiatives. Their framework was firmly based on Technology Organization Environment (TOE) framework. Respectively, the TOE framework was proposed by Tornatzky et al. (1990) from Rogers's (1995) diffusion of innovation theory by integrating the environmental construct as a variable together with the existing technology and organization constructs recommended by Roger (Nedbal et al., 2011). The inclusion of environmental construct was significant for considering emerging technology deployment in organizational environments where the external factors could results to both challenges and prospects (Cooper and Molla, 2014). Besides, the TOE framework offers an all-purpose model that assimilates organizational, technological and environmental variables to investigate the variables that could influence the incorporation of novel technologies (Zheng, 2014).

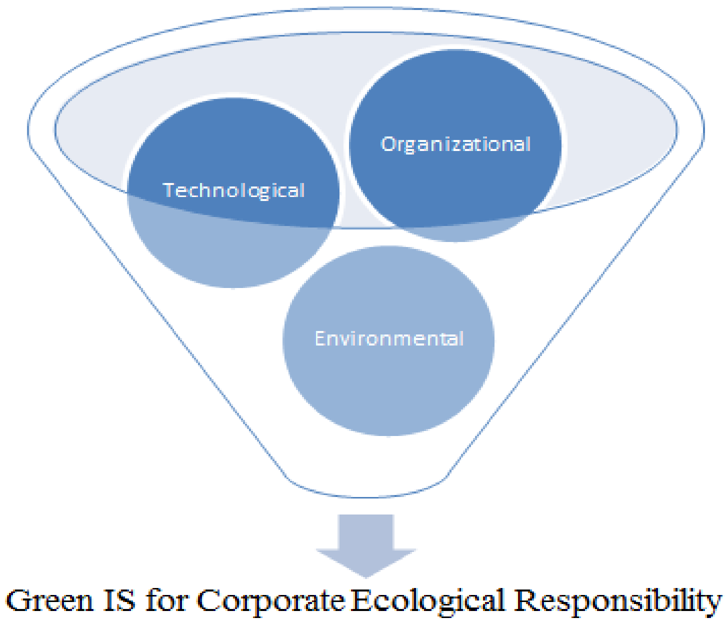

Figure 2 TOE framework for Green IS

Figure 2 shows the TOE constructs which involves environmental, organizational, and technological where the technological context describes the characteristics of technology which would influence Green IS in relation to existing and new technology (Zheng, 2014). Organizational construct refers to description of firm in relation to the business scope, asset size, resource availability and administrative organization (Cooper and Molla, 2014). Lastly, environmental context is the construct which explores how an enterprise carries out its business in relation to its rivals, and commitment in adhering to governmental regulations (Nedbal et al., 2011). The environmental context also concerns the external setting in which companies conduct their daily activities and extends to potential issues that could directly or indirectly persuade and/or constrain firm's maneuver towards the firm achieving competitive advantage (Tornatzky et al. 1990). In addition, prior researchers Molla (2008); Bose and Luo (2011); Nedbal et al. (2011); Cooper and Molla (2014); Zheng (2014) developed their research model on Green IT/IS based on TOE framework. This suggests that by developing a model based on TOE framework, scientists can conceptualize the pertinent attributes that are explicit to their research background (Nedbal et al., 2011). Therefore, the TOE framework is practical to be adapted as one of the theoretical grounds for examining Green IS refraction for corporate ecological responsibility reflection in ICT based firms.

Green IS Interpretive Model and Hypotheses Development

Drawing from TOE framework and based on prior literature, this study develops a Green IS interpretive model (see Figure 3) that shows the factors that influences Green IS refraction for corporate ecological responsibility reflection. Accordingly, this Section discusses each factor and also presents the related hypothesis.

Technological Context

The technological construct comprises of IT infrastructure and information diffusion.

IT Infrastructures

This entails IT technologies, systems, facilities and other equipment utilized in organizational operations (Radu, 2016; Junior et al., 2018). The IT Infrastructure entails the organizations effort on the reuse of technologies and systems towards modernization and persistent restoration for energy competence and economic turnover (Karanasios et al., 2010). ICT based firms acquiring, deploying eco-friendly technologies and systems can facilitates ecological responsibility (Nedbal et al., 2011). According to Zheng (2014) IT infrastructure involves the technical perspective that influences ecological responsibility. These technologies and systems enable Green IS aimed at decreasing energy depletion of deployed IT facilities thereby lessening Greenhouse gas emissions. Respectively, technologies such as Radio-frequency identification (RFID) and sensors that computerize the collection of data could help produce corporate ecological responsibility report. This generated report can be used to enhance firm’s polices on pollution reduction (Dao et al., 2011). Furthermore, electronic filing and digitizing documents can be utilized to help organization realize energy savings by reducing paper usage and also lessen waste generation (Chen et al., 2008). On the basis of these, the following hypothesis is formulated:

Hypothesis 1: Deployed IT infrastructure resources have a positive effect on Green IS refraction.

Information Diffusion

Information diffusion aims to provide data on how ICT based firms can attain ecological responsibility (Melvin, 2010). Furthermore, information on how firm can achieve ecological responsibility is becoming a valuable and intangible asset that can be used to facilitate Green competitive advantage in organizational process (Pitt et al., 2011). Hence, it is imperative to disseminate information across enterprise to support staffs in decreasing cost incurred and also improve quality of enterprise operations (Watson et al., 2010). Furthermore, information diffusion signify activities and practices that facilitate the procedure of creating, capturing, dissemination and sharing of Green IS initiatives to provide knowledge that can be used to enhance ecological responsibility (Butler, 2011b; Junior et al., 2018). Thus it is hypothesized:

Hypothesis 2: Information diffusion is positively associated with Green IS refraction.

Organizational Context

The organizational context comprises of firm's strategy, institutional pressure, IT practitioners, and IT managers.

Firms Strategy

This comprises activities and procedures carried out in the business (Jenkin et al., 2011; Vykoukal et al., 2011). The firm's strategies infused may include supporting organization in reducing operational cost (Butler, 2011b; Anthony Jr, 2018), minimizing carbon emissions thereby changing the direction towards realizing the goal of ecological responsibility (Seidel et al., 2010). Additionally, firm's strategy aims to influence corporate growth and also promotes the firm's bids to achieve ecological responsibility advantages in the long term (Karanasios et al., 2010). Thus, firm's strategies can be established with activities to promote ecological friendly awareness on the cause of environmental problems and how to promote ecological responsibility (Jr et al., 2017). In relation to the argument, the hypothesis is proposed:

Hypothesis 3: The current firm's strategy is positively associated with Green IS refraction.

Institutional Pressure

ICT based firms are faced with pressure by governmental and nongovernmental associations to adopt ecological friendly initiatives by initiating policies to safe guard the eco-system (Jenkin et al., 2011). According to Butler (2011a) these institutional pressure can be categorized as coercive, normative, and mimetic pressure. Thus, mimetic pressure refers to external force that motivates firms to emulate other enterprise that adopts Green IS initiatives (Butler, 2011b). This happens when Green IS adoption in other firms is positively deployed thus leading to reduction in energy depletion, CO_2 emission reduction and cost savings (Vykoukal et al., 2011). This influences competitive firm to implement Green IS initiatives in their own firm (Jnr et al., 2017). Likewise, coercive pressure results from non-governmental, industrial, and governmental policies which motivate organizations to adopt Green IS initiatives (Nedbal et al., 2011). Lastly, normative pressure is internal pressure inside the firm, which is initiated based on in-house, polices which induces the organizational community to adopt Green IS (Chen et al., 2011). This results to the following hypothesis:

Hypothesis 4: Institutional pressure will positively impact Green IS refraction.

IT Practitioners

This refers to the human infrastructure who adopts Green IS initiatives to ensure that the organization attains ecological responsibility (Vykoukal et al., 2011). IT practitioners need to be dedicated since they are involved in scheduling, organizing, executing and retaining organizations system (Loeser et al., 2017). However, the collaboration among these staffs is based on their norms, beliefs, attitude, ethics, and obligation in achieving the objectives of the firm (Chen et al., 2008). Furthermore, the perception of the staffs towards the environment is a important attribute for the adoption of Green IS initiatives, although this is reliant on their commitment to adhere to corporate environmental rule, along with active reassurance of environmental ingenuities that transpire within the firm (Karanasios et al., 2010). Moreover, Dao et al. (2011) mentioned that organizations should improve and educate their employees to attain the state of rational awareness related to ecological responsibility. So it is imperative to empower staffs by developing their expertise through training so that they can utilize the skills obtained to advance the firm's ecological goals (Jnr et al., 2018). Hence it is hypothesized:

Hypothesis 5: IT practitioner's attitude and belief will positively influence Green IS refraction.

IT Managers

Currently, ICT based firms are currently adopting Green IS practices, but the scope of ecological responsibility differs in respect to executive culture (Anthony et al., 2018b). Thus, it is vital for management to provide adequate support (Kim and Suh, 2017) and also participate by adopting Green IS hence showing good behaviour to staffs in the organization that they are serious about improving the firm's ecological responsibility (Butler, 2011a). Therefore, IT manager further outlines Green policy metrics for evaluating the impacts of Green activities in the organization operations (Gholami et al., 2013). Likewise, IT managers' commitment for Green IS practice is also an important attributes for successful ecological responsibility attainment (Jenkin et al., 2011; Anthony Jr, 2018). Accordingly, in achieving ecological responsibility, IT managers policies should captures the organizations intent to fully adopt Green IS practices by defining strategies required to measure the outcome of Green IS initiatives in the business (Loeser et al., 2017). Thus, these policies comprise the agenda put toward by IT managers to support staffs adopt eco-friendly practices in the firms daily activities (Molla et al., 2014). This leads to the following hypothesis:

Hypothesis 6: IT manager's support and commitment will positively impact Green IS refraction.

Environmental Context

In terms of environmental context, the three key practices that influence Green IS refraction include eco-effectiveness, eco-equity, and eco-efficiency.

Eco-efficiency

Practically, efficiency means achieving more with less input. Thus, this practice aims to lessen ecological problem by utilizing non-renewable raw materials (Chen et al., 2008). Accordingly, eco-efficiency is attained by the distribution of competitively-inflated goods and services that fulfill firm's requirements and thus results to quality outcome. Respectively, while gradually decreasing environmental outcome and natural resource usage all through the product life cycle to a point that is in line with the earth's capability (Molla and Abareshi, 2012). In addition, eco-efficiency lays great prominence on the profitable viability of ecological strategies, which are considered as both corporate and ecological opportunity (Chen et al., 2008). Correspondingly, economic prospects ascends from eco-efficiency are main incentive for establishments to be environmentally responsive (Hernandez, 2018), where management decisions are made based on a cost-benefit examination, with economic reimbursements as the primary goal (Chen et al., 2011). Essentially, eco-efficiency is aligned to ''doing things right''. This proceeding discussion leads to the following hypothesis.

Hypothesis 7: Eco-efficiency practice is positively related to Green IS refraction.

Eco-equity

This is mostly concerns with the rational sharing of natural resources between the present and imminent generations to come (Chen et al., 2008). Respectively, eco-equity needs to be inculcated into the managerial policies in order to promote the number of IT practitioners involved in ecological friendly initiatives, even if there are inadequate cost-efficiency strategies (Molla and Abareshi, 2012). Besides, eco-equity correlates to business and society nexus. In addition, eco-equity is based on ecological centered standards that refer to equal rights to all inhabitants to get equal access to available natural resources (Chen et al., 2011). The above discussion leads to hypothesize the following.

Hypothesis 8: Eco-effectiveness practice is positively related to Green IS refraction.

Eco-effectiveness

This practice aims beyond simply decreasing negative ecological impact by mitigating ecological degradation but also provides alternatives for addressing environmental related problems (Chen et al., 2008). Moreover, eco-effectiveness transpires as the definitive goal of environmental conservation (Chen et al., 2011), which aims to mitigate pollution and exhaustion by directing societal and managerial responsiveness to the fundamental and major factors of environmental degradation. This practice also aims to attain long-term prosperity through organizational operations (Molla and Abareshi, 2012). The above discussion leads to the following hypothesis.

Hypothesis 9: Eco-effectiveness practice is positively related to Green IS refraction.

Green IS Refraction

Green IS refraction efficiently defines natural resources in the form of enterprise reflection in becoming more ecologically sustainable (Jr et al., 2017). Additionally, Green IS facilitates the effective combination, deployment and effective management of the organization's technological infrastructure as well as IS based ecological practices (Opitz et al., 2014). Moreover, Green IS further deliver methods that help enterprise implement ecological management that reflects the organization's reputation and image. According to Loeser et al. (2017) Green IS refers to ecological initiatives implemented in organizations while focusing on minimizing IT-based environmental impacts. In addition, Molla et al. (2014) argued that environmental concerns need to be translated into corporate strategies if Green IS initiatives are to be adopted in ICT based firms for e-waste reduction. Thus the following hypothesis is postulated:

Hypothesis 10: Green IS refraction will positively impact ecological responsibility reflection.

Based on literature and related hypotheses discussed above on the factors that influence Green IS refraction for ecological responsibility reflection in ICT based firms, the Green IS interpretive model grounded on TOE framework is developed as show in Figure 3.

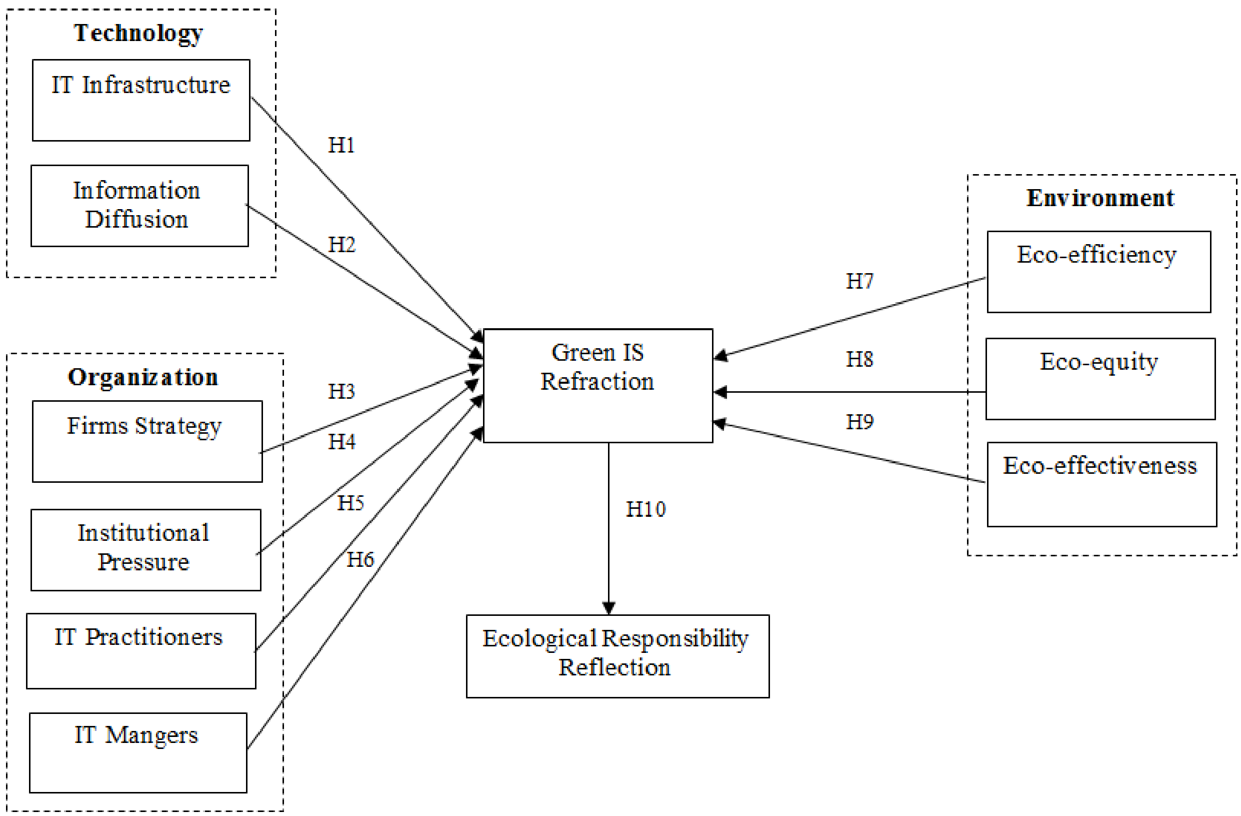

Figure 3 Developed Green IS interpretive model

Figure 3 depicts the developed Green IS interpretive model proposed based on TOE framework to identify the factors that influence Green IS refraction and further examines to what extent these factors impact Green IS refraction for ecological performance in ICT based firms.

Research Methodology

Research Procedure and Instrument Measurement

To test the developed Green IS interpretive model (see Figure 3), a measurement instrument was developed based on relevant previous studies on Green IT/IS and environmental sustainability (see Table 1). After which data was collected through online survey questionnaire. The survey instruments were pre-tested by five IS experts that checked for grammatical, typographical and technical errors in accomplishing face and content validity. Next, call to prospective respondents in the web-based survey was sent to prospective participants email addresses of appropriate respondents extracted from their respected sustainability or Green practice firm websites of about 80 firms in Malaysia that adopts Green practice through the use of mailing lists where potential respondents were invited to participate through a link to the survey included in the email.

The respondents were chosen using Judgemental sampling method, where only participants that possess prior knowledge on Green practice are selected to provide data to validate the developed Green IS interpretive model. Next, after selecting suitable participants, the survey was administered in English language and mailed to respondents. The respondents are IT practitioner in various ICT based firms across Malaysia, each respondent possess more than two years' experience in Green practice implementation. The data collection lasted from January 2017 to April 2017. At the end of the survey 133 usable samples was collected which is moderate and still applicable to proceed with the research based on sample size employed in prior studies on Green IT/IS, where Kuo and Dick (2010) explored factors that influences Green IT based on 30 samples, Schmidt et al. (2011) examined their model based on 116 samples, whereas Chen et al. (2011) collected their data from 75 respondents. Likewise, Ryoo and Koo (2013) tested their model using 77 final sample and Molla and Cooper (2014) utilized 97 usable samples.

The questionnaire consisted demographic variables to collect data based on the respondents and their respective firms, questions to measure the degree of importance of the identified factors based on their associated items (see Table 1). The attributes were measured based on a 5-point Likert scale fixed from "strongly disagree" as "1" to "strongly agree" as "5" similar to prior studies (Kuo and Dick, 2009; Meacham et al., 2013; Ryoo and Koo, 2013; Cooper and Molla, 2014; Akman and Mishra, 2015) to measure the respondents perception towards the degree to which the items is important in relation to the firm's current Green IS practice. Table 1 show the factors related items utilized in this study.

Table 1 Model factors and related attributes

Factors	**Code**	**Attributes**	**References**
IT Infrastructure	ITI1	Transforming firm operations to be paperless.	(Info~Tech, 2007; Accenture, 2008; Elliot and Binney, 2008; Mines, 2008).
	ITI2	Server consolidation and virtualization to decrease energy usage.	
	ITI3	Use of e-meeting for consultations.	
	ITI4	Use of video based tools for daily activities.	
	ITI5	Employs telecommuting for moving within the firm.	
	ITI6	Deploy of on-line teamwork tools for business operations.	
	ITI7	Use of decision support programs to reduce CO_2 emissions.	
	ITI8	Install software to lessen e-waste generation.	
Information Diffusion	IFD1	My firm provides newest data relating to the eco-system.	
	IFD2	My firm provide information relation to environmental issues	

	IFD3	My firm provides accurate and detailed information.	(Daly and Butler, 2009; Molla and Cooper, 2014).
	IFD4	My firm disseminates reliable information within the enterprise.	
Firms Strategy	FMS1	My firm addresses the carbon foot print from IT systems.	(Chen et al., 2011; Butler, 2011a; Molla et al., 2011; Molla and Cooper, 2014).
	FMS2	Own an in-house firm strategy.	
	FMS3	Financial returns on investment.	
	FMS4	My firm provides policies on how to resolve environmental issues.	
	FMS5	Effective routines to aid the combination of newly acquired knowledge.	
	FMS6	My firm provides medium to aid acquiring new knowledge.	
	FMS7	My firm is interested in eco-friendly policies.	
Institutional Pressure	INP1	We influenced by forces from governmental associations.	(Daly and Butler, 2009, Kant, 2009; Chen et al., 2011; Butler, 2011a).
	INP2	Administration influences Green IS initiatives in my firm.	
	INP3	My firm provides incentives to support Green IS initiatives.	
	INP4	My firm mimics other organizations in adopting Green IS initiatives.	
	INP5	My firm provides is inflicted by external pressure.	
	INP6	My firm provides is influenced by to go Green by external associations.	
	INP7	My firm adopts Green IS practice because of future consequences	
IT Practitioners	ITP1	Positive attitude of staffs in regards to the eco-system.	(Hart, 1997; Gartner, 2008; Jenkin and McShane, 2008; Molla et al., 2011).
	ITP2	Ethical consideration of staffs in regards to the eco-system.	
	ITP3	Social-culture of staffs in regards to the eco-system.	
	ITP4	General capabilities of staffs in regards to the eco-system.	
	ITP5	Beliefs and norms of staffs in regards to the eco-system.	
	ITP6	Knowledge of staffs in regards to the eco-system.	
	ITP7	Capability of staff's influences Green IS adoption.	
	ITP8	The staff's commitment influences Green IS adoption.	
IT Managers	ITM1	Formal management organizations.	(Hart, 1997; Gartner, 2008; CFO, 2009; Molla, 2009; Molla et al., 2011).
	ITM2	Management playing leading role.	
	ITM3	Management support.	
	ITM4	Executives explore on ways to decrease energy consumption.	
	ITM5	Executives supporters the use of eco-friendly IT facilities.	
	ITM6	Executives initiate policies to decrease e-wastes.	
	ITM7	Executives initiate policy to use only energy competent IT facilities.	
	ITM8	Executives provide budgets for Green IS advancement.	
Eco-Efficiency	EEF1	Fix programs to make creation more eco-friendly.	(Info~Tech, 2007; Velte et al., 2008; Schmidt et al., 2009; Molla et al., 2011).
	EEF2	Change energy ineffective systems in our firm.	
	EEF3	Investigates how to reduce cost of electricity.	
	EEF4	Employ the service of experts to service firms' data center.	
	EEF5	Deploy energy proficient lightings in our firm.	
	EEF6	Renovate to efficient power converters.	
	EEF7	Review energy usage for lesser electricity consumption.	
	EEF8	Change and replace unused IT systems.	
Eco-Equity	EEQ1	Uses programs that suggest Green sourcing vendors.	(Gartner, 2008; Murugesan, 2008; Molla, 2009; Schmidt et al., 2009).
	EEQ2	Purchase mainly recycled IT equipment.	
	EEQ3	Purchase from vendors who supply Green products.	
	EEQ4	Considers ecological purchase in firm's procurement operations.	
	EEQ5	My firm adopts eco-friendly procurement policies.	
	EEQ6	My firm buy IT equipment from supplier that recycle old IT hardware,	
Eco-Effectiveness	EFS1	My firm employs ecological planning of IT facilities.	(Elliot and Binney, 2008; Velte et al., 2008; Molla, 2009; Schmidt et al., 2009).
	EFS2	My firm deploys power management for IT facilities.	
	EFS3	We turn off It facilities when not in use to conserve energy.	
	EFS4	We practice double side printing in my firm.	
	EFS5	My firm utilize IT facilities that monitor power workloads.	
	EFS6	My firm uses natural cooling to diminish energy charge.	

Green IS Refraction	GIR1	My firm is put in place policies to reduce power usage for cooling.	(Accenture, 2008; Gartner, 2008; Molla, 2009; Velte et al., 2008).
	GIR2	My firm is put in place policies to reduce power usage for lighting.	
	GIR3	My firm considers ecological factors in the design of infrastructures.	
	GIR4	My firm uses clean and renewable energy	
	GIR5	My firm consumes power from clean energy suppliers.	
	GIR6	My firm enforces energy management initiative.	
Ecological Responsibility Reflection	ERR1	My firm recycles paper, tins, glass, cartridges, batteries, etc.	(Gartner, 2008; Murugesan, 2008; Molla, 2009; Schmidt et al., 2009).
	ERR2	My firm disposes old IT hardware in an eco-friendly approach.	
	ERR3	My firm implements policy on controlling e-waste.	
	ERR4	My firm reuse IT facilities.	
	ERR5	My firm repair out-of-date IT facilities.	

Data Analysis

Data analysis was carried out using Partial Least Squares (PLS), a Structural Equation Modeling (SEM) method that utilizes a factor based approach for estimation. The PLS method is oriented mainly to predictive causal examination (Hair et al., 2013). Moreover, PLS-SEM has been widely adapted in prior Green IS and environmental literatures (Meacham et al., 2013; Gholami et al., 2013; Akman and Mishra, 2015; Loeser et al., 2017). PLS-SEM is flexibility in confirming hypotheses regarding model specifications and also provides parameter estimates to explain the percentage variance of dependent variable towards supporting prediction for confirmatory theory testing (Hair et al., 2013). Therefore, PLS-SEM is utilized to test the developed interpretive model in relation by operationalizing the factors based on reflective measurement. Respectively, the analysis was performed using the SmartPLS 3 application based on 500 iteration method to assess the model. Moreover, all analytical tests were computed with two-tailed tests because of the unidirectional nature of the model hypotheses.

Results

Assessment of Measurement Model

The psychometric properties (validity and reliability) of the instrument were tested using PLS-SEM based on two phases. In the first phase, the measurement models were assessed for convergent and discriminant validity. The results (see Table 2 and Table 3) show that the measurement model is reliable and valid. In terms of convergent validity, all measurement item factor loadings are greater than 0.7 (Gholami et al., 2013) and the Average Variance Extracted (AVE) is higher than 0.5 (Loeser et al., 2017). The Cronbach's alpha and Composite Reliability (CR) values are also higher than 0.7 offering confirmation of dependability of the factors (Dalvi-Esfahani et al., 2017b) as seen in Table 2.

Likewise, results of descriptive statistics (mean and Standard Deviation (SD)) is also presented, where descriptive statistics provide information needed to determine whether the factors are amply normally dispersed, and the correlations are used to confirm relationships among the model variables (Meacham et al., 2013). The mean values of all factors are above 2.5. Also, SD is lower than 1 for all attributes depicting that the replies from the participants are close and not extensively distributed suggesting that all there are no outliers in the data.

Table 2 Item loadings, reliability and descriptive analysis

Factors	Code	Loadings	Cronbach's Alpha (α)	CR	AVE	Mean	SD
IT Infrastructure	ITI1	0.899	0.952	0.960	0.751	3.79	0.771
	ITI2	0.825					
	ITI3	0.829					
	ITI4	0.840					
	ITI5	0.905					
	ITI6	0.903					
	ITI7	0.880					
	ITI8	0.845					
Information Diffusion	IFD1	0.955	0.969	0.977	0.916	3.80	0.819
	IFD2	0.959					
	IFD3	0.959					
	IFD4	0.955					
Firms Strategy	FMS1	0.911	0.970	0.975	0.849	3.77	0.774
	FMS2	0.911					
	FMS3	0.886					
	FMS4	0.962					
	FMS5	0.948					
	FMS6	0.956					
	FMS7	0.871					
Institutional Pressure	INP1	0.814	0.932	0.945	0.710	3.60	0.706
	INP2	0.794					
	INP3	0.818					
	INP4	0.862					
	INP5	0.862					
	INP6	0.896					
	INP7	0.847					
IT Practitioners	ITP1	0.879	0.956	0.963	0.765	3.93	0.736
	ITP2	0.890					
	ITP3	0.887					
	ITP4	0.872					
	ITP5	0.871					
	ITP6	0.860					
	ITP7	0.812					
	ITP8	0.923					
IT Managers	ITM1	0.895	0.973	0.977	0.843	3.98	0.773
	ITM2	0.939					
	ITM3	0.938					
	ITM4	0.934					
	ITM5	0.836					
	ITM6	0.947					
	ITM7	0.957					
	ITM8	0.892					
Eco-Efficiency	EEF1	0.855	0.957	0.964	0.771	3.35	0.910
	EEF2	0.919					
	EEF3	0.823					
	EEF4	0.813					
	EEF5	0.875					
	EEF6	0.908					
	EEF7	0.909					
	EEF8	0.913					
Eco-Equity	EEQ1	0.882					
	EEQ2	0.890					
	EEQ3	0.930					

	EEQ4	0.917	0.959	0.967	0.829	3.25	0.967
	EEQ5	0.933					
	EEQ6	0.909					
Eco-Effectiveness	EFS1	0.925	0.937	0.950	0.761	3.51	0.836
	EFS2	0.942					
	EFS3	0.852					
	EFS4	0.757					
	EFS5	0.874					
	EFS6	0.873					
Green IS Refraction	GIR1	0.798	0.927	0.942	0.732	3.46	0.812
	GIR2	0.874					
	GIR3	0.869					
	GIR4	0.867					
	GIR5	0.861					
	GIR6	0.862					
Ecological Responsibility Reflection	ERR1	0.880	0.923	0.941	0.761	3.49	0.846
	ERR2	0.898					
	ERR3	0.883					
	ERR4	0.872					
	ERR5	0.828					
Note: Loadings>0.7; AVE>0.5; CR and **α** >0.7; Mean: 0.00-2.49 = low, 2.50-3.49 = moderate, 3.50-5.00 = high.							

In addition, the Fornell-Larker criterion (Fornell and Larcker, 1981) was used to examine the discriminant validity which is computed by considering the square roots of the AVE values which is used to compare the constructs correlations which should be higher than 0.5 (Gholami et al., 2013). Accordingly, results from Table 3 shows that the square root of the AVE is larger than the off crosswise inter-construct association hence discriminant validity is supported.

Table 3 Discriminant validity test

	Factors	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	Eco-Effectiveness	**0.872**										
2	Eco-Efficiency	0.857	**0.878**									
3	Eco-Equity	0.842	0.864	**0.910**								
4	Ecological Responsibility Reflection	0.878	0.774	0.798	**0.873**							
5	Firms Strategy	0.602	0.422	0.373	0.554	**0.921**						
6	Green IS Refraction	0.818	0.843	0.801	0.753	0.574	**0.855**					
7	IT Infrastructure	0.556	0.439	0.328	0.542	0.799	0.559	**0.866**				
8	IT Managers	0.485	0.321	0.249	0.434	0.788	0.443	0.772	**0.918**			
9	IT Practitioners	0.404	0.269	0.175	0.338	0.712	0.379	0.693	0.851	**0.875**		
10	Information Diffusion	0.597	0.454	0.364	0.570	0.904	0.594	0.771	0.797	0.717	**0.957**	
11	Institutional Pressure	0.624	0.512	0.468	0.532	0.855	0.686	0.751	0.694	0.651	0.822	**0.843**
The bold figures on the leading crosswise are the square root of the variance common between the variables and their attributes The values should be>0.5												

Assessment of Structural Model

To validate the hypothesis (H1-H10), the bootstrapping approach was used to test the significance level of the path coefficients of the model relationship.

Table 4 Results of measured structural model (hypotheses confirmation)

Hypotheses	**Path Description**	**Path coefficient**	**Standard error**	**Beta (β)**	R^2	**t-value**	**Significance level**	**Outcome**
H1	IT Infrastructure -> Green IS Refraction	0.584	0.076	0.555	0.341	9.589	***	Supported
H2	Information Diffusion -> Green IS Refraction	0.632	0.070	0.593	0.399	9.908	***	Supported
H3	Firms Strategy -> Green IS Refraction	0.607	0.075	0.572	0.369	9.366	***	Supported
H4	Institutional Pressure -> Green IS Refraction	0.699	0.074	0.674	0.488	13.64	***	Supported
H5	IT Practitioners -> Green IS Refraction	0.428	0.090	0.369	0.183	5.894	***	Supported
H6	IT Managers -> Green IS Refraction	0.494	0.082	0.440	0.244	6.308	***	Supported
H7	Eco-Efficiency -> Green IS Refraction	0.844	0.042	0.841	0.712	25.09	***	Supported
H8	Eco-Equity -> Green IS Refraction	0.819	0.045	0.795	0.670	21.98	***	Supported
H9	Eco-Effectiveness -> Green IS Refraction	0.817	0.050	0.809	0.668	19.57	***	Supported
H10	Green IS Refraction-> Ecological Responsibility Reflection	0.757	0.062	0.734	0.573	19.66	***	Supported
Notes: ***p>0.05; t-value>1.96 to be significant								

Based on the recommendation of Hair et al. (2013), the bootstrapping method was deployed using 5,000 resamples. Table 4 and Figure 4 show the significance testing results of the structural model hypotheses.

Accordingly, Figure 4 and Table 4 shows the path coefficient, Beta (β), R^2 (percentage of variance explained) and t-value that relate to the significant structural correlation among the established variables. As shown in Table 4 all of the hypotheses were strongly supported since t-value is greater >1.96 benchmark (Hair et al., 2013). The results indicate that IT infrastructure has a direct effect on Green IS refraction (β = 0.555, t= 9.589) and R^2 of 0.341 which implies that IT infrastructure explains 34.1% Green IS refraction signifying that Hypothesis 1 is supported. The coefficient for the path from information diffusion to Green IS refraction is positive and significant (β = 0.593, t= 9.908) and R^2 of 0.399 showing that information diffusion explains 39.9% Green IS refraction (39.9%) which supports Hypothesis 2. The data also shows that firms strategy has a direct effect on Green IS refraction (β = 0.572, t= 9.366) and R^2 of 0.369 indicating that firms strategy influences 36.9% Green IS refraction which means that Hypothesis 3 is supported.

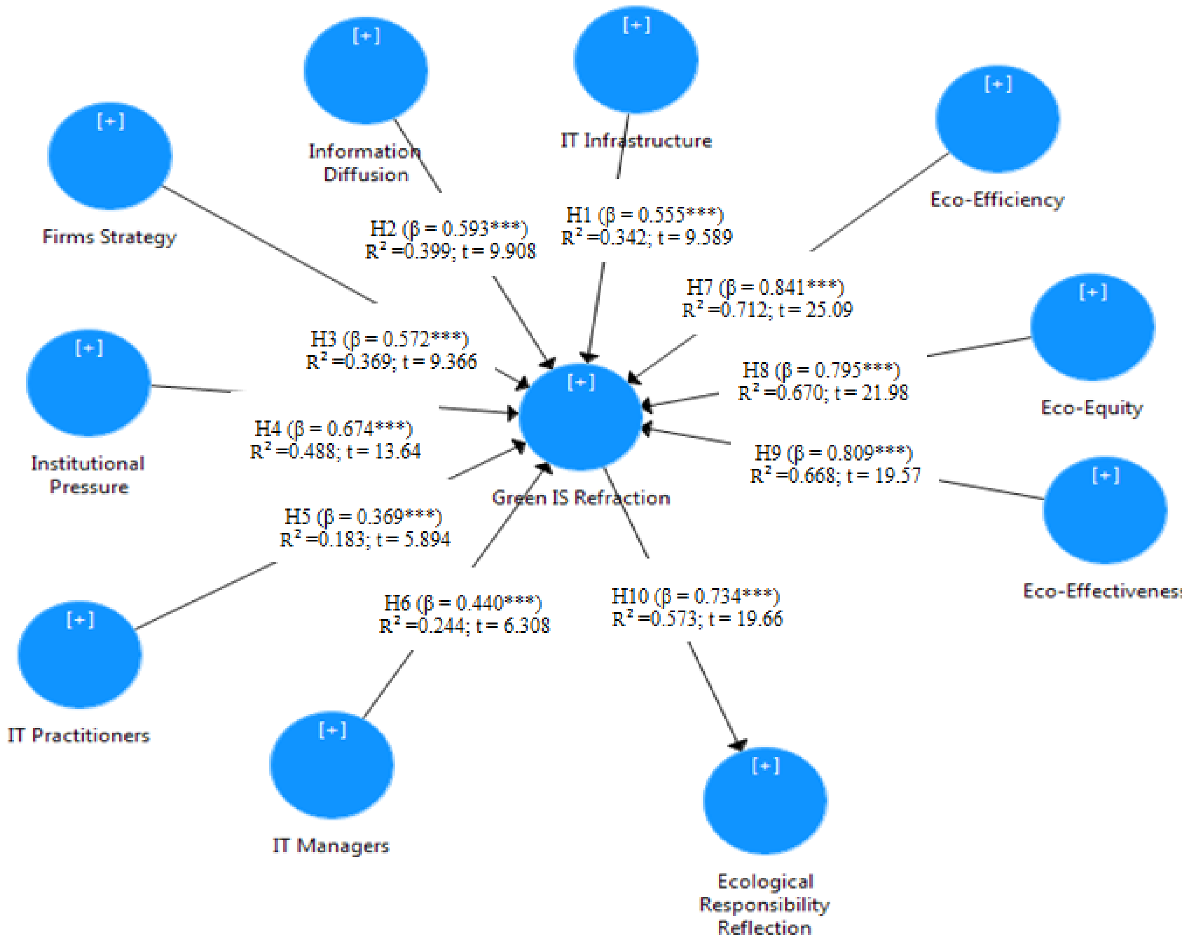

Figure 4 Results of the structural model (hypotheses confirmation. Note: ***$p < 0.05$)

Consistent with the hypotheses, the results reveal that institutional pressure has a positive effect on Green IS refraction (β = 0.674, t= 13.64) and R^2 of 0.488 which means indicating that that institutional pressure has an effect of 48.8 % on Green IS refraction hence supporting hypothesis 4. As hypothesized in hypothesis 5, IT practitioners action has a significant direct impact on Green IS refraction (β = 0.369, t= 5.894, R^2 of 0.183 (18.3%)), hence supporting hypothesis 5. Furthermore, IT managers is significantly associated with Green IS refraction (β = 0.440, t= 6.308, R^2 of 0.244 (24.4%)), therefore supporting hypothesis 6. Hypotheses 7, 8 and 9 also receive strong support from the data. Specifically, eco-efficiency influences Green IS refraction (β = 0.841, t= 25.09, R^2 of 0.712 (71.2%)), eco-equity determines Green IS refraction (β = 0.795, t= 21.98, R^2 of 0.670 (67.0%)) and lastly eco-effectiveness has an effect on Green IS refraction (β = 0.809, t= 19.57, R^2 of 0.668 (66.8%)), thus confirming hypotheses 7, 8 and 9 respectively.

Results from Table 4 reveals that Green IS refraction positively influences ecological responsibility reflection and account (β=0.734, t=19.66) and explains 0.573 (57.3%) variance in ecological responsibility reflection underlying the structural model. Moreover, the path coefficients as seen in Table 4 which is the main predictive associations in the model are all greater than or equal to 0.20 as suggested by Benitez-Amado et al. (2010), ranging from 0.428 to 0.844, hence the results are considered meaningful and theoretically pertinent in confirming the factors derived from the leietarture (Chin, 1996). In addition, all values were statistically significant ($p < 0.05$), indicating the proposed interpretive model is valid.

Assessment of Total Effect and Performance of Factors

In addition to checking the hypotheses, there is need to check interpretive model's total effect and performance value which assess how much the individual factor influence Green IS refraction and also measures the effect Green IS refraction has on ecological responsibility reflection. Accordingly, the effect size assesses the magnitude or strength of relationship between the variables, thus helping in confirming the overall contribution of this research. Congruently, Chin et al. (1996) clearly pointed out that academicians should not only indicate whether the hypotheses are significant or not, but also report the effect size between constructs.

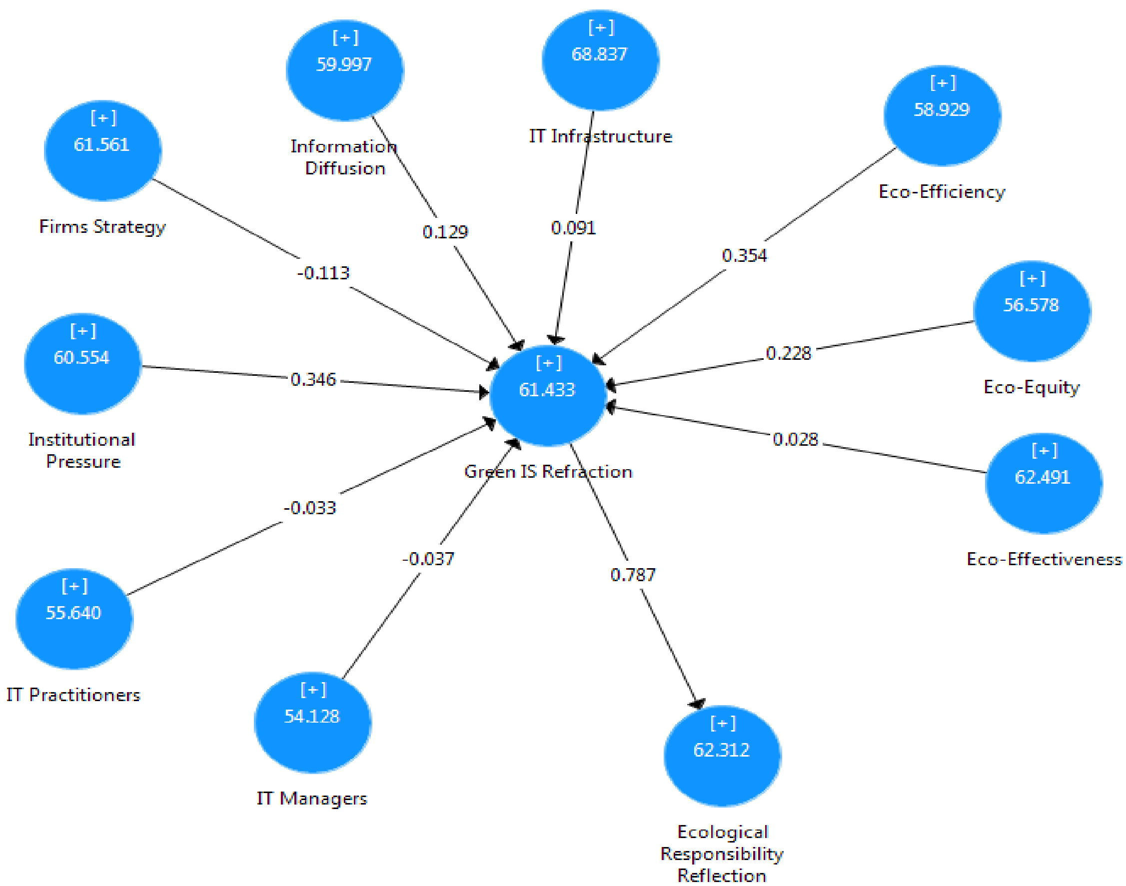

Figure 5 Results of IPMA test for total effect and performance on Green IS refraction

Hence, results from Importance-Performance Map Analysis (IPMA) test in SmartPLS3 as depict in Figure 5 reveal the test of total effect and performance for the structural model. Results suggest that IT infrastructure and eco-effectiveness is the most performing variable with total performance of 68.837 and 62.491 respectively in relation to Green IS refraction for ecological responsibility reflection in ICT based firms. This implies that ICT based firms should lay more emphasis on the eco-effectiveness items (see Table 1) as well as technologies and systems deployed in their organization in adopting Green IS for ecological responsibility. In addition, result from IPMA test also disclose that eco-efficiency and institutional pressure possess the most effect on Green IS refection with a value of 0.354 (35.4%) and 0.346 (34.6%) correspondingly. This confirms that pressure from governmental and non-governmental associations influences ICT based firms in implementing eco-friendly practices. Lastly, IPMA test confirms that Green IS refraction influences ecological responsibility reflection at an effect of 0.787 (78.7%) and at a performance of 61.433.

Discussion

Drawing on TOE framework and Green IT/IS literature, this study developed an interpretive model which was empirically tested based on questionnaire data validation using PLS-SEM. Data supported the predicted technological factors relationship, that there is a significant relationship between IT infrastructure and Green IS refraction (Hypothesis 1) and information diffusion and Green IS refraction (Hypothesis 2). This finding is consistent with results of previous studies (Radu, 2016). The result implies that IT infrastructure deployed can facilitate Green IS adoption for the attainment of ecological responsibility in ICT based firms. Accordingly, IT infrastructure can enable eco-friendly initiatives in organizations as they aims to decrease energy depletion of IT facilities (Brauer et al., 2016). In detail, the results lead to the conclusion that IT infrastructures used in businesses also diminish the power utilized in cooling of enterprise facilities by improving energy proficiency of IT hardware, thus reducing CO_2 emissions.

In addition, findings suggest that information diffusion influences Green IS refraction. This is reasonable, because information diffusion to the organizational society regarding Green IS adoption aims to provide information on how firms can attain ecological responsibility (Watson et al., 2010). As Butler (2011a) stressed, one of the major determinants of ecological responsible behavior in firms is the availability of data on how organizations can consume reduced energy which results to the lessening of CO_2 emitted throughout firm's operations. So, it is recommended that information should be provided on how staffs can decrease energy consumption, decrease e-wastes and lessen utilization of natural resources in ICT based firms.

The results of this research support the hypothesis that firms strategy influencing Green IS refraction (hypothesis 3), institutional pressure positively influence Green IS refraction (hypothesis 4), as well as IT practitioners action determining Green IS refraction (hypothesis 5) and lastly IT managers support positively influencing Green IS refraction outcome (hypothesis 6).

The outcomes of prior research (Chen et al., 2011; Lei and Ngai 2014) confirm the results of (hypothesis 3). This study found that firm's strategy is an important factor that impact organizational development and also determines staff's perception to adopt Green IS practice toward achieving ecological responsibility in long term (Seidel et al., 2010).

Likewise, the outcomes of this study also support the proposed Hypothesis 4, that there is significant relationship between institutional pressure and Green IS refraction. This result is analogous with findings of earlier research (Ainin et al., 2016). This study data reveal that governmental, industrial, and non-governmental regulations induce ICT based firm's to adopt Green IS practices. Results from this study suggest that internal executive policies within the enterprise pressure staffs to adopt Green IS practices. As Jenkin et al. (2011) confirmed, these pressure influence the decision of organizations towards adopting Green IS practices thus resulting to reduction of electricity usage (Vykoukal et al., 2011).

The results of this study also support the proposed hypothesis 5, that there is a significant association between IT practitioners and Green IS refraction. These findings also support the results of previous research (Loeser et al., 2017). The results suggest that IT practitioner's belief toward the natural environment will affect the outcome of Green IS adoption for ecological responsibility in ICT based firms. In addition, the behavior of IT practitioners can be changed by creating awareness on Green IS initiative adoption in increasing their rigidity to ecological friendly practices (Loeser et al., 2017). Moreover, the findings of this study also support hypothesis 6, which implies that IT manager's commitment and support positively influence Green IS refraction. This is also in line with findings of previous studies carried in other nations (Benitez-Amado et al. 2010; Butler, 2011a; Vykoukal et al., 2011; Molla and Abareshi 2012). In this sense, IT manager's support is an important attribute for any establishment success. Accordingly, the commitment of IT manager's influence organization bid to adopt Green IS practice towards ecological responsibility.

The results of this research confirm the environmental factors, that eco-efficiency positively influences Green IS refraction (hypothesis 7), eco-equity significantly determines Green IS refraction (hypothesis 8) and eco-effectiveness positively influences Green IS refraction (hypothesis 9). This study shows that the eco-efficiency, eco-equity and eco-effectiveness initiatives need to be implemented for Green IS refraction. This is analogous with prior studies (Chen et al., 2011; Molla and Abareshi, 2012) where the authors mentioned that such practices help in lessening CO_2 emission, reducing e-waste generation, decrease energy usage as well as conserve the natural environmental for the present and future needs. Finally, the results of this research support (hypothesis 10), that Green IS refraction influences ecological reflection similar to previous studies (Molla et al., 2014; Loeser et al., 2017). This discloses that Green IS practices adopted in ICT based firm's significantly possess the capability to address ecological issues related to environmental degradation.

Research Implications

Theoretical Implications

Theoretically, this study explains how ICT firms can adopt Green IS to resolve environmental issues caused by traditional IT usage in their organizations. In particular, findings from this study show how ICT based firms can develop ecological management capabilities from IS enabled innovativeness. In addition, results of this study increase IT practitioners and IT managers understanding of the impact of Green IS practices for ecological responsibility. Furthermore, this study has implications for IT managers to draw upon the developed interpretive model to assess the factors that influences Green IS adoption. For policy makers, the interpretive model presents eco-efficiency, eco-equity and eco-effectiveness as eco-friendly initiatives to be adopted for successful Green IS adoption.

Respectively, eco-efficiency supports Green IS by maximizing productivity for a limited amount of input (such as time, man power, and resources). Eco-efficiency which reduces by-products wastes released to the natural environment. Similarly, eco-effectiveness which aims to achieve positive tangible benefits such as cost saving as well as intangible benefits which includes environmental conservation gains through Green IS initiatives. Likewise, eco-equity aims to resolve not only service throughput but also the social responsibility of ICT based firm. Respectively, this is achieved when the firm deploys telecommuting based applications which includes remote desktop access from home to reduce traffic congestion which thereby save office space and also provide staffs with flexibility.

Additionally, theoretical findings from this study contribute to theory building in the emerging domain of Green IS as well as Green IT research by providing a survey instrument (see Table 1) with items corresponding to TOE framework to identify factors that influence Green IS refraction and further examines to what extent these factors impact Green IS refraction in ICT based firms. Thus, future researchers can readily use the instrument to replicate the study across industries in other countries. Besides, this study fills this research gap by holistically evaluating ICT based firms readiness for Green IS initiatives by considering the technological, organizational and environmental factors for successful Green IS retraction towards corporate ecological responsibility. This study, thus adds new knowledge to this emergent area of IS research by providing insight into the impact of IT usage, and its influence on the society. Similarly, this research contributes not just to IS researchers, but also to a diverse audience such as environmentalists, organizational decision makers, IT specialists, and policy makers whose interests include environmental, social and economic sustainability.

Managerial Implications

Intrinsically, this research brings to the attention of ICT based firms the separate roles played by Green IS and traditional usage of IT in the attainment of ecological sustainability. This careful differentiation aids organizations to find the right positions for Green IS and IT usage in their ecological friendly initiatives for sustainability achievement. Accordingly, findings from this research have significant implications for managers towards adopting Green IS for corporate ecological responsibility. Based upon the technology organization environment framework this study develops an interpretive model to explore on the factors that influence ICT based firms to adopt Green IS for ecological responsibility and further examines to what extent these factors impact Green IS refraction for corporate ecological responsibility reflection.

The model suggests that Green IS refraction is driven by technological, organizational and environmental factors which lead to ecological competitive advantage. For IT managers who are considering to adopt Green IS in their organizations, the interpretive model can be used as an analytical framework to guide their decision making process. For those who are presently adopting Green IS for ecological responsibility, the interpretive model can help in focusing the key performance factors as identified in this study. Accordingly, this study adds to the limited empirical research in the domain of environmental management and policy to provide an agenda for other researchers to better apprehend the factors that enables Green IS refraction. Therefore, this research provides academicians with further guidance on how they can carry out future exploration towards developing their own theories.

Conclusion, Limitations and Future directions

Environmental sustainability is a multi-dimensional endeavor that requires action from organizations, societies and individuals. Over the years, due to global warming, climatic changes and environmental deterioration ICT based firms are beginning to adopt Green IS practices. In order to stay viable in this shift, IT practitioners and IT managers in ICT based firms need to be prepared for changes in both behavior and mindset. The insights gained from this study aids in providing clear understanding of technological, organizational, and environmental factors that can be used to improve and further promote Green IS practice in organizations. Thus, by considering these factors ICT based firms can decrease the ecological impact of IT systems and technologies usage in utilizing Green IS to promote environment performance within their organization. In the context of environmental sustainability, this study identified the factors that determine Green IS practice for ecological responsibility through a review after which a Green IS interpretive model was designed based on technology organization environment framework. To this end, survey method was employed to test the model hypotheses using PLS-SEM based on survey data.

Although this research offered significant contributions to the literature concerning Green IS for ecological responsibility, this study possess a few limitations. First, all of the respondents were located in Malaysia as such the findings from this study cannot be generalized to other regions. Secondly, another limitation of this research related to the sample size which was limited based on the low response from invited participants. While, the author does not claim that the sample in this research is a representative of all ICT based firms in Malaysia, this study still provides useful insights on current Green IS practice being adopted in organizations based in

Malaysia. Thirdly, an additional limitation is that respondents in this study are mostly IT practitioners and IT managers. Accordingly, further research would be necessary to carry out a longitudinal data collection from multiple respondents based in more than one country to increase sample size. Lastly, a multiple-respondents method that included both staffs and experts and professionals from other domains would be a fruitful endeavor.

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